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Simulation and Gaming for Social and Environmental Transitions

Nicolas Becu

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Proceedings of the 54th Conference of the International Simulation and Gaming Association



SIMULATION AND GAMING FOR SOCIAL AND ENVIRONMENTAL TRANSITIONS



EDITED BY **NICOLAS BECU**
La Rochelle, 2023



Nicolas Becu

Simulation and Gaming for Social and Environmental Transitions

Proceedings of the 54th Conference of the
International Simulation and Gaming Association



La Rochelle, 2023

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The ISAGA community inherits from a long tradition and a large knowledge base in the domain of simulation and gaming, and related methods. More than 50 years of research and practice in the domain have consolidated the community's understanding, know-how, and reflection on the use of simulation games in various fields of application such as management, social and environmental sciences, education, health, planning and technical sciences.

The proceedings of the 54th edition of the International Simulation and Gaming Conference, covers a wide range of application types such as serious games for education, participative use of simulation games, design of board games and role-playing games, gamified environments and more. Some are meant to raise awareness on specific issues, others are intended for training purposes, and still others are designed to facilitate and encourage collective action.

In this publication, readers will find full papers and extended abstracts dealing with the evaluation of the effects of simulation games, including learning effects, effects on organizational or collaborative behavior, effects on motivation and engagement as well as, in a more innovative vein, effects on players' emotions. Other papers deal with design issues, analyzing role design, co-design processes or even the treatment of system complexity in game design. The use of new technologies, such as augmented reality, or the use of online educational games, are also addressed. Interestingly, several papers address the facilitation of simulation games, and seek to better characterize the facilitation role and its associated skills. Similarly, some authors propose characterizations of player profiles.

Meanwhile, the 54th edition of ISAGA conference highlighted the theme of "Simulation and gaming for social and environmental transitions". The ISAGA community responded enthusiastically to this call, and these proceedings include a large number of full papers and extended abstracts that approach this theme from different angles. Readers will find a large number of simulation games dealing with the multiple challenges of transitions, from games on energy transition, low carbon, sustainable development, "limits to growth", nature-based solutions, to games on the relation to science, equity issues, or ethics in transitions. Some of these games are meant to explore various transition pathways, others are meant to encourage social awareness about critical social or environmental problems. Finally, a number of papers present critical thoughts about the role of simulation and gaming in transition processes. Some question the concept of transformational learning, others analyze the rhetoric of social change games, and still others discuss the role of simulation games in the participation of citizens in transition processes.

In short, the proceedings of the 54th ISAGA conference provide a condensed overview of international research and current practices in the domain of simulation and gaming, focusing on issues of design, use and evaluation of simulation games in the present period of social and environmental transitions.

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FULL PAPERS

Sustainability through Simulation Games? Towards Designing a Research Agenda for Transformational Learning

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Abstract. Learning sustainability is closely linked with transformational competencies. Exploring formats and corresponding experiential methods are conducive to acquiring sustainability-related competencies. Simulation games are formats involving elements of experiential learning and qualifying for simulated realities of sustainable transformation. Research designs addressing experiential learning *for* sustainability are to adopt their logic and inherent principles. Considering simulation games in a paradigmatic way enables realizing their transformational potential for learning sustainability. This contribution advocates establishing a research design for experiential learning through simulation games driven by grounded theory, and embedded into an analytic and systematic reflection on teaching and learning.

Keywords: simulation game; sustainability; experiential learning; transformation; grounded theory

1 Experiential Patterns for Transformational Learning

Designing and facilitating simulation games have always been at the heart of implementing them in thrilling contexts [2] [15] [37] [42] [51] [64]. There are certainly a couple of good reasons to highlight creating and performing aspects. This may primarily have to do with the quest for innovative, entertaining and customized formats of considering simulation games *healers* for each and every purpose of agile learning assignments. Another explanation may be inherent in the particular attitude of *homo ludens* of committed simulation gamers [20] [56].

Even though the importance of reflexive and debriefing has continually and strenuously been emphasized [41] [54], conducting open or focused research on simulation games has emerged only recently due to a) challenging the format through new trends of virtual gamification [53], b) providing third-party funding for learning-outcome-impact analyses [6] [18] [61], c) improving monitoring competencies [38], d) accommodating with transformational learning paradigms [40] [51] [58], or e) evolving societal implications with an articulated need of methodological justification and foundation [60].

Following these arguments, there is evidence that “(t)he serious (or simulation) games community is moving toward research focusing on direct comparisons between learning outcomes of serious games and those of more traditional training methods (acknowledging that) (s)uch comparisons are difficult, however, due to the lack of a consistent taxonomy of game attributes for serious games” [6]. Put differently, there is an evolving tendency from simulated *ludospheres* [56] towards some kind of serious game science [39] that anticipates and incorporates experiential learning [63].

Taking into account the different transition pathways of transformational development (see **Fig. 1**) from niche innovations, via transforming socio-technical regimes, towards socio-technical landscapes, progress triggered endogenously as small-scale evolution in niches clearly outweighs socio-technical regimes in terms of visionary design potential and consistency. Whereas regime changes largely depend on *revolutionary windows of opportunity*, mainly exogenous, novelties

are results of nuclei of networking functions through learning from scratch. Following this rationale, transforming whole socio-technical landscapes may be result of gradual evolution of approved practice or exogenously-induced shift of paradigms, either due to external shocks or positive *leap-frogging* techniques or technologies.

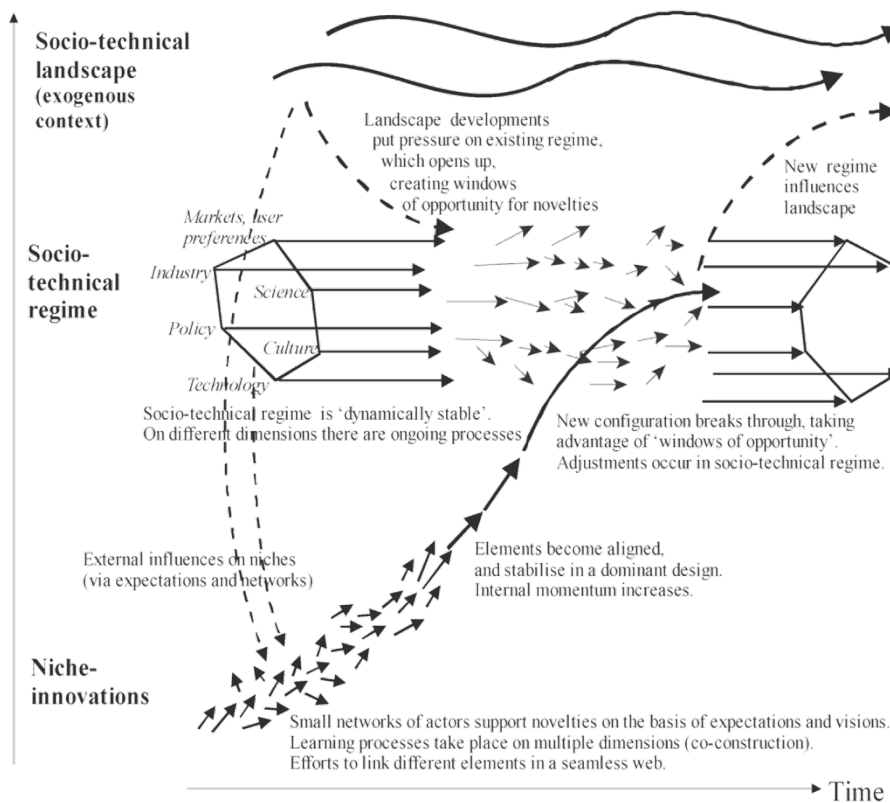


Fig. 1. Transition pathways (see [19])

Transformational learning is a paradigm of holistic learning in formal, non-formal and informal contexts to radically change the world. Related competencies reach far beyond cognitive knowledge acquisition, but liaising emotional affectedness with consciously changing behaviour in deed.

The framing objective is contributing to a research agenda while trying to elucidate experiential patterns for transformational learning that evolve from scratch in co-creative and co-constructive networks, and provide niche solutions to scale up. The nucleus for enabling multi-dimensional, visionary and liaising learning processes for both participants and scholars is the simulation-game context. Thus, *considering simulation games in a paradigmatic way enables realizing their transformational potential for learning sustainability.*

In a nutshell, the following considerations are intended to outline a framing agenda for continuing research on exploring those experiential patterns in simulation games that spark off, enable and advance transformational, sustainability-related learning.

2 Transformational Competencies for Learning Sustainability

Sustainability translates into meeting present needs without compromising the ability of future generations to meet their own needs. Thus, the concept embodies a vision of future-perfect thinking through transformational abilities to sustain in environmental, economic, societal, and cultural terms. *Learning sustainability is inextricably linked with transformational competencies.*

What these competencies consist of has been systemized through a comprehensive framework (see Fig.) of key competencies in sustainability [9] [65] [66]. Partly updated, adjusted and rephrased they include...

- *systems-thinking competency* as the ability to collectively analyse complex systems across different domains – including the quadruple line of sustainability dimensions of society, environment, economy and culture – and across different scales/levels – from local via regional to global –, thereby considering cascading effects, inertia, feedback loops and other systemic features related to sustainability issues and sustainability problem-solving frameworks;
- *anticipatory/futures-thinking competency* as the ability to collectively analyse, evaluate, craft/design and communicate imaginative visions of the future aiming at positive notions of sustainability issues and empowering, facilitating or enabling frameworks;
- *normative/values-thinking competency* as the ability to collectively map, specify, apply, reconcile, and negotiate sustainability values, principles, goals and targets, providing the *intrapersonal competency* of inner dialoguing for negotiating moral concepts;
- *strategic-thinking competency* as the ability to collectively design and implement interventions, transitions, and transformative governance strategies toward sustainability; and
- *interpersonal/collaborative competency* as the ability to motivate, enable, and facilitate collaborative and participatory sustainability research and integrated problem solving.

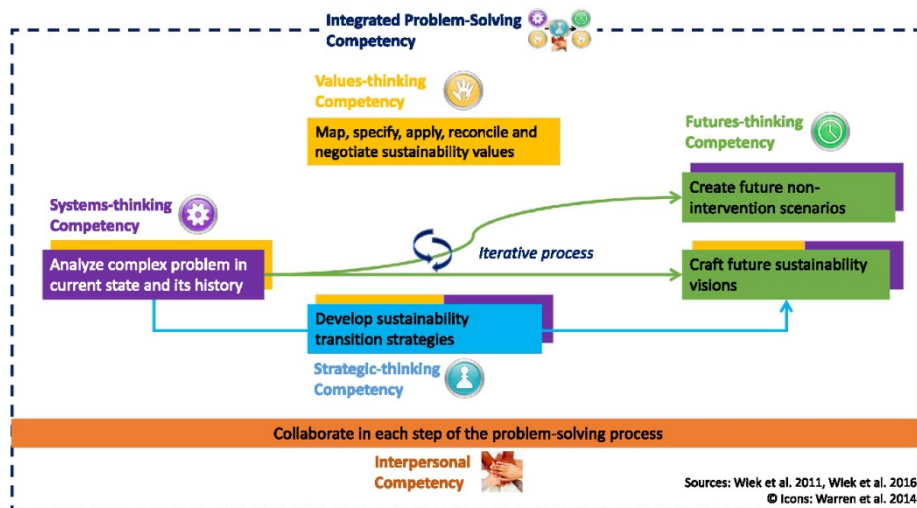


Fig. 2. Key competencies in sustainability (see [9])

When taking an analytic look at learning sustainability it can be useful to consider key competencies in sustainability as guideline or benchmark, mainly for two reasons:

1. There is an evaluating, monitoring or assessing need or impetus of qualifying specific transformation processes; and/or
2. There is the end of indicating a nexus between transformational competencies and experiential learning.

3 Patterns of Experiential Learning for Sustainability

Transformational learning correlates with experiential learning. Before analysing the transformational potential of simulation games for learning sustainability what is assumed by experiential learning, in first place [24] [25] [26] [27] [28] [32] [33] [34] [50] [59]. There is reasonable evidence for the *Big Five* in/of experiential learning consisting of...

1. a well-introduced subject matter and/or formulated research question,
2. adequately stated and applied research methods,
3. substantial research results,
4. documented and consistent reflection, and
5. novel scientific insights.

Exploring formats and corresponding experiential methods are conducive to acquiring sustainability-related competencies. There is some reason to believe that experiential methods potentially match with transformational methods; at least, both share certain elements that can be interpreted as such in mutual terms. Those are, for instance, and by no means comprehensive: collaborative real-world projects, service-learning projects, campaigns and flash-mobs, future conferences, bar camps, scenario analyses, utopian/dystopic storytelling, science-fiction thinking, fore-/back-casting, participatory research, case studies, stakeholder analyses, modelling/systems' games, critical thinking, fish-bowl discussions, learning logs etc. [52].

Even though science-based and didactically-sound evidence still needs to be delivered, certain didactic intuition provides promising tendencies of formats inducing, inspiring or fostering sustainability, amongst them simulation games. Since they provably contribute to developing and/or improving competencies in dealing with complexity, uncertainty and value conflicts [38], this may apply to the scope of sustainability, in particular. The proof of the pudding is actually part of the research agenda, which means, validating patterns of experiential learning for sustainability in simulation games through finding evidence for experiential approaches in methods and corresponding transformational competencies.

4 Simulation Games and Sustainability

Is the simulation-game technique a viable and promising vehicle for addressing transformational issues? What are those elements or properties inherent to simulation games to address sustainability-related contexts, in particular, and what are the factors that contribute to successful transformative changes? Can games be transitional spaces allowing people to redefine their relationships with others and the environment?

Simulation games are fascinating, because they provide real-world learning opportunities in sustainability for many different contexts [10], such as biodiversity and ecosystem services in a social-environmental transition process, to randomly pick an example [21] [22]. Technically speaking, simulation games may be described as formats at the transition from *niche innovation* to established *socio-technical regimes* (see Fig.). Why? Simulation games contain certain characteristic or design elements, such as playful, interactive and participatory methods of dynamic and self-determined learning to train multiple competences [20] [58] [61], that evolved from small networks and nerd-like communities, and gradually aligned during the last decades stabilising in a dominant simulation-game design [15] [37] [51]. Moreover, simulation games typically embody the notion of liaising different elements, such as embracing heterogeneous target groups, addressing hot-potato-issues or tackling systemic conflicts, and of creating an internal momentum that nudges and inspires the simulation-game community [39] [43] [51] [55] [64].

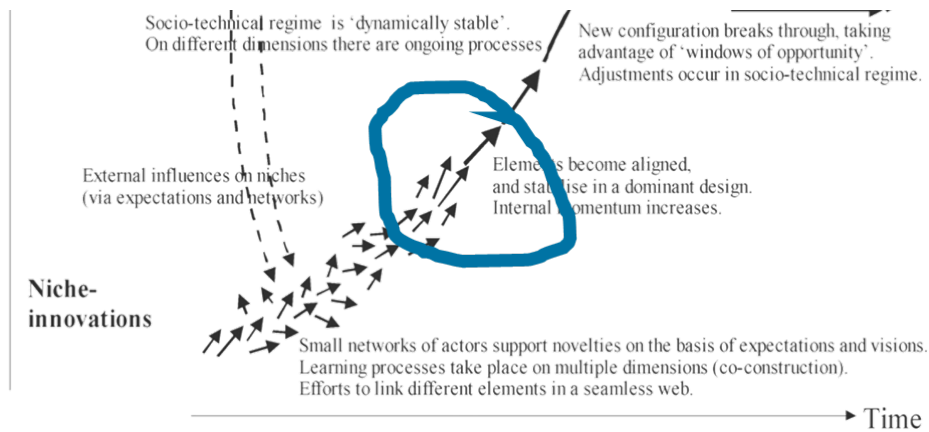


Fig. 3. Transition pathways of simulation games (adapted from [19])

Since sustainability requires the collective ability and willingness to plan for the future, system-thinking simulation games may be regarded as formats involving elements of experiential learning and qualifying for simulated realities of sustainable transformation. This applies to simulation games both in the context of a participatory process, and in the context of (professional) training and (higher) education.

In order to validate, further underpin or refute this hypothesis, different samples of self-conducted, sustainability-related simulation-game experiences provide the corpus for research (see Fig.). Each sample contains a set of associated e-portfolios ready for analysis. The selection captures proper simulation-game expertise in transformative or transformational processes, respectively, for stakeholders to transform in either rules/values, roles or assumptions on resources of their organization.

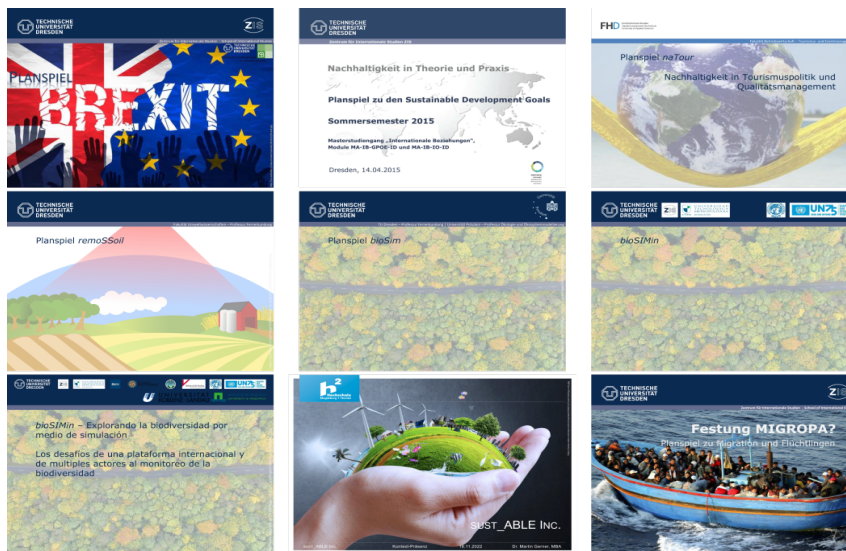


Fig. 4. Sampling of sustainability-related simulation games

Further samples can easily be added as the experiences with scalable or newly created learning assignments are advancing. In this respect, they may serve as continually extended corpus available for evidence-inducing saturated grounded-theory analysis of e-portfolios in the context of *Scholarship of Teaching and Learning* (SoTL).

5 Scholarship of Teaching and Learning through Grounded Theory

Scholarship of Teaching and Learning (SoTL) can roughly be described as “systematic reflection on teaching and learning made public” [44]. It “is a kind of going meta in which faculty frame and systematically investigate questions related to student learning – the conditions under which it occurs, what it looks like, how to deepen it and so forth – and do so with an eye not only to improve their own classrooms but to advancing practice beyond it” [35]. Originating from *targeted observation*, moving to *reflective teaching*, and shifting from *scholarly teaching* (see Fig.), *SoTL* follows a couple of principles [17], such as being...

- focused on student learning;
- grounded in context (both in literature and in a teaching-learning context);
- conducted using sound methodology;
- conducted in partnership with students (ethics approval, at a minimum); and
- disseminated to contribute to both knowledge and practice.

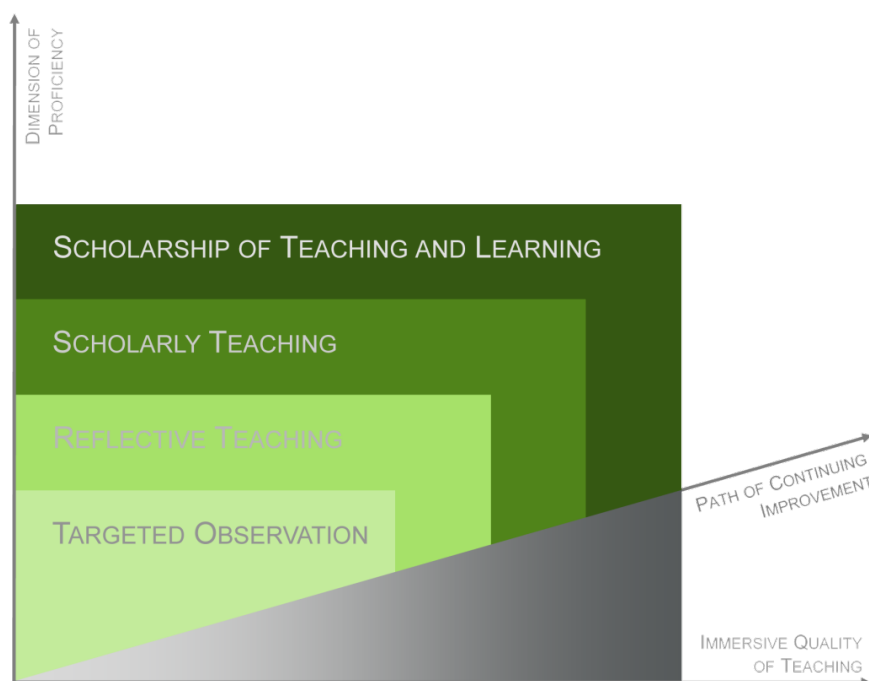


Fig. 5. Contextualizing *Scholarship of Teaching and Learning* (SoTL)

Advancing *SoTL* in the context of simulation games is for quality enhancement in first place [8] [29] [30] [31] [47]. Following a paradigm of incremental improvements, portfolio analyses are appropriate ways of tracing progress through formative assessments [3] [4] [7] [49]. Portfolios can make a meaningful difference for integrated knowledge [11] [12] [16] [48]. As *living portal* [45] they may serve as record of one’s progress throughout the year, for instance, repository for one’s work, and mirror of reflecting student’s learning. Particularly digital ones – *e-portfolios* – do provide added value as collections of digital resources. They compile evidence of formative progress and achievements drawn from formal, non-formal and informal learning activities. Hence, they provide access to...

1. resources of self-directed or self-determined learning,
2. resources of reflective practice, such as review and reflection, and
3. resources of personal development planning.

Students frequently encounter challenges in developing individual e-portfolios, since they require degrees of freedom and foster creativity. However, “creativity, furthermore, is a concept that is not well understood by the students. Supports that nurture understanding of creativity and ‘how to be creative’ (are to) be developed for future students” [5] [46].

Nudging transformation through learning, either gradual-iterative or disruptive, is to be planned or anticipated. To certain extent, e-portfolios can be regarded as potentially transformative; from some didactic-pedagogic, technological and institutional points of view they appear disruptive, since they bypass existing systems of assessing performance [36]. Alternative ways of complementing assessment are supported from students’ perspectives instead [14]. Taking the simulation-game context, e-portfolios are diverse; they are touching upon cognitive, emotional and behavioural aspects from a highly reflective angle. And, e-portfolios are more than qualitative research diaries, while documenting processes and outcomes at the same time [23] [57]. Thus, they combine formative assessment with documented personal developmental. Without a doubt, “e-portfolios are (certainly not) the panacea for all diseases”, in fact, they serve as an evaluation, monitoring and feedback tool for students’ learning journeys of how to select, collect, reflect, write and respond to learnings experiences made [1] [67].

Interpreting e-portfolios follows *SoTL* principles through applying grounded theory as methodological framework. In doing so, systematically sampled and analysed e-portfolios are to “suddenly become more digestible, user-friendly, and theoretically grounded” [62]. Put differently, the corpus composed of single e-portfolios obtains abstract meta-quality of theory-involving meaning (see Fig.).

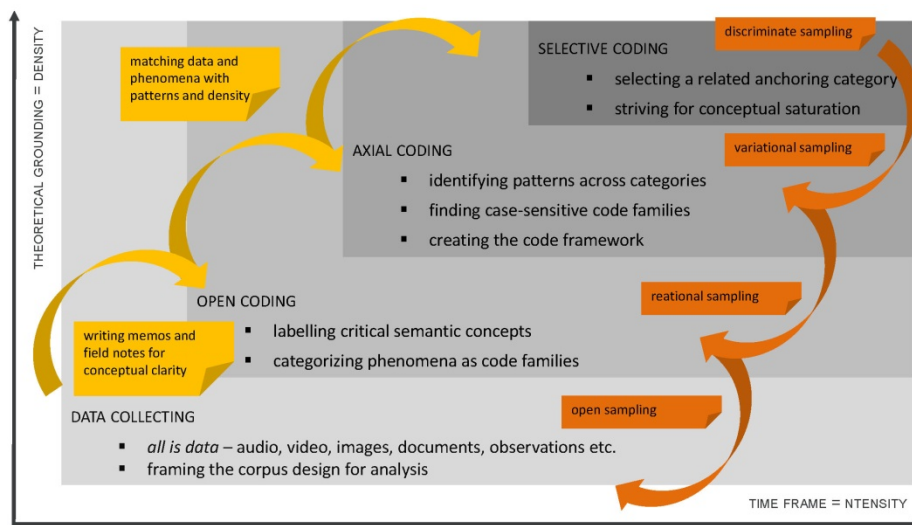


Fig. 6. Analytic procedures in grounded theory (inspired by [13])

To sum up, *research designs addressing experiential learning for sustainability are to adopt their logic and inherent principles*. It is purposefully considered through adopting an inquiry-focused, context-grounded, methodologically-sound, partnership-involving and publishing-affiliated approach of research that is in line with the *Big Five* in/of experiential learning.

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Educational Effects of Gaming Simulation for Experiencing “The World Lacking Something”: Through an Experimental Lesson about Society without Scientific Communication

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Abstract. In this study, the authors introduced the learning effects of gaming simulation in which students experience “the world lacking something.” This study developed a lesson in which students experience a world without science or scientific communication as a gaming simulation of the world lacking something.

Hypotheses in this study are as follows: 1) Through the games, students can realize the difference between the real world and the world lacking science, 2) By experiencing “the world lacking something,” students can realize the social significance of science.

In the lesson, the students experienced the world lacking something, which was completely devoid of the formative aspiration of science and very different from the real world where discussion was not possible for the students. Thus, the students could realize the difference between the real world and the world lacking science. So, it can be said that Hypothesis 1 was backed up.

Furthermore, the students learned two things through the lesson: (1) the significance of science as a medium for democratic discussions with others, (2) the significance of science for enabling them to judge democratic decisions. From the above, by experiencing the world lacking something, the students could realize the social significance of science. So, hypothesis 2 is backed up.

In the near future, in order to extend the results of this study, it is necessary to examine what would happen if students did not usually have interest in science.

Keywords: Citizenship education, Lesson design, Sociology of science, the Formative aspiration of science, Unreality

1 Introduction

The purpose of this study is to clarify the learning effects of gaming simulation in which students experience “the world lacking something” through an experimental lesson. In this study, the world lacking something refers to a virtual world that lacks important elements of the real world.

In today’s citizenship education, in order to educate citizens to create a better society, it is required to cultivate competency in the real world [1]. To this end, a number of studies have been proposed to make students engage in real problem-solving processes. For example, students propose strategies to solve problems to the local government, or discuss controversial political issues in the classroom.

However, it is not possible in all cases to have students engage in real problem-solving processes. For example, exposing students to very severe problem-solving processes or debates on politically serious topics can face them to risks associated with political conflicts.

On the contrary, using gaming simulation in lessons has no risk because it enables students to experience problem-solving in a virtual world. So, gaming simulation has become popular. In preceding studies, it has been discussed that learning through gaming simulation can foster understanding and competency that can be used in the real world [2]. In fact, several types of

gaming simulation have been developed to foster citizenship education by having students experience virtual worlds that imitate the real world [3, 4].

However, we have persisted in the assumption that the world in gaming simulation must be close to the real world. On the contrary, it is possible to have students experience a virtual world that is different far from the real world. For example, the students who are required to make a political decision without discussing it with other students should be able to realize the importance of the discussion before making a political decision. Such an experience of the world lacking something has significant learning effects. Thus, in this study, the world lacking something refers to a virtual world that lacks important elements of the real world.

In considering learning effects of experiencing the world lacking something, Heidegger's philosophy is instructive. According to Heidegger, in order to become aware of the elements or rules of the world in which we exist, we need to be thrown into a situation in which they do not exist [5]. For example, it is difficult for a craftsman skilled in handling a hammer to be aware of the details of its use, because his skill with the hammer is embodied in him implicitly. It is only when the hammer breaks or is lost that he becomes aware of its presence in the world.

Thus, in order to understand the importance of the competency required for citizens, it is not always necessary to experience a real situation. For example, in a soccer game without a keeper, the fun of the game may be spoiled by scoring too many goals. This experience will make them realize how important the keeper is. In summery, it is only by experiencing the world lacking something that we can understand how the world works, how it functions, and how important the elements of the world are.

This study examines whether the experience of the world lacking something enables students to realize the importance of the elements they are familiar with.

2 Method

2.1 Contents of the Lesson

This study developed a lesson in which students experience a world without science or scientific communication as a gaming simulation of the world lacking something. Through the experience of the world lacking something, this study aims at making students realize the significance of science in society.

According to the sociology of science, the significance of science in society is defined as follows: the significance of science not as activities of superior knowledge production, but as values embodied in the activity of science, which is indispensable in a democratic society [6]. Today, under the influence of "constructionism" in the humanities and social sciences, there is a widespread view that the knowledge produced by science is merely the product of negotiation and adjustment of interests among social groups. The value embodied in the activity of science is called "formative aspiration of science" by Collins. The formative aspiration of science refers to the norms that are expected to be shared by the scientific community, such as "Observation", "Falsification", and "Disinterestedness" (Table 1). According to Collins, the social significance of science lies in that the existence of the norms enables and promotes democracy.

Based on the above, this study makes students experience the world lacking something in which the formative aspiration of science does not exist. For this purpose, two levels were set (Table 2). The first level was "Conspiracy Theory Championship" (Game 1) in the first half of the lesson. Conspiracy theories are those that deny general scientific theories on the basis of conspiracies [7]. They lack a part of the formative aspiration of science. It claims that scientists engage in science relying on their own political positions and interests. Conspiracy Theory Championship is an activity that requires students to make conspiracy theories about sciences that demonstrate global warming. Afterwards, each group presents their conspiracy theories and decides which one is the best. Students were advised to focus on social interests, such as "Who would benefit from asserting global warming?"

Next, “Unscientific Class Meeting” (Game 2) was conducted as Level 2. “Unscientific Class Meeting” was an activity in which all the formative aspiration of science was prohibited perfectly. In the meeting, students were required to discuss whether or not group work should be conducted in the lessons. Specifically, some volunteer students took part in a debate and are divided into affirmative and negative groups. Other students are audiences. Since it was not possible to fully explain the content of the formative aspiration of science, “Observation”, “Falsification” and “Universalism” were introduced with specific examples. Students were instructed to communicate unscientifically referring to conspiracy theories.

As described above, the first step was to have students think about the conspiracy theories that are relatively familiar to them (Level 1), and second step was to have students communicate without using the formative aspiration of science (Level 2).

Table 1. Summary of formative aspiration of science [6]

Title	Content
<i>Observation</i>	Scientists should make claims based on observations.
<i>Corroboration</i>	Scientists should make reproducible statements.
<i>Falsification</i>	Scientists should be willing to undergo falsification.
<i>Communism</i>	Knowledge should be shared (as opposed to secrecy).
<i>Universalism</i>	We can contribute equally to science regardless of ethnicity, nationality, culture, or gender.
<i>Disinterestedness</i>	Scientific results should not be presented in a way that reflects the influence of one’s personal beliefs or ideological activities.
<i>Organized Skepticism</i>	Scientific claims must be subjected to critics.
<i>Honesty and integrity</i>	Scientists should be honest and honorable.
<i>Locus of interpretation</i>	Scientific results are evaluated by professional scientists (as opposed to evaluation by the public, that is populism).
<i>Clarity</i>	Scientists should aspire to communicate only correct interpretation (as opposed to art which allows a diversity of interpretations).
<i>Individualism</i>	In science, one always has the right to challenge the authoritative majority.
<i>Continuity</i>	New discoveries should aim at being recognized by the existing scientific community.
<i>Open-endedness</i>	The work of science is eternal.
<i>Generality</i>	Scientific statements should have a broad sense of applicability.

Table 2. Contents of games

Level	Game	Content
<i>1</i>	Conspiracy Theory Championship (Game 1)	Students experience communication which lacks a part of the formative aspiration of science in making conspiracy theories.
<i>2</i>	Unscientific Class Meeting (Game 2)	Students experience a debate in which all the formative aspiration of science was prohibited perfectly .

2.2 Hypotheses and Methods

Hypotheses in this study are as follows:

1. Through the two games, students can realize the difference between the real world and the world lacking science.

2. By experiencing “the world lacking something,” students can realize the social significance of science.

Participants: Participants consisted of 39 first-year high school students in a science and mathematics class (38 valid responses to the questionnaire), who usually have no doubt about the significance of science. The students’ academic achievement is relatively high in Japanese high schools, and the majority of the students wish to go on to university to study science. In response to the question in the pre-lesson questionnaire: What is the role or significance of “science” or “learning science” in today’s society, 36 out of the 38 students (94.7%) answered that science exists for progress and welfare.

Study date: The pre-lesson questionnaire, the lesson with two games and post-lesson questionnaire were conducted on September 16, 2022.

Tasks and procedures: Students’ responses were analyzed from audio data recorded during the lesson and the post-lesson questionnaire. Author 1 was in charge of the lesson (facilitator), and Author 2 assisted in recording and other tasks.

To examine Hypothesis 1, the audio data and the students’ responses to the post-lesson questionnaire were analyzed. There were 2 questions: When thinking about conspiracy theories (in Game 1), what did you pay attention to? and how did you feel after experiencing Unscientific Class Meeting (game 2)? The students answered these questions by free description.

To examine hypothesis 2, the students’ responses to the same questions in the pre and post-lesson questionnaires were analyzed: What is the role or significance of “science” or “learning science” in today’s society? The students answered the question by free description.

For an analysis, students’ answers were coded into several categories. The coding was drafted by the Author 2, checked by the Author 1, and revised by the Author 2.

3 Results

The students’ discussions during the lesson are introduced as follows. Then hypotheses 1 and 2 are examined.

3.1 Students’ discussions of Conspiracy Theory Championship

As stated above, before making the conspiracy theory, an instruction was given to draw students’ attention to the concept of interests: Who would benefit from asserting global warming? What did the students actually pay attention to when they were making their theories? Table 3 shows the first half part of one group’s discussion. The students began to discuss who would benefit in the real world.

Table 3. One group’s discussion when making conspiracy theory (first half)

A: What is global warming?
B: I wonder. Whose conspiracy is it?
[...]
C: Will oil-producing countries benefit?
A: Maybe, they should deny global warming.
C: Yes, they should.
[...]
C: Isn’t it the same with cars?

Some students felt the content of the discussion was too realistic and lacked impact. They decided to discuss the issues unexplained by science. Table 4 shows the last half part of the discussion and “aliens” appeared in the content of the discussion.

Table 4. One group’s discussion when making conspiracy theory (last half)

D: Well, I think it can be more unrealistic.
A: Yeah, yeah, that’s right.
C: More like....
D: So, Teacher X is actually an alien, and he has a constitution that would die if carbon dioxide levels increase too much.
[...]
D: An assumption is that people with top positions are actually extraterrestrials, and they have intelligence higher than that of human beings.
B: Wow, I can easily imagine the situation.
D: They’ve been trying to keep other life from getting smarter since the beginning of history...
B: They are leading us to the wrong direction.

The conspiracy theory ultimately developed by this group is as follows: In fact, world top leaders are aliens, and global warming was spread by them in order to prevent human development. While focusing on the students’ own interest and concern, the content of the theory emphasizes fun and impact for them.

Overall, what did the students pay attention to when making their conspiracy theories? The students’ free description of the question was coded for analysis. The left side of the table 5 shows the codes, the center shows the examples of students’ descriptions and the right side shows the number and percentage of the students. Note that one student’s statement may contain more than one code. For example, the description of “Fear of not being able to agree nor deny” contains two codes: “Fear” and “Uncertainty”.

Table 5. Attentions students paid in Conspiracy Theory Championship

Codes	Description examples	Number	Rate
Interests	<input type="checkbox"/> Who can benefit?	11	28.9 %
Persuasiveness or Logic	<input type="checkbox"/> Making a sense of a story <input type="checkbox"/> Mixing some reality	27	71.1%
Fun and Impact	<input type="checkbox"/> Something that would be unusual and interesting if it were possible <input type="checkbox"/> We focused more on fun and impact than on reality	21	55.3%
Uncertainty	<input type="checkbox"/> Fear of not being able to agree nor deny <input type="checkbox"/> Not knowing whether it is a lie	3	7.9%
Fear	<input type="checkbox"/> Fear of not being able to agree nor deny.	2	5.3%

Like a group introduced above, many groups paid attention to “Fun and Impact”. More than half of the students responded that they paid attention to “Fun and Impact” in the post-lesson

questionnaire. They added things that science has not yet figured out for “Fun and Impact”. This is evidenced by the description examples of “Something that would be unusual and interesting if it were possible” and by the appearance of “aliens” as well in the discussion seen above.

However, this does not mean that the students did not use the formative aspiration of science at all, as 27 students (71.1%) paid attention to “Persuasiveness or Logic”. “Making a sense of a story” and “Mixing some reality” (in the description examples) can be taken as an awareness of the formative aspiration of science: “Clarity: scientists should aspire to communicate only correct interpretation” and “Corroboration: scientists should make reproducible statements.”

In spite of the announcements before the discussion, not many students (28.9%) responded that they paid attention to “Interests.” The reason may be that “Interests” was the premise of the discussion, and the students created their conspiracy theories with “Fun and Impact” and other factors in mind. The discussion of the above also started with the premise: “Who would benefit”? But in the end, they were led to the conclusion that impact was necessary. In fact, 4 out of 5 members in the group answered that they paid attention to “Fun and Impact”; 1 answer was invalid.

From the above, it can be seen that in Conspiracy Theory Championship, while presupposing unscientific “Interests,” the students paid attention to the unscientific “Fun and Impact” and the scientific “Persuasiveness or logic.” As such, it is an incomplete experience of a world that lacks the formative aspiration of science. Nevertheless, it is clear that the students began to see science from a different perspective.

3.2 Students’ discussions of Unscientific Class Meeting

In Unscientific Class Meeting, the students debated whether or not group work should be conducted in the classroom with the formative aspiration of science prohibited. Before the discussion, the facilitator (author 1) gave some examples of the formative aspiration of science, especially “Falsification”, “Universalism”, and prohibited their use. Table 6 shows some of the facilitator’s explanations. After the explanation, Unscientific Class Meeting began with student candidates. Table 7 shows some of the discussions.

Table 6. Explanation of the rules by the facilitator

F: The opinion is no good that we did group work, but it didn’t go well at all because everyone just chatted, so I oppose group works. This is based on “Falsification.” I think it’s better to do group works for everyone’s benefit.” This is no good because the opinion is a neutral one, it is based on “Universalism.” I’ll give you good examples: “Well, you know, the group is all we have.” “Don’t be fooled by the group-work advocates, they’re hiding the truth. you should not be deceived”.

Table 7. Students’ debate in Unscientific Class Meeting

S1: The problem is in the discussion itself whether or not to do group works. It would be impossible to have no group works. There is no choice. We should do group works.
 S2: Basically, we don’t need group works. The reason is that I don’t need group works. I don’t need them. You don’t need them. Because we are the same human being, so if I don’t need them, you don’t, either.
 S1: Because I am a different person from you. Unfortunately, I was not convinced by your forceful argument. Because I am a human being and you are supposed to be a human being, too.

S1 and S2 are particularly good debaters in this class. They usually listen to what their opponents have to say and then argue logically. However, here, S1 and S2 tried to make arguments not to accept the opponent’s counter arguments. For example, S1 said, “There is no choice” in the first statement and did not accept any counter arguments from the opponents. On the other hand, S2 made a selfish assertion that if S2 does not need group works, then everyone else who is the same human being does not need them, either. Thus, S2 did not allow the possibility of “Falsification.” In response to this, S1 was not convinced because S1 is a different person from S2. In this way,

there were many statements in Unscientific Class Meeting that did not allow the other party to disprove them. The situation continued where any conversation could not take place.

Next, examples of rule violations are introduced. When a statement was made that conformed to the formative aspiration of science, the facilitator who played the role of a referee blew a whistle and presented a yellow card to the speaker. Table 8 shows the whole scene in which the yellow card was given. “S” represents student and “F” facilitator in the table.

Table 8. Presentation of a yellow card

S3: I think that group work is something that should be done. <u>Because</u> the term “group work” exists in the world. <u>It would be worthless if we do not use the term.</u> If we don’t do group work, we can no longer use the term “group work,” and the term will disappear.
<input type="checkbox"/> The facilitator blew a whistle and presented a yellow card to the speaker <input type="checkbox"/>
S2: <u>Why? Why? Why?</u>
F : <u>Because of its high generality.</u>
<input type="checkbox"/> Some Audience: other students who did not join the debate, said “Got it!” <input type="checkbox"/>
F : Also, there is the idea of “Clarity” in the formative aspiration of science. Scientists should aim at communicating correct interpretations and since the opinion was aiming at “Clarity,” it was no good.

The yellow card was given to a student because the referee judged the statement has high generality: it would be worthless if we do not use the term and the detailed explanation of the reason was appropriate for “Clarity.”

This comment was made by S3 who was in the affirmative, but S2 in the negative voluntarily asked the referee the reason of the whistle. When the referee explained the reason, the students in the audience also raised their voices saying ,“God it”! In this way, the four players also played a role in deepening the audience’s understanding by clarifying the formative aspiration of the science.

Unscientific Class Meeting ended with the four students finally giving up on continuing the discussion. When Unscientific Class Meeting was over, some students in the audience said, “It’s impossible,” and “There’s no substance in the discussion”. S2, a player, encouraged himself by saying, “The yellow card is a medal for speaking scientifically”. All students seemed to agree with this statement. In general, both players and audiences enjoyed the activity, but they did not see any meaning in the discussion itself. In the post-lesson questionnaire, 37 out of 38 students (97.4%) indicated that Unscientific Class Meeting was not for a discussion. One student commented: “The most interesting activity in the lesson was Unscientific Class Meeting. I realized it would be hard to have discussions without the formative aspiration of science”. Through the Unscientific Class Meeting, the students became acutely aware that they cannot communicate (discuss) as they normally do without the formative aspiration of science.

3.3 Examination of hypothesis 1

In the Conspiracy Theory Championship (Game 1), although the students saw the science from a different perspective, playing Game 1 was an incomplete experience of a world without the formative aspiration of science. In contrast, Game 2 took place in the world lacking something, which was completely devoid of the formative aspiration of science and very different from the real world where discussion was not possible for the students.

From the above, through the two games, the students can realize the difference between the real world and the world lacking science. So, hypothesis 1 is backed up.

3.4 Examination of hypothesis 2

To verify hypothesis 2, the students’ answers to the question were analyzed: What is the role or significance of “science” or “learning science” in today’s society? The students’ free description of the question was coded for analysis as shown in Table 9. From left to right, the table shows the codes, description examples, the number and percentage of students in the pre-lesson

questionnaire, and the number and percentage of students in the post-lesson questionnaire. Note that a single statement may contain more than one code.

Table 9. Descriptions of the role or significance of science or learning science

Codes	Description examples	Number pre-lesson	Rate pre-lesson	Number post-lesson	Rate post-lesson
Individual thinking	<input type="checkbox"/> Logical thinking	4	11.1%	0	0.0%
Progress & welfare	<input type="checkbox"/> Social development <input type="checkbox"/> Expanding and applying knowledge in daily life	36	94.7%	6	15.8%
Communication	<input type="checkbox"/> Reaching a consensus <input type="checkbox"/> Essential for communication and discussion.	1	2.6%	23	60.5%
Pursuit of truth	<input type="checkbox"/> Understanding unknown nature <input type="checkbox"/> Exploring the true nature of things.	6	15.8%	1	2.6%
Judgement & action	<input type="checkbox"/> Developing the ability to judge the possibility <input type="checkbox"/> Determining what is right and wrong	5	13.2%	14	36.8%
Government & order	<input type="checkbox"/> Explaining the world rationally to avoid division <input type="checkbox"/> Governing the world	0	0.0%	3	7.9%
Generality	<input type="checkbox"/> Knowing generally accepted events	0	0.0%	2	5.3%

Notable points are “Progress & welfare,” “Communication,” and “Judgement & action.” Each of these is explained below.

Progress & welfare

In the pre-lesson questionnaire, 36 students (94.7%) answered that the significance of science is for progress and welfare of human beings. As indicated by the description example: expanding and applying knowledge in daily life, many students in this class want to become engineers. Therefore, they see science as a useful invention. However, the number of the students who had this perception was 6 (15.8%) in the post-lesson questionnaire. This indicates that there was some kind of change in their perception.

Communication

The increase in the number of descriptions regarding this code shows the main change in the students’ perception. The number increased from 1 (2.6%) in the pre-lesson to 23 (60.5%) in the post-lesson. There is no doubt that the cause of this increase is due to Unscientific Class Meeting. In the Unscientific Class Meeting, the students were keenly aware that conversation cannot take place without the formative aspiration of science. From this experience, they realized the significance of science as a prerequisite for communication. This is related to the fact that the number of “Individual thinking” became 0 (pre: 4). Before the lesson, the students focused on “Individual thinking,” as if science was necessary to learn to think logically. “Pursuit of truth” was about connecting human beings with nature and phenomena through the medium of science, without the presence of others with whom one shares our social life. It can be interpreted that the students became aware of the existence of others with whom they communicated through the medium of science after Unscientific Class Meeting.

Judgment & action

The number increased from 5 (13.2%) in the pre-lesson to 23 (36.8%) in the post-lesson. This code is related to "Communication." The difference between this code and "Communication" is that this code focuses more on judgments of right and wrong than on the existence of others. The reason for the increase was also influenced by Unscientific Class Meeting. One student's comment on Unscientific Class Meeting was that there was no factor to judge with. This student participated as an audience, and the student could not make a personal judgment. This indicates that the student realized the significance of science for citizens who make policy decisions in a democratic society.

Through the games, especially Game 2 (Unscientific Class Meeting), the students learned two things: (1) the significance of science as a medium for democratic discussion with others, (2) the significance of science for enabling them to judge democratic decisions. In relation to the competency required in citizenship education, the students learned (1) the significance of science in communication as a player involved in policy making, (2) the significance of science for the audience who makes judgments about political decisions. Thus, by experiencing the world lacking something, the students could realize the social significance of science. So, hypothesis 2 is backed up.

4 Discussion

4.1 Generalization

The results of the lesson showed that the students realized the social significance of science through the experience of the world lacking something. Specifically, the students realized the necessity of science for democratic debates, not for social progress, as Collins argues. From the above, it can be considered that the experience of the world lacking science was effective because the class was composed of students who were familiar with the science. Thus, it can be said that experiencing the world lacking something has the effect of making the students realize the significance of elements that they usually utilize unconsciously.

In order to extend the results of this study, it is necessary to examine what would happen if students did not usually have interest in science. For this purpose, it is required to conduct additional experimental lessons, for example, with students in lower achievement levels and at elementary schools.

4.2 Comparison with Other Studies

In preceding studies, gaming simulation was considered to have a learning effect because they imitated the real world [2]. This study shows the learning effect of the experience of the world lacking something, which is different from the real world, and opens up further possibilities for gaming simulation.

Debriefing as presented by Kriz is a gradual process from games to the real world [8]. This study shows the theory by Kriz could be applied to the transition from the real world to games. However, the effect of conducting Game 2 after Game 1 was not fully verified in this study. This study only showed that the students' thinking was changed according to the distance between the real world and the game. In order to verify the effectiveness of Game 1 as a scaffold, it is necessary to compare this study with a lesson in which only Game 2 was played.

4.3 Possibilities of Further Verification

It is often insisted that in order to involve students in learning, the learning needs to be authentic in citizenship education [9]. The results of the lesson show the opposite. That is, the students were engaged and learned a great deal because the activity was not authentic and different from the real world. Communication that lacks the formative aspiration of science, which is an

unacceptable practice in the real world, is possible only in schools. Gaming simulation will lead to a reevaluation of the virtuality of the school lessons.

5 Conclusion

In this study, the authors introduced the learning effects of gaming simulation in which students experience “the world lacking something.” This study developed a lesson in which students experience a world without science or scientific communication as a gaming simulation of the world lacking something.

Hypotheses in this study are as follows: 1) Through the games, students can realize the difference between the real world and the world lacking science, 2) By experiencing “the world lacking something,” students can realize the social significance of science.

In the lesson, the students experienced the world lacking something, which was completely devoid of the formative aspiration of science and very different from the real world where discussion was not possible for the students. Thus, the students could realize the difference between the real world and the world lacking science. So, it can be said that Hypothesis 1 was backed up.

Furthermore, the students learned two things through the lesson: (1) the significance of science as a medium for democratic discussions with others, (2) the significance of science for enabling them to judge democratic decisions. From the above, by experiencing the world lacking something, the students could realize the social significance of science. So, hypothesis 2 is backed up.

In the near future, in order to extend the results of this study, it is necessary to examine what would happen if students did not usually have interest in science.

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Simulating the impact of cognitive biases on the mobility transition¹

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Abstract Climate change is becoming more visible, and human adaptation is required urgently to prevent greater damage. One particular domain of adaptation concerns daily mobility (work commute), with a significant portion of these trips being done in individual cars. Yet, their impact on pollution, noise, or accidents is well-known. This paper explores various cognitive biases that can explain such lack of adaptation. Our approach is to design simple interactive simulators that users can play with in order to understand biases. The idea is that awareness of such cognitive biases is often a first step towards more rational decision making, even though things are not that simple. This paper reports on interactive simulators of potential factors of resistance, and illustrates their explanatory power on various scenarios. These simulators can be played online, with the goal to provide users with food for thought about how mobility could evolve in the future. Work is still ongoing to design a user survey to evaluate their impact.

Keywords: Mobility · Agent-based modelling · Cognitive biases.

1 Introduction

In recent decades, the average daily distance traveled by the French population has increased considerably (5 km in the 1950s vs 45 km in 2011 [23]), as has the number of personal cars (11,860 million in 1970 [4] vs 38,3 million in 2021 [7,13]). The evolution of mobility is therefore an essential question, for the climate crisis but also for public health, knowing the negative impact of sedentary lifestyle [4], road accidents, or air and sound pollution [19]. Indeed, each year 40000 deaths are attributable to exposure to fine particles (PM2.5) and 7000 deaths for nitrogen dioxide (NO₂), i.e. 7% and 1% of the total annual mortality [11]; this report also concludes that the 2-month lockdown of spring 2020 in France saved 2300 and 1200 deaths by reducing exposure to particles and nitrogen dioxide respectively. This shows that public policies and individual behaviour changes can have an impact on public health, for instance setting temporary cycling lanes during the pandemics [20]. However, aside from such emergencies, public policies take time to set up and are not always well accepted. Many of these temporary cycling lanes were thus returned to cars after the lockdowns [3].

Indeed, despite feeling more and more concerned about climate change, citizens are often reluctant to constraining public policies that could slow it down. As a result, mobilities evolve very slowly, for instance in France a large proportion of commuting is still done by car, even for very short journeys [6]. Some reasons for this inertia are well-known: lack of alternatives (limited public transports, cost of newer cars...); difficulty of changing habits [5,16]; or individualism [10]. Yet another possible explanation is the influence of cognitive biases in human reasoning: [12] show that people tend to “stick” to the car, even when it is more costly than metro or bus, and explain this deviation from rational behaviour by the influence of cognitive biases.

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Cognitive biases are heuristics that facilitate reasoning in situation of uncertainty or danger [22]. They are often useful, but can also lead to mistakes with potentially serious consequences [21]. They were shown to be important to consider when simulating human evacuation in wildfires [1], to inform buildings safety design and procedures [15]. Research shows that becoming aware of one's biases can help overcoming them in decisions [18]; they thus propose debiasing interventions (game or video) and show their positive impact. We suggest that interactive simulation could be used as another debiasing intervention; indeed it has been successfully used previously to explain various complex phenomena, for instance the mechanisms of the pandemic [8].

We propose to use interactive simulators to raise awareness about cognitive biases and their influence on our mobility decisions in the face of climate change. This article describes agent-based simulators illustrating how two cognitive biases (reactance and halo) can explain resistance to the adoption of soft mobility. A serious game has been proposed previously to simulate the role of habits in mobility decisions [2], but it is implemented with the GAMA simulation platform and cannot be played online; it is also more complex and based on realistic geographical data from an actual town. On the contrary, our simulators are intended to be played online without guidance with a philosophy more similar to that of the CovPrehension collective [8]. We therefore implemented them in Netlogo [24] and willingly kept them relatively simple to facilitate exploration and discovery. This work is part of a larger project aiming at simulating the transition of cities towards more sustainable mobility. All simulators described in this paper are already available to play online, but have not yet been evaluated.

2 Reactance bias in mobility

Reactance is defined as a tendency to react inversely to persuasion attempts when they are felt as coercive. The individual might thus strengthen their noncompliant opinion or intention in order to assert their undangered free-will. Persuasive messages can therefore agonize their receivers and have an effect contrary to that intended. This bias could cause mixed reactions to communication campaigns in favour of soft mobility or ecology: part of the population might get angry at these attempts to force them into a constraining behaviour, and react by asserting their right to behave as they want.

2.1 Conceptual model

Opinion diffusion model. Our conceptual model is interested in how agents react to an official message. We consider opinions about one single fact (for instance "it is necessary to commute by bike rather than car") modelled as a real number on a continuum from 0 to 1 representing the degree of agreement about that fact. Each agent has its own opinion about this fact, that differs from the other agents' opinions.

When 2 agents meet, they "share" their opinions, and as a result, each agent tends slightly towards the opinion of the other. Concretely, we compute the new opinion as an asymmetrical average where one's own opinion weighs more (exact weight value configurable in the code) than the received opinion. If letting the agents interact for a while, resulting opinions tend towards a compromise in the middle of the continuum.

Confirmation bias. In a first model, agents can be endowed with a confirmation bias. In that case, when interacting, they only adjust their opinion if the other agent agrees with them; on the contrary they discard opinions that do not confirm theirs. As a result, opinions can only be reinforced, and tend towards the extremes. After a number of interactions, two groups of opposite opinions emerge, the population is polarised.

Reactance bias. Based on this basic model of opinion diffusion, we have designed a new model where an official messenger broadcasts a persuasive message (such as a campaign for ecology, soft mobility, or physical activity for health) to the population. When agents meet the messenger, they are confronted to its opinion.

Additionally, agents can be susceptible or not to the reactance bias. No-susceptible agents will get gradually persuaded by the message, as above. Susceptible agents might trigger the reactance bias based on a distance condition: when exposed to another opinion, the agent evaluates its distance with its own current opinion. If this distance is small enough, the new opinion is acceptable, and the agent tends towards it (asymmetrical weighed average, as above). On the contrary, if this distance is over a certain (configurable) threshold, the agent activate the reactance bias: in this case it adjusts its opinion away from the official message, reinforcing its disagreement.

Message targets. Based on this model, for given message content and reactance triggering threshold, agents can fall in one of three different categories:

Already convinced agents, whose opinion match the content of the message;

In-target agents, or positive target: they are not convinced yet, but can still be. Either they are not susceptible to the reactance bias, or they are but the message falls close enough to their own opinion to be acceptable and not trigger the bias.

Off-target agents, or negative target: they can never be convinced with the current message, because they are susceptible and their current opinion is far enough to trigger reactance bias. They will therefore react in the opposite direction.

2.2 Simulator

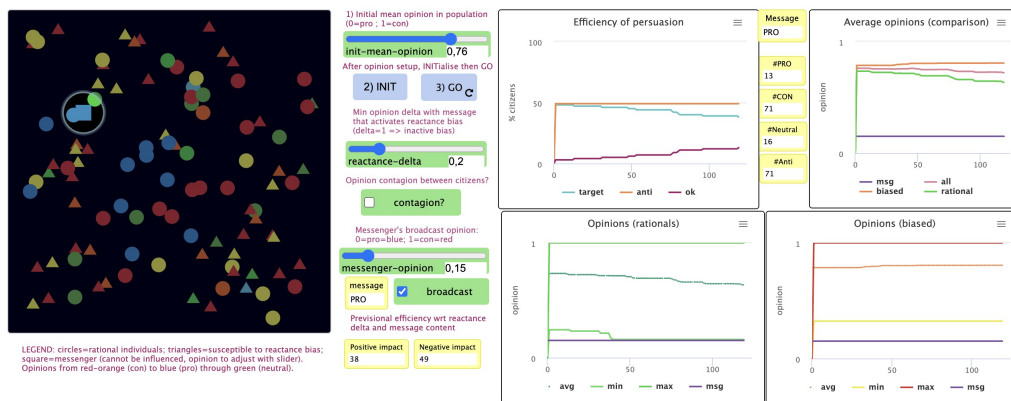


Fig.1. Interface of the reactance bias simulator

Population initialisation The simulator² interface is shown in Figure 1. The user can choose the desired initial average opinion in the population (0-1 range) by using a slider. When pressing the “INIT” button, the population is created with opinions distributed on a Gaussian centered around that mean, and a variance of 0.25. Opinions are kept bounded between 0 and 1 at all times. Each agent’s opinion is visually represented by a colour on a gradient between blue (value 0) and red (value 1), with undecise agents ranging from yellow to green.

Each agent has another attribute determining if it is sensitive to the reactance bias. This is visualised by their shape: circle agents are “rational”, *i.e.* they do not have the reactance bias; triangle agents are susceptible to the bias, *i.e.* they might activate it when the conditions are fulfilled (message too far from what they can accept). Once the population is created, the user can start the simulation with the “GO” button: the agents then start moving around the window randomly, and can meet other agents or the messenger (represented by a square). The simulation stops automatically when the broadcast message has no impact anymore (*i.e.* its positive target is empty).

² Simulator: <https://nausikaa.net/wp-content/uploads/2023/02/reactance-v2-en.html>

Input parameters At runtime, the user can modify a number of parameters, regarding both the message and the mechanics of opinion diffusion. First, they can use a slider to choose the value (on the opinion continuum) of the message and use a switch to suspend or resume broadcast. The messenger is shown as a coloured square (same opinion colour gradient) while broadcasting, and hides when broadcast is suspended.

The mechanics of opinion diffusion can be influenced in two ways. First, a contagion switch allows to decide if standard agents (other than the messenger) also share their opinion with each other. If enabled, agents can be influenced both by the messenger and their neighbours. If disabled, only the messenger can influence the agents' opinions. Second, a slider allows to configure the opinion delta that triggers the reactance bias (for the triangle susceptible agents). Concretely, if the value is set to 1, it means that only opinions distant by more than 1 from one's own opinion will trigger the bias, so it is in fact disabled. The smaller the value, the easier it is to activate the bias, and the harder it is for the messenger to persuade without agonising.

Outputs and feedback The interface displays useful information in various forms:

When the user selects the opinion delta triggering the bias, and the content of the message, two monitor boxes update in real time the resulting size of the targets: the positive target are those agents who can be persuaded, while the negative target is made up of those agents who will react reversely due to the reactance bias. The user should try to minimise the size of the negative target so that the message does not have the inverse effect. When the size of the positive target reaches 0, the message has no impact anymore and the simulation stops.

The top left graph illustrates the efficiency of the persuasive message. The blue line is the percentage of agents that are in the target; it decreases with time as these agents become convinced. The pink line is the percentage of convinced agents; it increases with time as the messenger persuades more agents. Finally the orange line is the percentage of agents that cannot be convinced; it does not change as long as the user does not modify either the message content or the reactance threshold.

The top right graph compares the official message (purple line) with the average opinion of three groups: the total population (pink line), the rational population not susceptible to reactance (green line), and the biased population (orange line).

At the bottom, two graphs further detail the opinion dynamics in the rational population (left) and the biased population (right), by showing the minimal and maximal opinion in addition to the average. This allows to see the full range of opinions in each group, and how homogeneous they are. If the persuasion is efficient, these lines should converge towards the message.

2.3 Scenarios

We have run some scenarios demonstrating explanatory power of our simulator.

Scenario 1: baseline We initialised the population with an average opinion of 0.8, and the message with a content at 0.2, so quite distant. We set the reactance delta to 1 to disable the bias, and toggle off the opinion contagion between agents to isolate the effect of the messenger. We then start broadcast and let the messenger move around and try to persuade citizens. The opinion dynamics graph (Figure 2) shows that all average opinions gradually converge towards the official message.

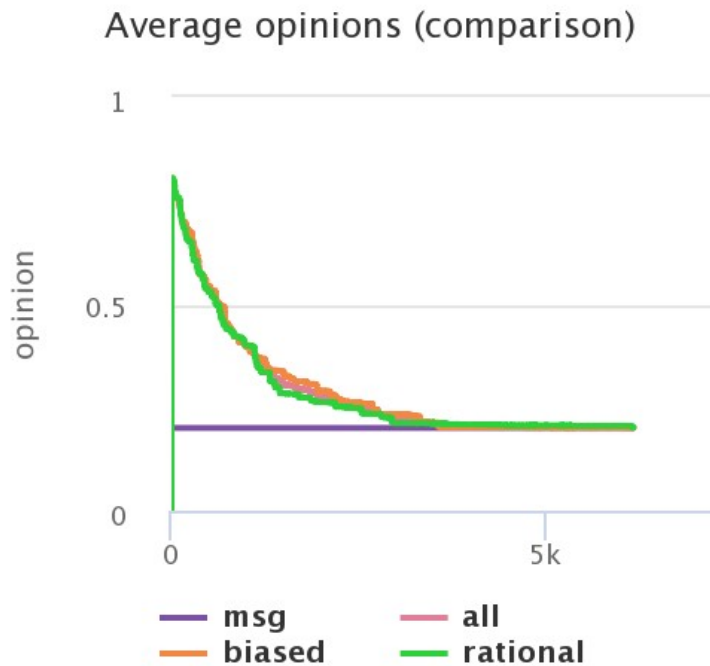


Fig.2. Average opinion dynamics without reactance bias: convergence

Scenario 2: reactance We initialised the population and messenger with the same values as above, and still toggled contagion off, but now set the reactance delta to 0, so that all susceptible agents trigger the bias. As a result, we observe that the two groups (rational vs biased) react differently (Figure 3). The average rational opinion converges to the message while the average biased opinion diverges away from it.

Scenario 3: gradual persuasion We now set the initial opinion to 0.75 and the reactance delta to 0.25 so that only some agents trigger the bias. The idea here is that the messenger will try to progressively bring the average opinion to 0.25 again, but in order not to agonize citizens who disagree, it will start with a softer message of 0.5 and progressively change the content towards 0.25. At 0.5, some biased agents are close enough to let themselves be persuaded, while the most extreme opinions will become even more extreme. As the average opinion becomes close enough to 0.5, the messenger can decrease the content of the message to 0.4, then 0.3 and finally 0.25. As shown on Figure 4, the average opinion diverges less since only some agents trigger the bias while some others are drawn gradually towards the official message.

This is in line with classical persuasion strategies of “putting a foot in the door” or inciting people to doing small gestures rather than requesting a big change that is more likely to discourage or agonize them. It applies for instance to energy saving gestures to fight global warming (switch your devices off rather than in standby); mobility change (take your bicycle once a week); or resuming physical activity (take the stairs instead of the lift, get out of the bus one stop early to walk, etc).

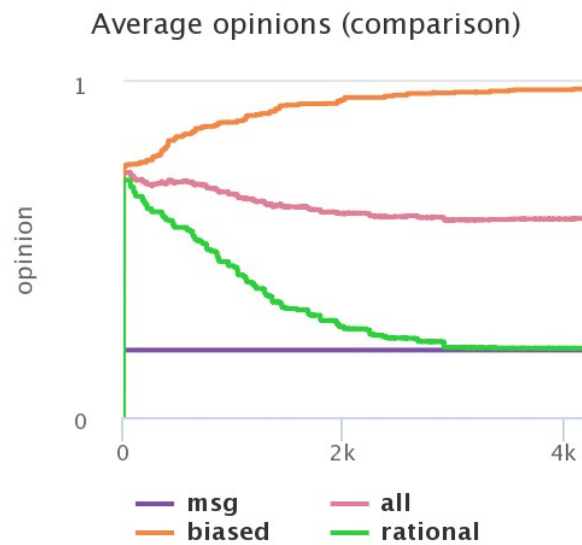


Fig.3. Average opinion dynamics with reactance bias: divergence

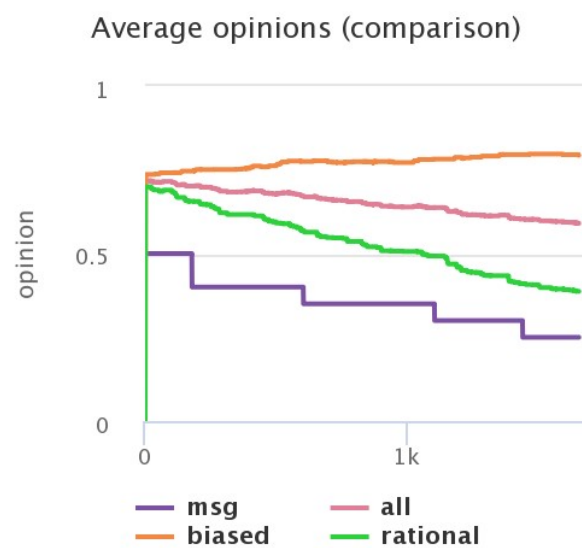


Fig.4. Progressively adapting the content of the message to avoid triggering reactance

Scenario 4: inter-individual contagion In the first scenarios, there was no contagion between citizens, so that only the messenger would influence other citizens. If we now toggle contagion on, the result is much more variability in opinions, since citizens can be influenced by their neighbours (whatever their opinion) while the messenger is away in another part of the window. If there are many biased agents with very strong opposite opinions, they might cancel the official message faster than it can be spread.

This is similar to the effect of social networks, where people can always connect to others who also disagree with the official speech, thus reinforcing their own opposition, until they might fall in a spiral of conspiracy theories. It forces the authorities to find efficient communication strategies to fight fake news and disinformation.

2.4 Discussion

In conclusion, this simulator shows that the further a broadcast message is from their current beliefs, the more individuals risk activating a reactance bias that consists in asserting their free will by adopting the action contrary to the recommendations (e.g. “I will commute by car if I want”). The recommendations must be more progressive so as not to antagonize citizens. This is in line with classical persuasion strategies of “putting a foot in the door” or inciting people to doing small gestures rather than requesting a big change that is more likely to discourage or agonize them. It applies for instance to energy saving gestures to fight global warming (switch your devices off rather than in standby); mobility change (take your bicycle once a week); or resuming physical activity (take stairs instead of lift, get out of the bus one stop early to walk...).

The simulator also shows the difficulty of fighting against online disinformation and fake news (with the opinion contagion option). The idea is that it is dangerous to lose citizens who will build increasing distrust and resentment towards official communication, affecting all further interactions.

It could be gamified by letting the user create several messengers, counting the total time and resources invested, and matching it to results in terms of percentage of the population actually convinced.

Finally, the way we modelled reactance as triggered by a distance between opinions could be debated. In particular, another idea would be to model reactance to repetition: the more a message is repeated (echo chamber) the more it might trigger adverse reactions from people who get tired of it.

3 Halo bias in mobility

Halo bias consists in ignoring certain negative aspects in the evaluation of an object, when they are inconsistent with a positive first impression. This bias thus allows to preserve that position impression. With respect to mobility, it could thus lead to ignoring new inconvenients of one’s usual mobility mode, for instance an increase in petrol price or traffic jams, in order to avoid a costly questioning of one’s habits.

3.1 Conceptual model

Rational multicriteria decision model The model is based on an existing model of rational multi-criteria evaluation of modes of mobility [14] in which 4 modes of travel (car, bike, bus, walking) are evaluated on the basis of 6 criteria (time, cost, comfort, safety, ecology, praticity) and their priority for each individual. Concretely each individual is defined with their personal priorities for the 6 criteria (for instance one individual can be very focussed on ecology but not care about comfort so much, while another will have a big priority on time but not focus on price too much). These priorities are supposed to be static.

Each mode is marked on each criteria depending on the context (town setting, weather...). For instance bicycle and walking are always very ecological while car is not at all; their safety depend on cycling lanes or speed limit; their comfort depend on temperature while car or bus are always more comfortable; etc. These marks can evolve with the evolution of the environment (new public policies, time of day, weather...).

Each agent then computes the global mark of each available mobility, as a weighed average of the mark and priority of all 6 criteria. This ensures that different agents, with different priorities, might rate the same mobilities differently in the same context. Agents are fully rational, and

choose the mobility mode with the best global mark. As a result, when the urban planning evolves (e.g. new cycling lanes, petrol price increase), citizens adapt their mobility choice.

Halo bias model Our model enriches this rational decision model with the halo bias. Concretely, agents have 6 priorities for the 6 criteria, and can be susceptible to the halo bias or not. Non-susceptible agents use the rational decision algorithm as described above. Susceptible agents might trigger the halo bias when re-evaluating their current mobility. The triggering condition is based on the distance between the value of this mobility on a criteria, and the priority of that criteria for the agent. If this distance is bigger than a certain delta, then the agent activates the halo bias and ignores this criteria altogether, by setting its priority to 0 when computing the new mark. This leads agents who have adopted a certain mode of mobility to ignore the criteria on which their current mode is poorly rated, in order to maintain a positive overall view. The idea is that it is less costly to question one's priorities than to change one's mobility mode. Halo bias does not influence the evaluation of the other modes.

Finally, agents also have a level of satisfaction or happiness, computed as the mark of their current mobility. It is expected that rational agents will switch to a different mobility when they grow unhappy with theirs, while biased agents will ignore the negative criterion in order to restore satisfaction without having to change mobility.

3.2 Simulator

Initialisation The initial urban planning (scores of the 4 modes on the 6 criteria) is empirically initialised to values matching a standard town: bike and walk are more ecological than bus, while the car is not at all; car and bus are more comfortable (eg less exposed to the weather) than bike or walk; walk is the slowest mode; etc. The exact initial values are visible and configurable in the code.

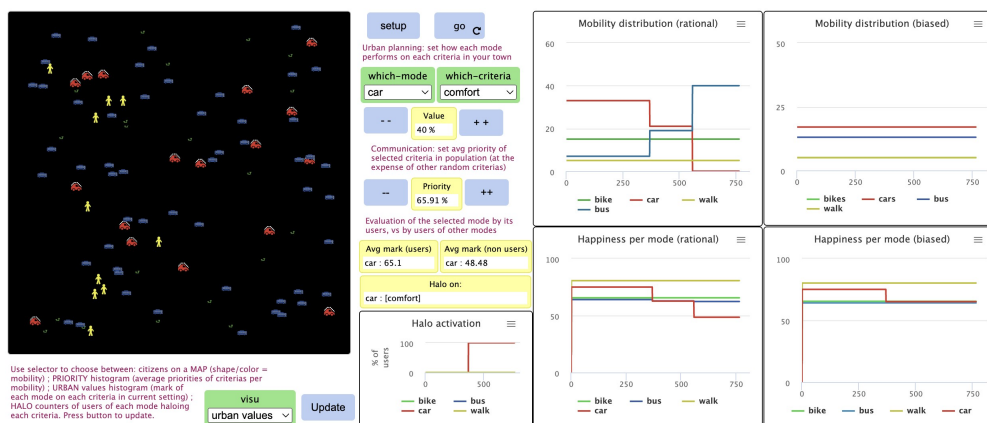


Fig.5. Screenshot of the halo bias simulator interface

The population is then initialised with a believable distribution of citizens on the 4 modes (50% cars, 20% bikes, 20% bus, 10% walk), and their initial priorities are set so that their rational choice in the current urban setting is indeed their chosen mode, but with some random variability so that not all users of each mode have exactly the same priorities. Again, this is configurable in the code, although our goal to visualise the impact of a bias does not require this distribution to match reality exactly.

Finally, half agents are susceptible to the halo bias, while the other half is not. The triggering threshold is set to 15: this means that when the score of the current mobility mode on a given criterion (rated between 0 and 100%) falls at least 15 points below the priority of that criterion for the agent (also rated between 0 and 100%), this agent will activate the halo bias and start

ignoring this criterion altogether. The halo bias does not influence the evaluation of the other available modes, which are rated rationally.

User interactions The interface (Figure 5) of the simulator³ allows the user to:

Modify the urban planning of the virtual town, by directly setting the score of each mobility mode on each criterion (what a different urban design would do, such as increasing the frequency of buses or decreasing the maximum authorized speed on roads). All changes are possible in the interface, even though some of them are semantically impossible (e.g. no urban policy can make walking not ecological), so it is down to the user to choose wisely.

Modify the priority of each criterion in the population (what a communication campaign could do). Again, reality is not that simple, no advertising campaign can ensure that ecology suddenly gets maximal priority for everybody, but this option allows to explore what could happen as a result.

Outputs and visualisation The interface has three parts. On the left, a dropdown menu below the main window allows the user to choose between four visualisation options. On the main map, the agents are shown with the shape and color indicating their mobility mode (bicycle - green; bus - blue; walk - yellow; car red). Agents are also surrounded by a white halo when they activate the halo bias. The other options are various histograms to visualise at a glance: values of each mode on each criteria in the current urban setting, showing which mobility is favoured; average priorities of each criteria among users of each mode, illustrating the different user profiles; counters of users of each mode putting each criteria in halo (and thus ignoring it), allowing to spot the "weak" criterias for each mode (discrepancy between value and priority).

On the centre, the user can select a mode and a criteria in the dropdown menus, which automatically displays the up-to-date value of that mode on that criteria in the current town (then editable with the buttons), as well as its up-to-date mean priority in the population. Under the parameters, additional monitors also display: the average mark for that mode among its users; its average mark among users of other modes; and the list of criteria put in halo by its users (details can be seen on the halo histogram on the left). These two marks can differ because users of different modes have different priorities (which can be visualised on the priority histogram), but also because of the halo bias activated by biased citizens when evaluating their own mobility mode.

Finally, on the right of the interface, 4 graphs display the evolution of mobility distribution (top) and average happiness (bottom) of rational (left) vs biased (right) users of each mode (one colour line per mode). This provides the user with feedback about how their actions (urban planning, communication) influence these indicators.

3.3 Scenarios

Various scenarios can be tested to illustrate the potential of this simulator.

Urban planning to encourage soft mobility. We start the simulation with the default settings, then use the urban planning buttons to progressively decrease the score of car on the time criterion (meaning that the travel time by car increases). This simulates the current trend in many towns where more space is being dedicated to bicycles or buses at the expense of car facilities (driving lanes, parking spots), which increases traffic jams or time to park. The same effect could also result from a slower speed limit (30 instead of 50 km/h) that slightly increases the total trip time.

As a result of the new setting, rational car drivers decrease their mark. They may then switch to another faster mode (such as the bus or bicycle) depending on their other priorities. We indeed observe an increase in the modal part of bus, which is closest to the priority profile of car drivers, since it preserves comfort. On the contrary, biased car drivers activate a halo on the now negative time criterion, to preserve their positive opinion of car. They continue driving to work, and their satisfaction even increases as a result of ignoring the most negative aspect.

³ <https://nausikaa.net/wp-content/uploads/2023/01/switch-halos-en.html>

Ecological crisis. We start the simulation with the default initialisation again, and this time use the communication buttons to increase the average priority of ecology for the population. This is meant to simulate the current energy shortages and ecological focus in European media. The resulting mobility switch is shown in Figure 6. Among the rational citizens, the first change happens when citizens usually commuting by bus switch to the more ecological bicycle, or to a lesser extent to walking (being much slower, it only attracts citizens with a very low priority for time). Car drivers had a lower priority for ecology at the start, so it takes longer before ecology actually impacts their decisions. When it does, they switch to the bus, which better fulfills the ecological requirement, while maintaining some level of comfort and safety (which are the next most important criteria for them).

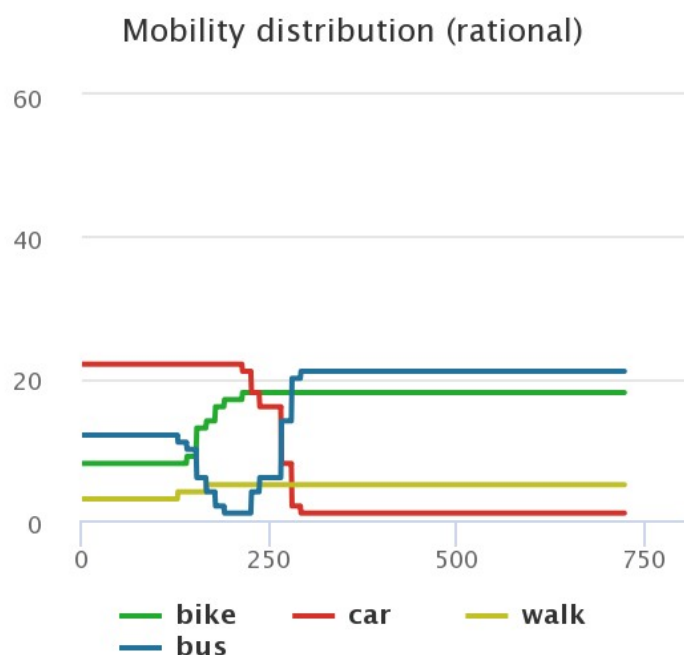


Fig.6. Rational mobility switch after ecology awareness campaign

Among biased users, things are a bit different (see Figure 7). Car drivers have the biggest gap between the high priority of ecology and its low value for their mode. As this gap grows bigger, it becomes more and more obvious to them that their current mode is not in agreement with their new priority. This gap grows to the point when it triggers the halo bias among all susceptible car drivers. As a result, they drop the ecology criterion in their evaluation, maintain a high satisfaction with the car, and keep driving. This might feel counter-intuitive initially, because increasing the priority of ecology leads some citizens to eventually ignore it, but it is in line with the mechanics of the halo bias. On the contrary, most users of other modes do not trigger the halo bias, because their mode mark on ecology is close enough to their priority for ecology (which was already high). Therefore, they keep using their mode if it is ecological enough, or switch to a better mode: we observe in particular that bus users switch to bike or walk.

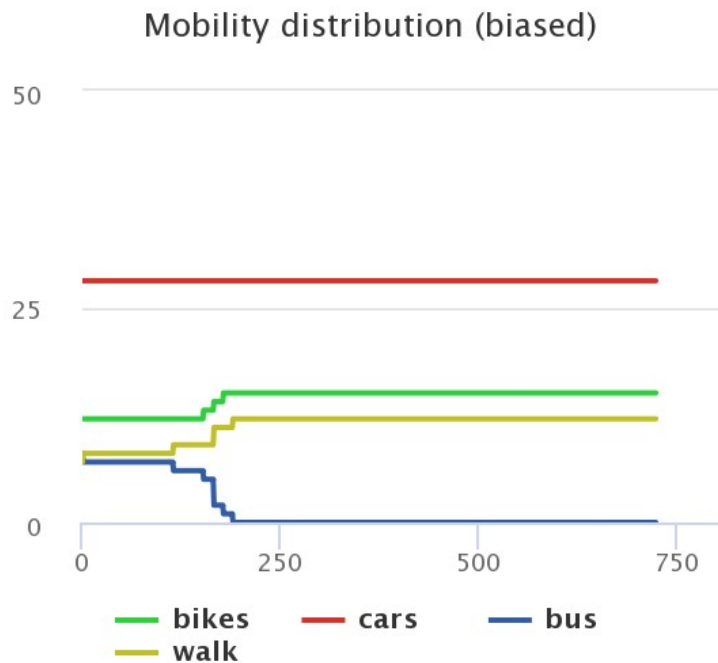


Fig.7. Biased mobility switch after ecology awareness campaign

3.4 Discussion

Realistic initial values. We have initialised the town and the population with believable but empirical values (initial urban planning and priorities). Real statistics could be found (for instance from INSEE for France) but it is not the goal of this work to get to that level of detail. Besides, exact figures differ for different towns or different time periods. The focus of this simulator is to illustrate the mechanism and impact of the halo bias, and as such it does not require to calibrate these values that precisely.

Concrete actions. We have investigated the impact of “positive” communication, trying to reinforce the priority of ecology for the population. But cars still benefit from a very positive global opinion, as conveyed by advertisement: car manufacturers often advertise their cars as related to positive values such as autonomy, safety, or adventure. It would be interesting to also study actions to restrain such (often misleading) communication.

User actions are still very abstract. The simulator could be made more playful and immersive by matching the abstract actions (increasing the value or priority of a given criteria) to actual concrete actions modifying public policies or communication (e.g. “advertise about road safety”, “raise awareness about climate change”, “make the town centre pedestrian only”, “make public transport free”, “increase petrol price”...). However it is hard to be exhaustive when listing such actions, and several actions can have the same concrete effect on underlying values, so the current interface offers more expressive and abstraction power.

Cognitive biases and coping strategies. Our agents can use two strategies to restore cognitive consonance between their mobility and their priorities: modifying their choice of mobility, or their priorities (putting a halo on the negative criteria). This is similar to the coping strategies that are activated by individuals when they feel negative emotions. According to Lazarus [17], coping strategies against negative emotions fall into two categories: either they address the stimulus itself when possible (problem-focussed coping) or they address the individual’s evaluation of the stimulus when it is not controllable (emotion-focussed coping). For instance, “denial” is a

strategy often triggered when someone is faced with bereavement: the negative stimulus cannot be controlled and is too intense, so the individual might react by denying its reality and refusing to believe that their relative actually died. Here agents who deal with a cognitive dissonance between their current mobility choice and their growing ecological priority might also feel that they have no control on the problem (choice of mobility), because they (believe that they) depend on their car (there might indeed be no alternative, or it would be too costly). Since they cannot or do not want to resolve the gap by changing mobility, a less costly strategy consists in denying the importance of ecology. As a result, they reappraise their current mobility without that criterion, which restores their positive opinion of it, and their satisfaction.

4 Conclusion

This paper introduced interactive simulators of the impact of cognitive biases on mobility inertia despite climate change. These simulators are published online and can be played autonomously by users. Even though we illustrated their explanatory power on various scenarios, we have not yet conducted a real evaluation. Short-term future work will be dedicated to evaluating the actual impact of each simulator on users via an online survey. Psychological validity will be harder to assess, since human behaviour is subject to interpretation, and many different causes can explain the same result.

It is therefore important to reassert that the goal of our simulators is not to teach any definitive explanation to mobility inertia, but rather to give users food for thought, and let them explore scenarios. Besides, in the absence of debriefing we cannot expect much learning to happen [9]. Making people think however is just as essential in these times of constant change, with new mobilities emerging and requiring adaptations. Another important aspect of the mobility transition that requires thinking is equity: it is easy to forget people along the way, who cannot afford the transition for various reasons (limited fitness, budget, or time). The goal of these simulators and the overarching project is to support prospective thinking about what the mobility of tomorrow could look like. Imagining a better future could be the first step before making it a reality.

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A Learning Game to promote Nature-based Solutions to manage flood risk

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Abstract. Different works (projects, articles, etc.) have demonstrated the interest of Nature-based Solutions (NbS) to reconcile flood management and sustainable development, particularly in a context of climate change. However, their concrete implementation has to face different obstacles, in particular the lack of knowledge on these solutions or on their efficiency for flood management. This leads to the need to include NbS in a global, participatory and integrated vision of risk management. This is the challenge set by the MANA project, which aims to design an approach, a model and a tool to raise stakeholders' awareness of NbS for flood risk management. We propose in this project a game 'Sim-MANA' which combines role playing game and computerized simulation based on Agent based-model (MANA-Flo model). Sim-MANA is designed for 5 to 15 players, and requires a game master. It does not require any initial knowledge or skills, although it can be played by experts in the field of flooding, or by a mixed team (experts and non-experts). It places players in charge of a city council for a period during which they must make decisions related to land use planning and flood control (flooding and runoff) in an urban area. This article presents the game, the model and the first results obtained.

Keywords: Flood, Risk management, Simulation game, Agent-based model, Nature-based solution

1 Introduction

The combination of the effects of climate change with the increase in the number of stakes exposed, and sometimes their vulnerability, especially in coastal urban areas, has made risk management a major issue for the development of these areas [1]. Various structural and non-structural strategies can be envisaged to deal with natural hazards, notably floods [2]. Classical structural strategies are based above all on "hard protection", i.e. an anthropic element intended to protect one or several buildings, infrastructures or activities from a hazard (dike, dam, etc.). This "hard protection" approach poses several problems as these structures often give a misleading impression of total protection to the population, thus encouraging urbanisation on the one hand, while they generate environmental impacts and degrade the landscape on the other. An alternative strategy would be to use Nature-based Solutions (NbS). NbS are defined by the IUCN as "actions to protect, sustainably manage and restore natural or modified ecosystems to directly address societal challenges in an effective and adaptive manner while ensuring human well-being and biodiversity benefits" [3].

These co-benefits can be highly diversified and concern socio-cultural and economic aspects such as improving the attractiveness of places and the quality of life and health, and the creation of green jobs [4]. More specifically, with regard to mental health, NbSs have been shown to improve psychological well-being, especially among urban populations [5]. Finally, the implementation of NbSs in urban areas has multiple co-benefits such as the creation or maintenance of habitats for different animal and plant species, and the development of new recreational areas [6]. In the longer term, "the socio-economic benefits of NbSs go far beyond the project itself, [...] the indirect and induced economic effects can increase local economic dynamics" [7].

Regarding the specific subject of urban runoff (which concerns 70% of French municipalities), the results of the H2020 NAIAD project (2016-2019) revealed that NbSs implemented in urban areas to reduce water heights or flows are effective for recurrent events but less so for extreme events [8]. Moreover, the effectiveness of NbSs depends on the good ecological health of systems. NbSs are technically effective at certain spatial scales and are highly dependent on the local context (social, economic, cultural). As such, the deployment of NbSs to implement transition in the framework of a more sustainable development pathway implies overcoming technical, institutional, regulatory, economic and financial obstacles. Indeed, the issues of sizing, implementation, assessment and monitoring of NbS and their co-benefits imply specific knowledge and skills at different scales (from the scale of sub-ecosystem to that of administrative area) which are lacking [9], [10]. The scarcity of feedback and standardised protocols to assess the effectiveness of NbS according to risk mitigation impedes the funding of these actions. Another constraint is related to the temporality of the effectiveness of these solutions, indeed some of them reach their maximum effectiveness over several years or even decades (when they involve the planting and growth of trees, for example) [8]. During these time steps, ecosystems evolve, as do climatic conditions, requiring flexibility in the monitoring of NbSs. In addition, many uncertainties are linked to “the resilience of ecosystems [to] the impacts of climate change and therefore to the sustainability of NbSs” [7]. Although this last point is not exclusive to NbSs (the question of the resilience of structures also arises for “hard protection”), it contributes to the complexity of the decision to invest in these integrated risk management solutions [9]. These uncertainties, especially regarding the effectiveness of preventive actions, are responsible for numerous social and cultural obstacles to the implementation of NbSs [9].

In order to promote NbS, and in particular to ensure the credibility of their risk mitigation effectiveness, it is necessary to integrate all the stakeholders, from the technicians, managers and decision-makers involved to the residents, into the decision-making process, so that they can collectively discuss the possible flood management strategies. To support and facilitate this debate, we propose a game called ‘Sim-MANA’ which combines a role-playing game and a computerised simulation based on the Agent based-model (ABM). The game is “a place where it is possible to experiment because the failure of attempts is not sanctioned by an irremediable loss, by a serious attack on physical integrity, or even death” ([11]; quoted by [12]). Game devices used in a scientific and/or decision aid context can serve several purposes: i) to study an individual’s behaviour in relation to different environmental factors, ii) to identify environmental factors that constrain decision making, iii) to modify the environment through decision making (*Ibid.*). These tools integrate games, simulations, role-plays, and simulation associated with games, for example.

Sim-MANA was designed for 5 to 15 players, and requires a game master. It does not require any initial knowledge or skills, although it can be played by experts in the field of flooding, or by a mixed team (experts and non-experts). It places players in charge of a city council for a period during which they must make decisions related to land use planning and flood control (flooding and runoff) in an urban area. The following sections will present related works, the ABM (MANA-Flo), the game (Sim-MANA) and results from first applications.

2 Related works

Various games have been designed to raise awareness of floods and/or to provide knowledge for risk management. In a literature review published in 2022, Forrest et al. identified 37 games related to flood risk management [13]. These games had a variety of characteristics: they could be computerised or not, consider the pre-event phase, the crisis phase and/or post-event phases, be designed for one or more players, etc. We will focus more specifically in this section on games which integrate the pre-event phase (management of the territory before the event) and offer the opportunity to use NbS strategies in an urban area.

Board games (BG) and/or Role-playing games (RPG). Some BG/RPG games focus on flood management, but few take into account the pre-event phase and even less NbS. For

instance, the Flood control game [14] and AnyCare [15] are dedicated to crisis management. The Floodplain Management Game proposes that the players build a strategy to mitigate flood events [16], but it focuses on the role of the farmers and the strategies are focused on farm production and on grey solutions (i.e. dikes and canals); the game does not propose to implement NbS. As far as we know, no BG or RPG is entirely dedicated to NbS for flood risk prevention.

Games based on computerised simulation. Several computerised games have been proposed to raise stakeholders' awareness of flood management. But, as far as we know, only two games in the literature propose strategies based on NbS: LittoSIM [17] and SPRITE [18]. LittoSIM is a participatory simulation model developed to raise awareness of coastal flooding on the island of Oleron. It is designed to make scientific knowledge accessible to local elected officials and agents of the local authority, and to allow them to link this knowledge to management strategies. Although LittoSIM was originally calibrated for Oleron, recent developments (LittoSIM-GEN [19]) have led to its export to other territories (such as the Camargue and Normandy) via the implementation of an archetype system defined by the type of coastline prone to flooding. SPRITE is an educational game that also uses the case of the island of Oleron. It is designed to provide a medium for teaching risk management to undergraduate students. These two models both propose that the players play the role of a mayor whose objective is to improve the safety of the inhabitants of their constituency, in particular by using NbS (such as the restoration of the dune cordon), while also considering economic and environmental issues, over a period of several years.

These games have differences with our objectives: (i) they target a specific audience (elected officials and communal agents for LittoSIM, risk managers for LittoSIM-GEN, and students for SPRITE); (ii) they focus on marine submersion and not on river flooding and runoff; (iii) the territory studied is that of the island of Oleron as a whole (SPRITE) or of several communes of the island (LittoSIM), whereas the territory targeted in our case is more restricted (commune/neighbourhood); (iv) these games offer its players the roles of mayors, whereas we wish to be able to play different local actors. To complete the picture, we mention the third foundational game for our work, Virtual River [20], which is a hybrid game combining board and computer games in order to allow collective reflection on the management of a river in the Netherlands. Although this issue is different from ours (it does not focus on floods or NbS), some elements are relevant to our objectives in Sim-MANA: the notion of differentiated roles, the combination of virtual and physical elements, and the use of a physical interface to manage the computer simulation.

3 The MANA-Flo Model

3.1 Model objective

In order to raise awareness and provide knowledge on flood risk management (prevention and mitigation actions), we designed a dedicated ABM called MANA-Flo. This model is based on SiFlo [21], which is an ABM dedicated to simulating flood events in urban areas. SiFlo considers both the hazard (water spreading) and the response of the population, who can perform different actions: protect their houses, evacuate, share information, etc. SiFlo is able to simulate different scenarios, but each scenario has to be instantiated in the model via the model's parameters. In addition, the calculation time for the simulation prevents using it in the context of an awareness workshop in which the participant must not wait 1 hour - or more - to be able to see the results of the simulation. Therefore, MANA-Flo is a simplified version of SiFlo, dedicated for use during a game session. The following sections describe the main elements of the model.

3.2 Agents

MANA-Flo considers 10 types of agents [22]: Grid, Building, Road, River, Dike, Car, People, Pool, Stormwater network and World (global agent). The **grid** is the medium of the virtual world and can be viewed as the game board. It is composed of a set of cells which correspond to a square of 10m x

10m. Each cell has an altitude (the grid integrates topographic information). The grid is used to compute the water flow dynamics. The **river** agent corresponds to the water bed. It constitutes a preferential path for the water to flow. Each segment of river is characterised by a broad and a deep part. The filling of the rivers must be indicated at the beginning of the simulation. Rainfall and water arriving upstream of the territory will modify this filling and may lead to an overflow of the river. The **building** agent covers all types of buildings. The model distinguishes between residential buildings, commercial buildings (shops or offices) and buildings open to the public. Each people agent lives in a building and can move from one building to another using roads. Water can enter into buildings and cause damage. The buildings are characterised by their height and number of floors, which may provide shelter for people in the event of rising water levels. The **dike** agent groups all types of elements whose purpose is to obstruct water. These can be embankment dams, walls, etc. Dikes are characterised by height and strength. The **pool** agent represents any structure or device that captures and holds water. It is characterised by a catchment area and a volume. The **road** agent corresponds to any road element. The roads constitute the network on which the people agents will move (on foot or by car). The **stormwater network** agent corresponds to all the elements of the network allowing the evacuation of stormwater. Like the road, it is geo-located and characterised by an evacuation capacity. The **car** agent is the preferred means of travel for people agents. People agents will be able to use them to move around quickly, but they also constitute a risk. Water can damage cars and prevent them from leaving an area; people agents travelling in cars in flooded areas are particularly vulnerable. The **people** agent model a household. Their behaviour is inspired by SiFlo [21] using the same possible actions: evacuate, stay at home, go outside (agenda), drain-off water, secure their car, protect their properties, weather-strip house, inform other people. But in order to simplify the model and reduce stochasticity, MANA-Flo does not use the BEN (Behaviour, Emotions and Norms) architecture [23]. Instead, MANA-Flo uses a more classical reactive model, based on “archetypal profile” which gives people behavioural preferences (i.e. escape, protect property, wait). The **project** agent corresponds to the possible actions that can be chosen by the players. Implementing a project can lead to several sub-actions such as create new buildings and roads.

3.3 Process

The MANA-Flo model uses a double dynamic: event and risk management. The flood event process uses a step time of 30s and simulates the processing of the flood. The flood management process uses a step time of 2 years and integrates the interactive component of the model, by proposing that the user chooses a project to be implemented.

Flood event process. The flood event simulation is based on the SiFlo model. Firstly, the world agent updates the environmental data (e.g., upstream water, rain) from pre-defined scenarios. It allows us to define the new input of water in the system. Then, a flow sub-model is used to simulate the water flow. At each flow action, the water flows to the lower neighbouring cells (considering topography, water height, riverbed and dike); the flow is distributed to the cells according to the slope. This results in an updated water level on each cell of the territory grid. From these water levels, MANA-Flo computes the state of the road; flooded roads can slow the speed of vehicles, be dangerous, or be unusable. After the road, MANA-Flo updates the building condition. Depending on the building’s permeability, the water on the cell can more or less penetrate into the building. The permeability can evolve during the simulation depending on the people’s behaviour. Like the road, the water in the building can cause damage (e.g., deterioration of furniture, floor coverings, etc.) and induce a hazard for the inhabitants. Then, people agents will act. In the first step, they “perceive” their environment and act according to their archetype and what they perceive. The process is reproduced at each time step until the end of the flooding event (parameter).

Game process. At the beginning of this process, MANA-Flo informs on the consequences of the previous flood. Then it computes the cost of repairs that the player must pay. It should be noted that

the financial part of the game is played with real coins and outside the framework of the model. The players can then act by choosing projects to implement. The model proposes 18 different projects set out in 3 levels (from the costliest and most preventive to the least costly), or locations. MANA-Flo updates the indicators after each new action. The indicators are grouped into three categories: attractivity, flood risk management and environment. The choice of indicators was based on several elements: a study of indicators in the literature ([24], [25], [26]), the objective and mechanics of the game, and their perception by the players (understanding, importance, etc.). They allow the players to have a global vision of the situation and its evolution according to their actions. Each project has an impact on the indicators, either improving or deteriorating them. Moreover, the consequences of flooding will also modify the values of flood risk management indicators (i.e. human protection, private property protection and public property protection).

3.4 Implementation

MANA-Flo was implemented with GAMA [27], which is an open-source agent-based simulation platform which offers many features which are particularly interesting for MANA-Flo. Indeed, GAMA allows the native integration of GIS data. It also provides moving skills for the agent which are used in MANA-Flo to simulate the people agents' travel. In addition, GAMA provides different features to integrate interactivity in the simulation. Notably it provides, via a specific plugin, a function to read and transcribe a QR code into an action during the simulation.

As input, the model uses OSM and ASC files for all geographical elements (buildings, road, topography, etc.). If, theoretically, the model can be applied to any territory, in the framework of the interactive simulation, it was designed to be applied to a specific virtual territory. This territory called La Vita gathers many characteristics of South-East French urban areas and in particular La Ciotat and Vitrolles.

As output, MANA-Flo provides a map of the simulated territory with the main elements (building, people, dike, etc.) (Fig. 1). It is possible to display on the map information on the current flood (i.e. water height, damaged building and road), on historical floods (information from a previous flood event), land use and topography. In addition to the map, the model provides different information for the game master: the value of each indicator, narrative elements related to the flood (such as a description of the weather), the consequences of the flood and elements related to implemented projects. Regarding the indicators, the model computes nine indicators belonging to three categories: environment (biodiversity, global warming and natural spaces), attractiveness (number of inhabitants, services and business, and the population's satisfaction) and security regarding floods (human, public material, private material).

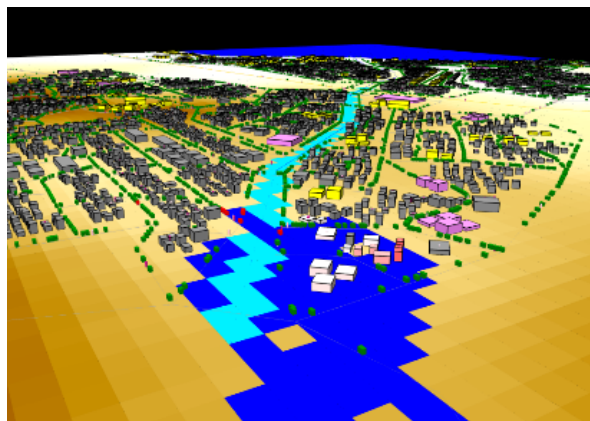


Fig. 1. Snapshot of the map screen during a flood simulation (GAMA).

For the interaction, the model uses QR-codes. Each project has a QR-code, and to implement a project during the simulation, the user has to show the QR-code to the camera. A “beep” validates the operation and the project is implemented directly in the simulated world. The map is updated considering this new project and the indicators are also updated.

4 Sim-MANA

4.1 Principles and components

The Sim-MANA game has been designed with the intention of bringing together players with different levels of knowledge and different points of view on flood risk management. The players take on one of five roles: Municipal Team, Technical Services, Environmental Union, Residents’ Representative and Business Representative. Three rounds are run, each round representing two years, thus forming the six years of a French municipal mandate, and allowing players to adapt their strategies. At each turn, the players are informed of the situation through the map and the indicators. According to their roles, the players choose the projects they wish to carry out from a panel of 18 different projects that can be NbS, hard protection, but also actions related to the town’s development (densification of urbanisation, asset relocation, etc.). The projects to be implemented were chosen by conducting a review of the scientific and grey literature on NbS in an urban environment [4], [6], [28], and by carrying out field work in the two municipalities on which Sim-MANA is based (La Ciotat and Vitrolles). The objective was to ensure that the prevention and protection measures proposed in the game were realistic regarding the local context and effective in limiting the damage associated with flooding.

A player who wishes to carry out a project must present it to the other players in the City Council. Each project is defined by the actors involved in it as well as the decision mode (unanimity or majority). If the project is selected, it is implemented in the simulation by reading its QR-code and the indicators are updated. A flood event is then simulated with an intensity ranging from a ten-year to a 100-year flood. The indicators are re-evaluated after the event.

The game uses different material elements. Firstly, it requires a computer capable of running the model in a reasonable amount of time (for testing purposes we used an Intel(R) Core(TM) i7-9850H CPU 2.60GHz with 32 GB of RAM) with a camera (any type of webcam is sufficient). The simulation is projected on a table which thus becomes the game board. To do this, it is necessary to use a specific projector and a light stand to hold the projector in position. The game also includes a set of cards. There is a card for each role specifying the objectives of each one, their means of action on the territory (budget and projects that they can carry out), and narrative elements of context. Each project also has a card, giving a brief definition, explaining who can carry it out (which role) and who can oppose it, its location, its consequences in terms of indicators, and its cost. The money in the game is a virtual currency called “espego” and is represented by metal coins with values ranging from 1 to 100.

4.2 Sim-MANA Game session

The game takes place within the framework of a workshop composed of 4 phases: set-up, briefing, game session, and debriefing.

The **set-up** phase takes place before the players arrive. Its purpose is to install the video projector and the cards. There are also the tasks of verifying the functioning of the model and of realigning the simulation with the model, if necessary.

The **briefing** begins by welcoming the players, and by gathering them in teams if necessary. Then the game master quickly explains the session and asks the players to fill in a preliminary questionnaire about their knowledge of flooding, NbSs, and their perceptions of flood mitigation measures. The game master then assigns each player – or team – a role. It is possible to assign roles to the players that are close to those they play in real life or to have them play a completely different role (e.g., an elected official playing the role of the environment union). Both

approaches have their advantages and shortcomings. As part of our objective to raise awareness of the inhibitors to the implementation of NbSs, we prefer the counter-role approach, which requires the players to approach a different point of view from their own. Each player must then read the role card; it gives a definition of the role, of the specific objectives, and a narrative that outlines the context or particular issues known only by the player. This information can be used in the game to negotiate, for example. After the roles have been assigned, the game master describes the general context of La Vita and starts the simulation which begins with an initial ten-year flood. While this is going on, the game master can explain certain other specific elements such as the role of the Vitello River for the city, the types of buildings that are in the hazard prone area, show how the inhabitants react to the flood, etc.

This stage starts the **game**. At the end of the flood, the game master explains the damage, as well as the principle of repairs and reconstruction, after which first phase of negotiation/decision of the players can begin. Each of the three turns of the game alternates between flooding and town planning phases (fig. 3). The game ends with a final flood and its outcome, before moving on to the debriefing.



Fig. 2. Example of a game session

The **debriefing** provides a moment of reflection to compare the game experience with reality [29]. It begins with the completion of a questionnaire for which most of the questions are common to the preliminary questionnaire and are aimed at assessing the knowledge gained and the change of perception regarding NbS. Then, the game master facilitates the debate on the feedback of the players on the game; they are asked to describe how they experienced it, encouraging exchanges between the players. Then, we ask them what they have understood or learned from the game; and, eventually, we ask them what they should have done to obtain a better result. This is done to make them re-think the different possibilities available to them, including the use of NbSs. Once this phase is over, the players are asked if they think this type of strategy is possible on their territory, and what specific strategies they could consider. The goal here is to come back to reality and contrast their game experience with the constraints and opportunities that their own city may have. This is intended stimulate exchanges between the players and motivate them to engage in a process of reflection on alternative flood risk management strategies. .

4.3 Game design

The game was designed around three objectives associated with knowledge to be transferred to the players: 1) raise awareness of the different issues related to the development of a territory subject to flooding; 2) inform about the different strategies employed to face floods and especially NbSs, their advantages and disadvantages; 3) show the trade-off between the different issues and the different approaches and perceptions of the different stakeholders, and thus the complexity of the system. In addition, Sim-MANA is aimed at initiating and developing discussion, sharing opinions and ideas, and fostering a collective debate on flood risk management and more globally on urban planning.

In order to achieve these objectives, Sim-MANA combines various game mechanisms: role playing, negotiation, action optimisation, asymmetric roles and semi-cooperation. The use of the role-playing mechanism reinforces immersion. Narrative elements are given by the player's cards, and during the game session by the game master in order to allow the construction of a shared story. This also contributes to building common memories which are beneficial to learning. The asymmetric role and the semi-cooperation mechanism provides more diversity to the role playing and also creates an opportunity for dialogue between different points of view. Indeed, each role represents one or several aspects of city life; for instance, the business representative provides the standpoint of the city's economic dynamics and attractiveness. This is reinforced by the semi-cooperative side of the game. Indeed, each player has two objectives: 1) the first is common to all and is about making the city as sustainable and resilient as possible; 2) the second objective is an individual one and consists in advocating for a specific issue. For example, the environmental union must raise the environmental dimension to an excellent level regarding our indicators. These conflicting objectives should encourage players to defend their own and sometimes irreconcilable interests, which requires negotiation to reach a compromise. To take actions, players must convince at least one other player to join their project. This has the advantage of challenging the players to identify and formulate the advantages (argument) and disadvantages (counter-argument) of each project, as well as to define together the compromise to be found between the different preventive levels and the types of project.

Regarding action optimisation, Sim-MANA is a game where players have to choose and plan actions, by maximising a set of indicators while respecting constraints (i.e. the budget versus the costs of the actions). This can be modelled as a multi-objective optimisation problem. We therefore modelled this problem and solved it using genetic algorithms. The results, which are presented in the form of Pareto fronts, provide information on the different optimal strategies (the non-dominated strategies). Without going into detail here, this approach justified that NbSs are among the most optimal strategies. Thus, the game tends to favour this type of approach without forcing the players to opt only for NbSs.

4.4 Assessment and first results

The protocol for assessing the learning from the Sim-MANA workshops is structured around three tools, a two-part questionnaire (before and after the game session), the qualitative analysis of the debriefing discussions, and an observation grid (based on the model of non-participant observations) are filled out by the scientific team. The questionnaire provides quantitative, individual, and anonymous data on the knowledge acquired during the game, the change in perceptions about floods and NbS, by the comparison of answers between before and after the game session. The transcript of the debriefing aims at collecting qualitative results, group feedback (also encouraging exchanges between group members). These results allow for further understanding of changes in perception, opinions on the game and the applicability of the game's strategies to the players territory. The observations during the game is relevant to have a look on the behaviours during the game, the dynamics of the game, the relationships between the players, their way of interpreting the roles. This provides us with the necessary elements to analyse the immersion of the players in the game, the space that each player was able to find in it, but also

the view of the players on the role they had to play. These three types of observation are complementary and will be cross-analysed. This arrangement requires the constant involvement of the project scientists, both to facilitate the workshops and to collect the assessment elements. As an iterative process, the game and the simulation will evolve according to the workshops conducted in the territories. The assessment process therefore focuses on both the device and the social learning that the participants obtain from it.

The game has already been tested in 2 workshops, and 2 others are forecast. As the game is still in the development phase, both it and the model may evolve between each of these workshops. Thus, the results obtained are not definitive and need to be completed. For these first two workshops, 10 people played Sim-MANA; they were mainly INRAE or Aix-Marseille University staff, they held various positions (trainee, researcher, research support) and had very variable knowledge on flooding and NbS.

Overall, many players enjoyed the role-playing aspect and the idea of working together to find solutions. Several players underlined that they found it interesting to use the roles to contrast several points of view on flooding and on land use planning. Some said that the game led them to develop knowledge and skills, and to adopt a new perception of flood risk in relation to land-use planning. They were all able to provide a definition of NbSs at the end of the workshop, whereas many had not been able to give one before. The first workshops were an opportunity to test the evaluation procedure (and to make it evolve), to get suggestions for improvement of the model and the game, and to obtain first results. However, these results are too partial for an in-depth analysis. Notably, we have not yet been able to assess the transferability of learning during the game to their territory. This will be the subject of the next workshops.

Among the criticisms were the lack of clarity of their actions and, in particular of the impact of each project on the indicators. Others highlighted the fact that they had too much information at the beginning of the workshop, and only felt comfortable with the actions in the third round. To address these problems, we redesigned the project and role cards by better synthesising the information (and in particular the impact of the projects on the indicators), and we modified the presentation before the game, adding elements to the game masters speech such as a very synthetic presentation of the different projects. Moreover, a rule of the game has been modified concerning the possibility of carrying out a project which obliges to convince other players to join it (with a differentiation according to the roles). This forces players to really negotiate, and argue to defend the projects they want to carry out.

During the second workshop, at the initiative of one of the players, the team wished to propose a new action, not available in the game (carrying out an impact study on a project). The game master was able to do this (thanks to his expert knowledge of the hazard and of land-use planning), so this “new” action was integrated in the game session. Thus, even if the game is linked to the simulation and the model, which limits the capacity for new and unforeseen solutions, there is still a margin for creativity that we encourage. The role of the game master is very important in this respect to define what can and cannot be done and to find solutions to follow the creativity of the players.

It should be noted that these first test workshops were not conducted with the targeted stakeholders. However, the authors know that it is not only one workshop that will change the mentality and lead the actors to directly carry out a NbS project, Sim-MANA’s ambition is to bring elements of reflection, discussion and exchange. *In fine*, the objective will be to lead the participants to carry out studies in order to implement such NbSs or hybrid (NbS and hard protection) projects in their territory.

5 Conclusion

In this paper, we presented the Sim-MANA game in view to raising awareness among different stakeholders regarding flood risk management, in particular through the use of NbS. It is based on an ABM, MANA-Flo, which allows the simulation of a flood by taking into account the

planning choices made by the players, and to assess the different dimensions of the prevention and development strategies chosen. Sim-MANA is above all a medium for encouraging players to consider this subject, to discuss together, and to understand the stakes and trade-offs behind flood risk management. The choice of using the 6-year municipal mandate has several advantages, including that it is plausible for territorial actors and risk managers, and that it allows the strategy to be modified from one round to the next (to rectify a negative effect of the projects implemented, for example). On the other hand, this temporality is too short to assess the evolution over the time of the effectiveness of the NbSs.

The game and the model are operational. Ongoing test games are likely to make them evolve slightly (especially regarding parameterisations), but the game is playable and has shown encouraging results during the first test workshops. These workshops will be continued over the next few months; the next challenge is to reach stakeholders in the field (elected officials, technical services, associations, residents, etc.).

In parallel, a 3D model (3D printing) of La Vita is being produced, with the challenge of projecting the simulation on the scale model and integrating the QR code in the different modules to reinforce the visualisation and the user-friendliness of the interface.

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Talk That Talk

Design and evaluation of a persuasive card game against sexually transgressive behaviour

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Abstract. Sexually transgressive behaviour (STB) causes serious health problems for, among others, students of higher education. The persuasive card game TALK THAT TALK was designed to promote *ethical bystander behaviour* in STB situations and contribute to a social transition to less sexual violence. To this aim, the game facilitates *Intergroup Dialogues* between female and male players. A controlled experiment was conducted to evaluate the game. The outcome variables of the experiment were obtained from the literature: *Willingness to Intervene*, *Awareness of prevalence of STB*, and *Bystander Responsibility*. Quantitative and qualitative analyses, including validated questionnaires and semi-structured interviews, were employed to measure the game's effects. Participants evaluated the quality of the game (session) and game experience positively and reported that meaningful intergroup dialogues about STB situations took place during the game session. As a result, in the experimental group a significant increase of the three outcome variables was observed, whereas in the control group a non-significant decrease was found. We concluded that the game TALK THAT TALK has the potential to promote ethical bystander behaviour in STB situations by facilitating an intergroup dialogue between female and male participants. Future research should establish if the results can be generalised to a more representative sample of participants and if the game effects may be improved when institutes for higher education include the game in large-scale intervention programmes against sexually transgressive behaviour.

Keywords: persuasive game, sexually transgressive behaviour, ethical bystander behaviour, controlled experiment, intergroup dialogue, higher education

1 Introduction

In 2021 Amnesty International commissioned research into sexually transgressive behaviour (STB) among students of higher education in the Netherlands [1]. A main outcome of the study was that one in ten students had experienced unwanted sexual penetration, i.e., rape. Three quarters of those STB victims suffered afterwards from problems of a mental, sexual, or relational nature. Many of them gave up their studies or (temp) jobs [1].

According to WHO, intervention programmes can contribute to a culture change and thus help reduce STB [2]. In school-based programmes the 'bystander approach' is considered effective [2,3]. This approach entails that students are made aware of their role as bystanders in STB situations and are empowered to intervene when they witness sexual violence. Intervening in STB situations, while also considering one's own safety and wellbeing, is called ethical bystander behaviour. Research shows that while bystanders are present in one third of STB cases, they only intervene in one third of the time [4a]. Promoting ethical bystander behaviour in intervention programmes may increase the latter number.

Persuasive gaming is a promising tool for behavioural interventions in organisations and society as a whole [5,6]. As such, persuasive games have the potential to promote ethical bystander behaviour and thus support a student culture with less sexual violence. An example of such a persuasive game against sexual violence is *Boxing the Boxes* [7]. However, instead of students in higher education, *Boxing the Boxes* targets secondary school pupils and, therefore, does not fit with the scope of this study. In addition, *Boxing the Boxes* was developed as a prototype and was not evaluated in a systematic way.

The objective of our research was to adapt and evaluate the prototype *Boxing the Boxes* to understand how persuasive games may be designed and used as an intervention tool to promote ethical bystander behaviour in STB situations and the social transition to a safe climate free from sexual violence.

Below, in Section 2, we operationalise the concept of ethical bystander behaviour as a set of outcome variables that may be used to establish the effectiveness of the adapted game. We review established methods to promote ethical bystander behaviour in Section 3. The outcomes of our review are used to adapt the prototype for our purposes. In Section 4, we design an experiment to evaluate the game and its use in facilitated game workshops with students. The experimental results are presented in Section 5, after which they are discussed, and conclusions are drawn, in Section 6.

2 Outcome Variables for Ethical Bystander Behaviour

To operationalise ethical bystander behaviour and develop outcome variables for the game, the health communication model by Kincaid et al. [8] for behavioural change is first introduced in Section 2.1. This model is thereafter adapted to yield a new health communication model for the transition to ethical bystander behaviour in Section 2.2. Finally, with the help of the new model, the outcome variables for measuring the effectiveness of the persuasive game are determined.

2.1 The Health Communication Model for Behavioural Change

The health communication model for behavioural change can be used to study and develop communication strategies to promote positive health behaviours [8]. It comprises four main components: communication, ideational factors, health behaviour, and health outcome. We will discuss each component below.

Health Outcomes. Health communication can be used to reach different audiences and share health-related information to promote healthy behaviour of important actors or policies to ultimately improve health outcomes [9]. Sexual violence is a public health problem, as it can negatively affect the physical, emotional, and social well-being of an individual [2]. Therefore, reducing sexual violence would be a desired health outcome.

Health Behaviour. Ethical bystander behaviour can help reduce sexual violence, and is therefore considered a health behaviour. Two types of decision-making affect health behaviour: behavioural intention and behavioural willingness [10]. Behavioural intention involves a deliberate effort requiring analytical processes to plan or perform a behaviour [11]. However, not all behaviour is planned or reasoned. This unintended reaction is called behavioural willingness [10]. Both behavioural intention and willingness were found to be independent predictors of behaviour [12]. There are however three reasons to choose willingness – and not intention – as a predictor for behaviour. Firstly, for behavioural willingness to be measurable, little experience with a behaviour is required in comparison to behavioural intention. Secondly, when social circumstances and social images are relevant, the intention is weak [12]. Thirdly, long term-evaluation is needed to measure behavioural change, which was not possible in the short-time frame of this study [13]. Therefore, behavioural willingness was taken as an outcome variable for ethical bystander behaviour.

Ideational Factors. Research shows that effective bystander intervention programmes can change bystander behaviour, attitudes, awareness, and knowledge about sexual violence, which can contribute to a cultural change [3, 4, 14, 15]. They can also lower rape myth acceptance, which was found to be a barrier in ethical bystander behaviour [16]. Rape myths are generally false, stereotyped, and prejudicial attitudes and beliefs, that serve to deny and justify male sexual aggression against women and put the blame on the victim [17]. If the bystander doesn't believe in the innocence of the victim, the bystander might feel less responsible [16]. A lack of responsibility was found to be another barrier [18]. Therefore, rape myth acceptance, awareness about sexual violence and bystander responsibility are taken as outcome variables, addressing the cognitive ideational factors of the health communication model. In this paper we prefer the use of sexual violence myth acceptance because this study includes a broader scope of rape myth acceptance.

Communication. Communication plays a key role in persuasive games, as they aim to persuade the player's attitudes, beliefs or behaviour by either argumentation or providing information [5, 19]. Communication also plays an important role in intergroup dialogue, which is a participatory and interactive student-centred approach. It is characterised by critical dialogue communication processes that can help participants from different identity groups cope with differences and conflict in intergroup contact [20]. It can contribute to cultural change within peer cultures by stimulating intergroup understanding, relationships and collaboration leading to individual and collective action against societal inequalities [21, 22]. Intergroup dialogue has the potential to promote ethical bystander behaviour and therefore can be considered as a communication approach in the persuasive game.

2.2 A New Conceptual Health Communication Model

Based on the theoretical findings above and the health communication model for behavioural change, a new conceptual health communication model was developed for this study (**Fig. 1**). According to the new model, a persuasive game –which integrates entertainment and dialogue and encourages communication – causally affects the ideational cognitive variables sexual violence myth acceptance (SVMA) and bystander attitudes existing of awareness and responsibility (BA). Research shows that lower rape myth acceptance and greater perceived responsibility are linked to greater willingness to intervene, and that awareness is an important factor for ethical bystander behaviour [4, 14, 18]. Therefore in **Fig. 1** SVMA and BA consequently influence the willingness to intervene (WI) which is a predictor of ethical bystander behaviour. As a result, the serious game can reduce the prevalence of sexual violence among students by promoting the transition to ethical bystander behaviour.

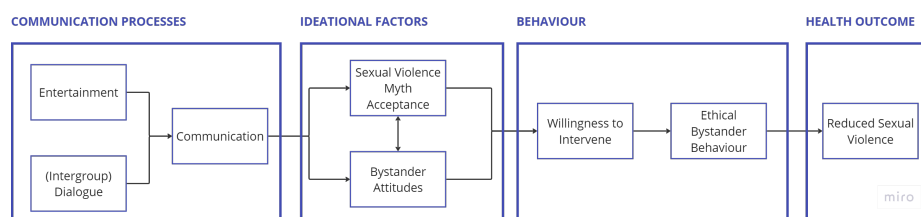


Fig. 1. New Health Communication Model for Promoting Ethical Bystander Behaviour.

In conclusion, the outcome variables for the evaluation of the game are sexual violence myth acceptance (SVMA), bystander attitudes (*i.e.*, bystander responsibility and awareness) (BA), and the willingness to intervene (WI) in situations of sexually transgressive behaviour. Moreover, communication processes (CP) are taken as mediating variables.

3 Game Design

We developed our game TALK THAT TALK by adapting the game prototype BOXING THE BOXES [7] to the scope of this study. BOXING THE BOXES is a persuasive card game about gender equality and safety. It was designed to facilitate an intergroup dialogue between female and male high school students. By posing a new scenario with each card, the participants are encouraged to share their experiences in a small group session, and to critically reflect on currently accepted gendered views and welcome new perspectives. Below we explain how we adapted the game to encourage intergroup dialogue within the study's scope of STB among university students. For the game framework design, we review established methods for promoting ethical bystander behaviour in Section 3.1. For the game content design, we review bystander opportunities and explore the system of sexual violence in Section 3.2.

3.1 Game Framework

Intergroup dialogue. To guide and support the communication process, it is important to: (1) pose questions to stimulate participatory engagement, (2) encourage positive and respectful interaction by implementing ethical guidelines, (3) have a structured activity in small groups with an equal number of members from either group identities, and (4) facilitate learning with two co-facilitators, one from each group identity [21, 23, 24]. Encouraging a meaningful dialogue between strangers is challenging [5, 6, 25]. However, diverse groups do contribute to a more critical dialogue and help to expand the worldviews. Therefore, a safe space is important, in which participants feel physically and emotionally safe to share their perspectives and experiences openly and honestly [26].

Several components can contribute to a safe space, such as having an unbiased, non-judgmental, well-informed, calm, open, and respectful facilitator. Moreover, the participants should have good discussion skills (e.g., listening, being open-minded and respectful). The environment can also be beneficial for the outcome (e.g., quiet rooms, good lighting, face-to-face seating arrangements). A successful safe space can lead to group learning and an increased sense of self-awareness [25].

To ensure a safe space, TALK THAT TALK is played in a small face-to-face group setting with people from different gender-identity groups, and two informed and open-minded facilitators from different sexes. A (de)briefing was added to discuss the ethical guidelines and provide additional information about sexual violence. This adaptation to the prototype was made to further ensure a safe space and intergroup dialogue. Moreover, an intergroup dialogue was encouraged by posing questions with scenario cards.

3.2 Game Content

Bystander Opportunities. Research [16] shows that in many college settings, bystanders are present in primary bystander opportunities (*i.e.*, before the assault). Primary high-risk situations pose an immediate risk for the victim of getting assaulted and are easier to be recognized. Primary low-risk situations present more subtle rape supportive behaviours and norms, making it difficult to recognize and therefore to intervene. As situations shift from low- to high risk, there is a higher probability bystanders will intervene [16]. To prevent sexual violence, it is important to intervene early. Therefore, the game focused on addressing the participants as bystanders in primary bystander opportunities.

Categories. The pyramid of sexual violence explains how an environment of sexual violence in society is created and sustained [27, 28]. With literature studies, these layers were further extended and explained by Baijanova [29], resulting in additional sub-layers. The primary bystander opportunities were divided over the sub-layers of the extended version. Therefore, the final five layers were introduced as the categories of the card decks. For more details see the report of Baijanova [29].

Scenarios. To create the content for each category, two brainstorm sessions with female and male students from Delft University of Technology were held, online desk research was conducted, and (personal) stories used. Additionally, Dutch data about the actors, type of relationship, location of transgression, and the circumstances before a transgression, related to sexual violence among students were used to shape the scenarios [1, 29].

Sexual violence is the most prevalent against young women and against people between 18 and 24 years old. It is most often perpetrated by their male peers and people between 17 and 30 years old [1, 30, 31, 32]. Thus, the focus of the game is on female victims and male perpetrators between 18 and 30 years old. In total 39 scenario cards were created which included scenarios or statements with either the question "What do you think" or "What would you do?". The first question reflects sexual violence myth acceptance, and the second the bystander's willingness to intervene in primary bystander opportunities. These cards are meant to reflect on what one would do in a scenario with a risk of sexual violence. The assumption is that the cards would create discussions about sexual violence myths and about how and when to intervene. These discussions would then lead to greater bystander attitudes. Consequently, these discussions would lead to greater willingness to intervene. **Table 1** provides an overview of the chosen design parameters, which are linked to the outcome and mediating variables.

Table 1. Link between Design Parameters and Outcome Variables

Design Parameters	Description	Outcome Variables
Content Cards	Content cards with scenarios or statements posing questions such as "What do you think?" or "What do you do?". Four answers per card are provided	<ul style="list-style-type: none"> • Communication Processes • Willingness to Intervene • Sexual Violence Myth • Acceptance • Bystander Attitudes
Briefing	Discussing ethical guidelines	Communication Processes
Debriefing	<ul style="list-style-type: none"> • Information about the system of sexual violence. • Statistics about the prevalence of sexual violence among students in the Netherlands 	Bystander Attitudes
Participant Characteristics	<ul style="list-style-type: none"> • Equal number of female and male participants • Students between 18 and 30 years • Students (bachelors, masters, PhD) from TU Delft 	Communication Processes
Game Environment	<ul style="list-style-type: none"> • Gender-mixed co-facilitators • Open-minded and well-informed facilitators • Fitted room to max eight people (6 participants and two facilitators) • Good lighting • Face-to-face seating arrangement • Room with limited distractions 	Communication Processes

Overall game design/set-up. The overall game design and set-up is shown in **Fig. 2**. TALK THAT TALK is played in small groups of four to six players and has a game time of 30 to 60 minutes.

There is a scoreboard with pawns, five decks of scenario cards with each a different category, one set ABCD cards for each player, a dice, and an hourglass of 3 minutes. One participant throws the dice, takes the respective card from the deck, and reads the scenario with the provided four answers out loud. Then the others guess which answer this participant will choose. Once everyone, including the respective participant has chosen, the answers are explained, starting with this participant. Once this participant is done explaining, the timer starts, and the others start talking. The respective participant gets a maximum of one point when at least one other participant guessed its answer right. The other participant gets one point for the correct answer. Points are kept with the scoreboard.

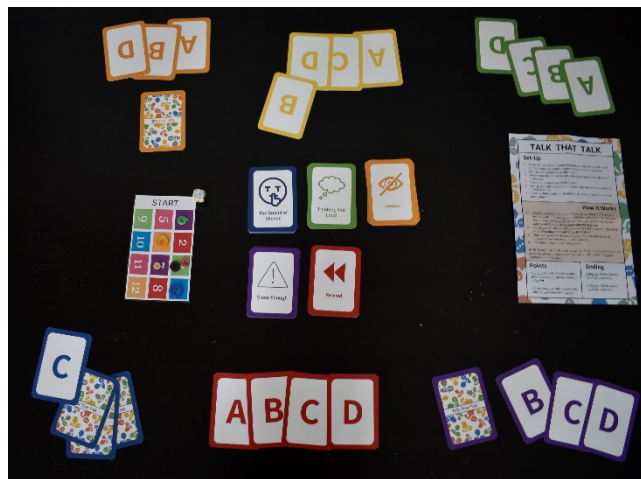


Fig. 2. Game Design and Set-up of TALK THAT TALK

4 Experimental Design for Evaluation

We designed an experiment to measure the following outcome variables: bystander attitudes (BA), sexual violence myth acceptance (SVMA) and the willingness to intervene (WI). Communication processes (CP) are taken as mediating variables. The effect of the game session on the outcome and mediating variables will be measured.

4.1 Setting and Participants

A quasi-randomized controlled trial was conducted with approval (ID nr. 2143) from the Human Research Ethics Committee of Delft University of Technology The Netherlands. A total of 64 students (32 females, 30 males, 2 undefined gender) between 18-30 years old ($M = 23.75$; $SD = 2.19$) and from different nationalities (23 Non-Western, 41 Western) participated. Participants were recruited via posters, email, social media, and study association channels for a study 'encouraging a dialogue among students about transgressive behaviour'. Participation was voluntary and rewarded with a 10 Euro shopping voucher.

4.2 Survey Development

The scales for measuring the outcome variables WI, BA, SVMA and the mediating variable CP were derived from different scientific literature sources [33, 34, 35]. First, the WI, BA, and SVMA scales were modified to fit the scales to the study scope. Then, these scales were pilot tested with 24 people, after which exploratory factor-analysis was conducted in SPSS to test the scales' quality. This process resulted in a one-dimensional 0 to 100 scale to measure WI and two-dimensional 5-point Likert Scale for BA (*i.e.*, No Awareness, Bystander Responsibility). We did

not succeed in acquiring meaningful factors for the SVMA scale. Therefore, the SVMA scale was excluded from further evaluation in this study. The details of the pilot-test can be found in the master thesis report of Baijanova [29]. Lastly, the original CP scale by Nagda [36] was used to measure intergroup dialogue. This scale exists of the variables “alliance building”, “engaging self”, “critical self-reflection”, and “appreciating difference”. The final scales, questionnaire, and interview items can be found in **Table 2** and **Table 3**.

Table 2. Items of Willingness to Intervene and Bystander Attitudes Scales

Willingness to Intervene Scale	Bystander Attitudes Scale
<ol style="list-style-type: none"> 1. I am willing to stop and check in on a woman who looks very intoxicated when she is being taken upstairs at a party to a bedroom. 2. I am willing to stop and check in on a woman who is surrounded by a group of men at a party and looks very uncomfortable. 3. I am willing to express discomfort/concern if someone makes a joke about a woman’s body. 4. I am willing to talk to people I know about the impact of using language that is negative toward women. 5. I see a guy talking to a woman I know. He is sitting close to her and by the look on her face I can see she is uncomfortable. I am willing to ask her if she is okay or try to start a conversation with her. 	<p style="text-align: center;">Variable: No Awareness</p> <ol style="list-style-type: none"> 1. There is not much need for me to think about sexual violence on campus 2. I don’t think sexual violence is a problem on campus. 3. I don’t think there is much I can do about sexual violence on campus. <p style="text-align: center;">Variable: Taking responsibility</p> <ol style="list-style-type: none"> 4. I plan to learn more about the problem of sexual violence on campus. 5. Sometimes I think I should learn more about sexual violence. 6. I think I can do something about sexual violence.

Table 3. Items of Communication Process Scale, Game Experience Questionnaire, and Interview Questions

Communication Process Scale	Game Experience Questionnaire	Interview Questions
Variable: Alliance Building		
1. I was able to listen to other student' willingness to understand their own biases and	1. In which part of the physical experiment did you gain most awareness about and understanding in sexually transgressive	1. What do you think of the game and its game elements?
2. I was able to hear other students' passion about social issues.	2. Was the content of the cards (the scenarios and its answers) relatable? Please elaborate.	2. How did the discussions/dialogue go?
3. I was able to hear other students' commitment to work against injustices.	3. Do you have any positive feedback or tips to improve this game?	3. How was it to listen to other people's experiences and opinions?
4. I was able to work through disagreements and conflicts.	4. How did you feel during the game?	4. Did you learn something from others? If so, what?
5. I was talking about ways to take action on social issues.	5. Did you feel safe to answer and discuss honestly during the game, if so why (not)?	5. What did you learn from the game play?
6. I was exploring ways to take action with people with a different gender.		6. What did you learn from the experiment overall?
7. I was feeling a sense of hope in being able to challenge injustices.		7. How was it to play the game with the other gender-identity group?
Variable: Engaging Self		
8. I was able to disagree.		8. Did you perspective change? If so, how?
9. I was able to share my views and experiences.		10. What kind of emotions did the game elicit with you?
10. I was able to ask questions that I felt I was not able to ask before.		11. With who do you think you play this game with?
11. I was able to address difficult issues and questions.		12. How do you think the game can be improved?
12. I was able to speak openly without feeling judged.		13. What else would you find interesting to know more about?
13. I felt allowed to make mistakes and reconsider my opinions.		14. Would you play the game? And if so, why and how often?
Variable: Critical Self-Reflection		
14. I was being challenged to examine the sources of my biases and assumptions.		15. How was the game environment for you?
15. I felt supported to appreciate the experiences different from my own.		
16. I was encouraged to think about issues that I may not have before.		
17. I was encouraged to understand how privilege and oppression affects our lives.		
Variable: Appreciating Difference		
18. I learnt from others.		
19. I was able to hear other students' personal stories.		
20. I was able to hear different points of view.		

4.3 Experimental Procedure

Before the game session started, all participants filled in an online pre-survey in Qualtrics measuring the willingness to intervene and bystander attitudes. One week after the pre-survey, the control group participants filled in their post-survey online, while the experimental group started their face-to-face experiment (game session). Each game session lasted 90 minutes and consisted of four parts: (1) filling in the consent form and demographics questionnaire, (2) explanation of game, creating a safe space and 30 minutes of game play, (3) a 10-minute break, and (4) a debriefing. Directly after the game session, participants completed the game experience questionnaire, the post-survey measuring the WI, BA, SVMA, and the CP scales as shown in **Table 4**. Next, one week after the experiment, the author conducted semi-structured interviews with participants from the experimental group over the phone. In all surveys, participants were asked to fill in the last three digits of their phone number to compare the results before and after the serious game session.

Table 4. Scales Linked with Surveys.

Note. A small x means that the scale/questionnaire was included in the survey, while a minus means that it was excluded.

	Pre-Survey	Post-Survey
Willingness to Intervene Scale	x	x
Bystander Attitudes Scale	x	x
Communication Process Scale	-	x
Game Experience questionnaire	-	x
Demographic Questionnaire	x	-

4.4 Data Collection and Analysis

All survey data was pre-processed in Excel, guaranteeing the participant's anonymity, and analysed in Python. Two participants from the experimental group were excluded based on gender, to make the experimental and control group samples equal in size (N=32). Ordinal scales were changed to numerical scales for descriptive and inferential analyses. Overall mean scores for each construct were calculated. Within and between-subject tests were performed between pre-, post- and follow-up surveys of the experimental and control groups. Qualitative analysis was performed on the interview, survey, and field notes data with the software program MaxQDA. A structured list was made with quotes from the data that could help explain quantitative findings.

5 Results

From the game experience questionnaire and the interviews, we derived qualitative results of the participant's game experience. Moreover, we extracted quantitative and qualitative results from the surveys, game session observations, and the interviews to determine the effect of the game session on CP, WI and BA.

5.1 Game Experience

We found that the overall game experience was positive. From the 32 participants 26 said they felt engaged. We linked the participant's experiences with the game session elements.

Relatability of Cards. Two-thirds of the respondents thought the cards were relatable. For instance, a 25-year-old person (gender unknown) explained: *"They were all situations that I've found myself in or which I know people close to me have found themselves in"*. However, the game was not relatable for everyone, particularly for male participants: *"I was engaged, but I think if there was a scenario more recognizable for me, I would have been more invested."* (male, 23 years).

Vagueness and Length of Cards. There were differing opinions about the vagueness of the cards. While some were frustrated about finding the meaning of the content cards, others thought the vagueness contributed to the dialogue, quoting: *"the situations and different answers were very clear, but they also left enough room to discuss, and left the scenario open for interpretation, which made the game a good talking place"* (male, 23 years). The length of the content was also questioned, with one participant suggesting a beamer to read the content on a big screen.

Game Duration. The discussions in the game were overall enjoyed. Many participants mentioned they would have liked to play the game longer than 30 minutes and play it more often.

In addition, the time-limited discussion rounds were found by some to limit the depth and number of discussions, as it didn't provide enough room for discussions.

Intergroup Dialogue. All interviewed participants seemed to be in favour of playing the game with other genders. Especially, the female students and some male participants thought it was important to include men in the conversation.

Safe Space. Out of the 32 participants, 29 expressed they felt safe to express their opinions without feeling judged. This safe space was by some contributed to the disclosure and discussion about ethical guidelines in the briefing; the consent forms before the start of the game; the open-minded participants who the game attracted due to selection bias; the unbiased scoring system, which also provided breaks during the serious discussions and added playfulness; the facilitators who are important when emotions run high; and the small group size.

5.2 Effect of Game Session on Communication Processes

Descriptive analysis was conducted to determine the effect of the game session on the communication processes (CP).

Quantitative Results. From the results it is clear that the game session had on average a positive effect on the communication process. "Appreciating Difference" elicited the highest positive response with $M = 4.42$ and $SD = .54$. "Critical Self-Reflection" scored the lowest with $M = 3.98$ and $SD = .61$, together with "Alliance Building" with $M = 4.04$; $SD = .44$. The variable "Engaging Self" had a mean value of $M = 4.19$ and $SD = .46$.

Qualitative Results. All interviewees indicated that they gained different perspectives and that they found the discussions the most interesting part of the game. Quoting: "*The game itself was super interesting. It required thinking and somehow challenging your point of view and different opinions. I think it was super valuable to have this discussion, and such a discussion would not have been available without such an environment*" (female, 26 years). Reflecting and challenging your own point of view is an indicator for the variable "Critical Self-Reflection". In fact, 10 participants indicated they felt self-conscious and six felt challenged.

Many seemed open to other perspectives and opinions, quoting: "*I felt open about talking about my experience with the group, because I also felt like nobody was there to try to win the argument to have the better opinion. It was just an exchange. I liked that.*" (male, 23 years). This openness to listen to other's worldviews and feeling allowed to make mistakes and speak openly without being judged fits with the variables "Appreciating Difference" and "Engaging Self".

Moreover, the cards seemed to be a good discussion starter, inspiring the participants to discuss topics they find difficult discussing with their peers in real life: "*The questions and answers were inspiring. Normally if people sit together, the topic of sexual violence won't appear. So, the game and the cards were needed to actually start a conversation*" (female, 26 years).

Conflict arose, but from observation and interviews it seemed to stimulate alliance building and the intergroup dialogue overall. Quoting one participant: "*In that situation the emotions were so high, so I took in a very extreme position and thought that no other answer was correct. But then we discussed it and I saw the others' perspectives. This situation was super valuable to me*" (female, 26 years).

5.3 Effect of Game Session on Outcome Variables

The effects of the game session in the experimental group on the outcome variables WI and BA were tested with paired t-tests and compared with the paired t-test of the control group, see **Table 5**.

Willingness to Intervene (WI). The paired t-test showed a significant positive effect of the game session on WI with $t(32) = -2.46$ and $p = .019$. These results were supported by the insignificant findings from the control group ($t(32) = .33$; $p = .742$).

One interviewee mentioned that the game was a reminder to intervene, while another realized that doing something is better than nothing. Others stated that the game was empowering and that the answers on the cards were a source of inspiration of what a bystander can do. These positive responses confirm that the game influences the willingness to intervene. However, most of the interviewees mentioned that they missed learning bystander skills. Quoting: *“I don't know how to translate this game to real life. Because if something happens, it's like, okay sure, this is a big situation, but then I wouldn't know what to do about it”* (female, 22 years).

Bystander Attitudes (BA). The variable “no-awareness” was significantly lower in the post-survey compared to the pre-survey survey in the experimental group with $t(32) = 4.78$ and $p < .001$. In the control group the awareness changed little between the pre-and post-survey ($t(32) = -1.18$; $p = .247$). This change was found to be insignificant supporting the findings from the EG.

Similar results were found for bystander responsibility. The difference between the pre-and post-survey in the experimental group is little albeit significant ($t(32) = -2.25$; $p = .032$). In the control group the difference between the pre-and post-survey was even smaller and insignificant ($t(32) = .482$; $p = .663$), supporting the finding that the game session had a positive effect on bystander responsibility.

Almost all interviewees indicated that their situational or problem awareness increased because of the game. One third of all the participants contributed it to the information provided in the debriefing and the discussions generated during the game. Quoting: *“The debriefing was especially informative because it covered topics that I wasn't well informed about”* (male, 28 years) and *“The game play increased my awareness the most, because discussing with peers gives more insights than just numbers”* (female, 23 years).

Table 5. Statistical Results for the Effects of Game Session on Outcome Variables.

Note. An asterisk * indicates that the p-value is $\leq .05$, meaning that it is significant; The number of asterisks indicated represents the significance level; p = p-value; t = t-value; M= mean; SD= standard deviation.

Variable	Statistical Comparison	Experimental Group	Control Group
Willingness to Intervene	Pre-Survey	$M = 71.88$; $SD = 17.88$	$M = 73.09$; $SD = 17.68$
	Post-Survey	$M = 77.11$; $SD = 20.58$	$M = 70.56$; $SD = 23.02$
	Pre-and Post	$t(32) = -2.46$; $p = .019^*$	$t(32) = .33$; $p = .742$
No Awareness	Pre-Survey	$M = 2.91$; $SD = .80$	$M = 2.86$; $SD = .80$
	Post-Survey	$M = 2.30$; $SD = .71$	$M = 3.05$; $SD = 1.03$
	Pre-and Post	$t(32) = 4.78$; $p < .001^{***}$	$t(32) = -1.18$; $p = .247$
Bystander Responsibility	Pre-Survey	$M = 3.48$; $SD = .82$	$M = 3.50$; $SD = .89$
	Post-Survey	$M = 3.67$; $SD = .77$	$M = 3.42$; $SD = .87$
	Pre-and Post	$t(32) = -2.25$; $p = .032^*$	$t(32) = .482$; $p = .633$

6 Discussion and Conclusion

6.1 Discussion

The results show that the respondents evaluated the game TALK THAT TALK and their experience positively (Section 5.1). This may be due to the extensive briefing, group discussions, and debriefing. Moreover, Section 5.2 showed that the game successfully facilitated an intergroup dialogue between female and male game participants. Participant explained that the safe space created during the game session, and the largely unbiased contents and scoring system of the game contributed to this result.

The results presented in Section 5.3 demonstrate that the persuasive game TALK THAT TALK, can promote ethical bystander behaviour and thus contribute to a safe climate free from sexual violence. The study found that after playing the game, participants showed a significant increase in willingness to intervene, awareness about sexual violence on campus, and bystander

responsibility. This is in contrast to the control group, where these variables showed a decreasing trend. These results are comparable to the findings of the role-playing adventure-based videogame SHIP HAPPENS [37], which also demonstrated a significant increase in bystander attitudes. The study confirms the effectiveness of the new developed conceptual health communication model for behavioural change. The model posits that a persuasive game can encourage systems thinking in community members about sexually transgressive behaviour in their environment by using entertainment and encouraging intergroup dialogue.

The outcomes of the qualitative analysis confirmed the quantitative results and provided some explanation of the quantitative effects. For instance, the interview results show that the participants' willingness to intervene had increased because the game had improved their bystander attitudes. The reason for this is that the in-game discussions and consecutive debriefing raised awareness about STB on campus and generated a feeling of responsibility to learn more about the problem. As a result, this led to a higher willingness of participants to intervene in future STB situations. Moreover, the game provided specific examples of how to intervene in STB situations, which also contributed to the willingness to do so.

6.2 Limitations of the study and suggestions for future work

Some design choices and unexpected circumstances limit the applicability of the outcomes of the study. For instance, the decision to recruit participants to the experiment on a voluntary basis introduced a selection bias. We believe that our participants may have been more open for learning and talking about this topic than the average student. This may have contributed to a more effective intergroup dialogue. Therefore, the effect of the game may have been less pronounced if a more inclusive sample had been attracted to play the game.

Additionally, the limited scope of TALK THAT TALK excludes other intersections of sexual violence with race, gender identity, and sexual orientation. Including other forms of intersection may increase game engagement, and result in increased understanding in how sexual violence affects different identity groups [23].

Moreover, the study did not evaluate the effect of the game on rape myth acceptance, and the behavioural change model did not integrate the effect of bystander skills. According to McMahon, et al. [16] and Bennet, et al. [18] rape myth acceptance and lack of bystander skills can hinder ethical bystander behaviour and form barriers to cultural change. Therefore, a lack of practical, hands-on activities in the game and the acceptance of rape myths may have limited its effectiveness. Many participants stated that, although the game had made them more willing to intervene in future STB situations, they did not know how to do so. It is important in future work to design additional activities for participants to learn intervention skills for future STB situations. A suitable approach may be to embed the game in a larger intervention programme that includes demonstration and hands-on practice of appropriate behaviour. Additionally, future work should include an evaluation of the game's impact on rape myth acceptance. Further evaluation can more clearly determine the effectiveness and limitations of the game and the new developed health communication model.

6.3 Conclusions

The game TALK THAT TALK addresses the issue of sexually transgressive behaviour (STB). Specifically, the game was designed to promote *ethical bystander behaviour* in STB situations among students of higher education. To evaluate the game, we conducted an experiment and measured the game effects using both quantitative and qualitative methods. To operationalise *ethical bystander behaviour*, we adapted the Health Communication Model for Behaviour Change by Kincaid *et al.* [8] and selected the constructs Willingness to Intervene (WI), Bystander attitudes (BA), and Sexual Violence Myth Acceptance (SVMA) as dependent variables in our experiment. Validated questionnaires were used to measure these variables.

The game and debriefing were designed to create a safe space for the exchange of ideas and experiential learning. Following the literature on cultural change we used the idea of *intergroup dialogue* between male and female game participants as the game's prime mechanism. Game cards were used to trigger such dialogue about situations of sexually transgressive behaviour. The quality of this dialogue and its communication processes was therefore hypothesised as a mediator variable in our experiment.

We conclude that a persuasive card game like TALK THAT TALK has the potential to create awareness about the issue of sexual violence against women. Respondents also reported a significant increase of bystander responsibility and willingness to intervene in STB situations. The use of intergroup dialogues seems a successful strategy to encourage the exchange of different perspectives between game participants. To improve the effectiveness of the game even further we suggest that institutes for higher education embed the game in a large-scale intervention programme. In such a programme the game should be followed by hands-on activities, facilitated by experienced trainers, to practice skills to intervene in situations of sexually transgressive behaviour.

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Development of Car Insurance Game

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Abstract. We receive enormous benefits from automobiles, but at the same time, we can cause accidents or be the victims. The accident risk is huge, and most people cannot afford to pay for it personally, so most drivers subscribe to car insurance, but most placeholders don't understand the rules. Car Insurance Game (CIG) is a gaming simulation in which players role their lives as drivers for ten years. It follows the grade system, a characteristic idea of the Japanese automobile insurance system. Players must decide whether to use their insurance, accept a premium increase for the following years, or compensate themselves. In two-way accidents, they also match with the other party over the responsibility ratio. Throughout these processes, participants will understand the significance of automobile insurance and will be able to act correctly in the event of an accident in the future.

Keywords: Business Game, Car Insurance, Traffic Accident, Responsibility Ratio

7 Introduction

The corresponding author had been working in an insurance company to resolve claims from accidents caused by insurance policyholders. If a driver has caused an accident without insurance, then the driver might have to pay a large amount of compensation to the victim. Therefore, the car insurance system is extremely important to maintain safe traffic.

In Japan, the government mandates automobile liability insurance to prepare for unexpected traffic accidents. However, its compensation is the least which is likely to be awarded. Therefore, most drivers subscribe to voluntary insurance. Similarly to other countries, systems exist to evaluate driver behavior to raise or discount prices on the next contract renewal. This is a great system developed by insurance companies, but it is somewhat complicated. Although the insurance vendor explains the rules well, most customers do not read the contract carefully. Drivers remember the rule only in case of an actual accident. In the case of a severe accident, no one hesitates to use insurance. However, in minor accident cases, perhaps paying compensation to the other party is cheaper than the expected premium rise in the next year. Therefore, in such cases, a driver might agonize over whether to use the insurance, or not.

To increase such skills through experiential learning, the authors developed the "Car Insurance Game (CIG)". As described in this paper, the authors introduce an outline of the game.

8 Literature Review

Insurance is a complicated system to understand for ordinary people. Sharon (2011) introduced a relatively low understanding of financial insurance using a questionnaire survey. Kim, Braun, Williams (2013) mentioned the low insurance literacy of consumers in the health insurance field and proposed starting research and teaching is needed.

Goto, Hayakawa, Hamano (2002) addressed Japanese people tend not to buy car insurance, even though they expect they might have a significant loss on the car. Sasaki (2016) found that a certain number of drivers in Japan do not subscribe to voluntary car insurance because of a lack

of understanding of the insurance system. There is a significant need to learn about the insurance system and the risks of not subscribing to insurance. In addition, he mentioned the time available for education related to insurance is limited, therefore, learning should be concentrated in a short time. From a perspective of game-based learning for insurance literacy, Imamura, Sasa (2016) developed a game to learn nursing insurance and examined the game-supported understanding about it for Japanese people.

Meanwhile, there are several games about safe driving, such as those created by Dimitriadis, Dimokas, Karveliss (2022). However, there were few games about automobile insurance and repairs, which are the events waiting for drivers after an accident.

9 Car accident resolution through the car insurance system and obligation to make decisions

9.1 General Process

Most traffic accidents in Japan are resolved using the insurance system as described below.

- (1) The policyholder contacts the insurance company by telephone. After receiving a report of the accident from the policyholder, if necessary, an agent rushes to the accident site to examine the accident, and to take photographs.
- (2) In the following cases, procedures differ.
 - (a) Accident with human injury: Contact the hospital and confirm arrangements for treatment.
 - (b) Accident with property loss: Ask the repairer about arrangements for repairing the damaged property.
 - (c) If the other party is a car and has an insurance contract, then confirm the accident circumstances with the other party's insurance company.
- (3) The insurance company manager determines the Responsibility Ratio (RR) of each party involved in the accident.
- (4) The respective insurance companies of the offender and victim mutually discuss the accident to finalize the responsibility ratio. Total payments are fixed and are notified to the policyholder.
- (5) The policyholder makes a decision.
 - (a) They use insurance. The premiums in subsequent years rise for three grades.
 - (b) They do not use insurance and make a payment personally to maintain the expected discount on premiums in the next year.
- (6) When the policyholder uses insurance, the repairer fixes the damaged property.
- (7) The insurance company completes all payments to the policyholder, victim, and repairer.

9.2 Grade System

Despite purchasing insurance to avoid obligations related to a traffic accident, why do policyholders hesitate to use the system? A "Grade System" is applied equally to all voluntary car insurance. Table 1 presents an example.

Table 1. Standard Premium Amounts and Grades Used in CIG

Grade	Premium/year
3	120,000 JPY
4	104,000 JPY
5	88,000 JPY
6 (No previous contract)	80,000 JPY
6 (Previous contract exists)	75,000 JPY
7	72,000 JPY
8	68,000 JPY
9	64,000 JPY

Table 1 presents an example of the premium price for each grade. The premium slides depend on the car type, the policyholder age, vehicle size, etc. The contract always starts from "Grade 6 without a prior contract". If there is no compensation during a year, then the premium in the subsequent year will be discounted at one grade. If there's an accident, then the price will be increased at three grades.

9.3 Comparative Negligence

Drivers sometimes become victims of accidents. The insurance company calculates compensation if both drivers have faults and the cars are damaged. We explain this point in Figure 1.

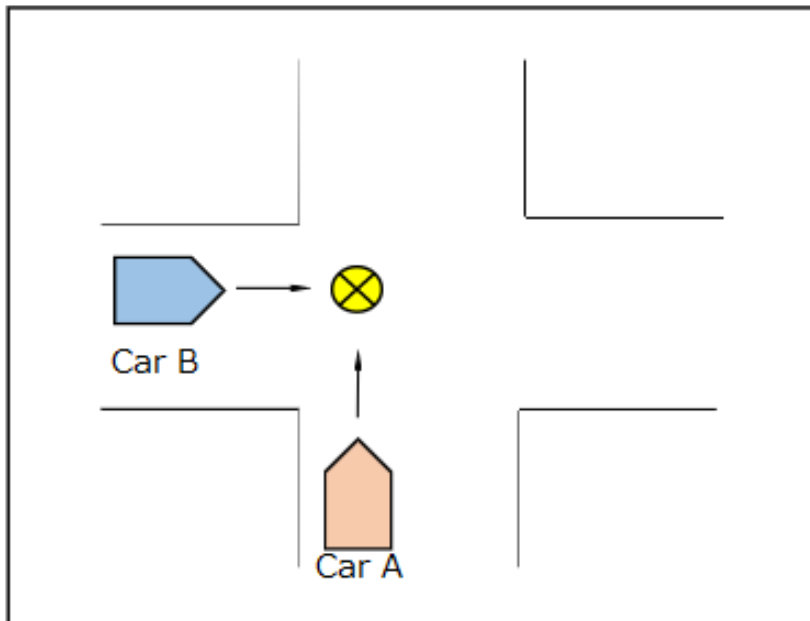


Fig. 1. Accident example at the intersection

There are no traffic lights and stopping are not required. Therefore, RR is 50% for each.

Table 2. Compensation Negligence Calculation Process

	Car A	Car B	Total
Vehicle damage	700,000(Da)	500,000(Db)	1,200,000 (Dt)
Responsibility ratio	50%(RRa)	50%(RRb)	100%
Compensation	250,000(Ca = Db x RRa)	350,000(Cb = Da x RRb)	
Receivable	100,000 (Cb - Ca)	-100,000 (Ca - Cb)	

We present aspects if the accident in Figure 1 and the relevant calculations in Table 2. Orange car (A) and Blue car (B) collide at an intersection. Both cars are physically damaged: Car A, 700,000 JPY; Car B, 500,000 JPY. In this case, the insurance companies of both parties discuss and define the responsibility ratio as 50% each. Therefore, they must compensate each other. However, before paying the others, they might offset the cost that one party has already paid.

Consequently, A can receive 100,000 from B to resolve the accident (Table 1). In this example, B has a Grade 6 contract. He asks his company for complete payment instead of three grades down in the next year's contract. Table 3 presents the reason.

Table 3. Difference of Premiums When Using Insurance or Not

	Using insurance	Not using insurance
Compensation	0	350,000
Premium in next year(Py1)	192,000	72,000
Year 2(Py2)	146,000	68,000
Year 3 (Py3)	106,000	64,000
Total payment(Tp)	444,000	554,000

B might have different options if the damage is less than that described above. In minor accident, if a person uses insurance, then the total payment for the coming three years will be higher than paying the compensation personally. Table 4 and Table 5 show typical case.

Table 4. Compensation Negligence Calculation Process for a Minor Accident

	Car A	Car B	Total
Vehicle damage	400,000(Da)	200,000(Db)	600,000 (Dt)
Responsibility ratio	50%(RRa)	50%(RRb)	100%
Compensation	100,000(Ca =Db x RRa)	200,000 (Cb=Da x RRb)	
Receivable	100,000 (Cb - Ca)	-100,000 (Ca - Cb)	

Table 5. Difference of Premiums When Using Insurance or Not for a Minor Accident

	Using insurance	Not using insurance
Compensation	0	200,000
Premium in next year(Py1)	192,000	72,000
Year 2(Py2)	146,000	68,000
Year 3 (Py3)	106,000	64,000
Total payment(Tp)	444,000	404,000

In addition, when an accident occurs with injuries, compensation for it is made prior to compensation for property. The insurance company treats property damage and human injury separately. Human injury related compensation is omitted from the table shown above.

9.4 Demand for Gaming Simulation

Most drivers recognize the risk of traffic accidents and choose to contract for voluntary insurance. The insurance reduces the compensation when the driver is involved in an actual accident. However, the insurance is unable to decrease the risk. The risk of an accident depends on behavior and luck. Everyone can become an accident offender or victim over a long term, but common people find it difficult to understand.

Gaming Simulation is a valuable method for learning complex systems in society. By applying Gaming Simulation, the policyholder can remember the correct meaning of the grade system, Comparative Negligence, and how to ascertain whether to use insurance in the case of a minor accident. That is the reason we developed the CIG.

10 Major ideas of CIG

In this section, the authors present an overview of the game.

10.1 CIG at a Glance

CIG is simulation gaming designed to help students learn the functions of the Japanese automobile insurance system throughout the gaming process. Players pitch dice to model accident risk. If an accident occurs, then the accident type is defined by the “accident card.” If the accident includes other vehicles, then one other player might become involved in the resolution process. First, they make a match by throwing dice to decide the compensation. Then, a player must make a decision about whether to use the insurance or not. By repeating the process described above for ten years, the player who pays the least expense will be the winner.

10.2 Parts

Die

Few drivers intend to cause accidents. Few people cause accidents every year. Accidents occur with a certain probability. There’s no exception. Therefore, drivers might be offenders and also victims. To demonstrate such uncertainty, the authors used six-squared die to reflect the probabilistic nature of accidents.

Accident Card

There are accidents of various types. They are impossible to forecast. The accident is modeled by the player drawing an accident card with the accident status and an amount of damage. There are 50 cards in the game, with information resembling that presented below.

- Hit by a stepping stone (victim, RR=0)
- Rear-end collision (at-fault RR=100)
- Rear-end collision (victim RR=0)
- Own Damage (to public property, at-fault party RR=100)
- Own Damage (to own property RR=100 but sometimes no need make a payment)
- Bilateral accident (RR=0 to 100, the other party’s RR= 100 to 0)

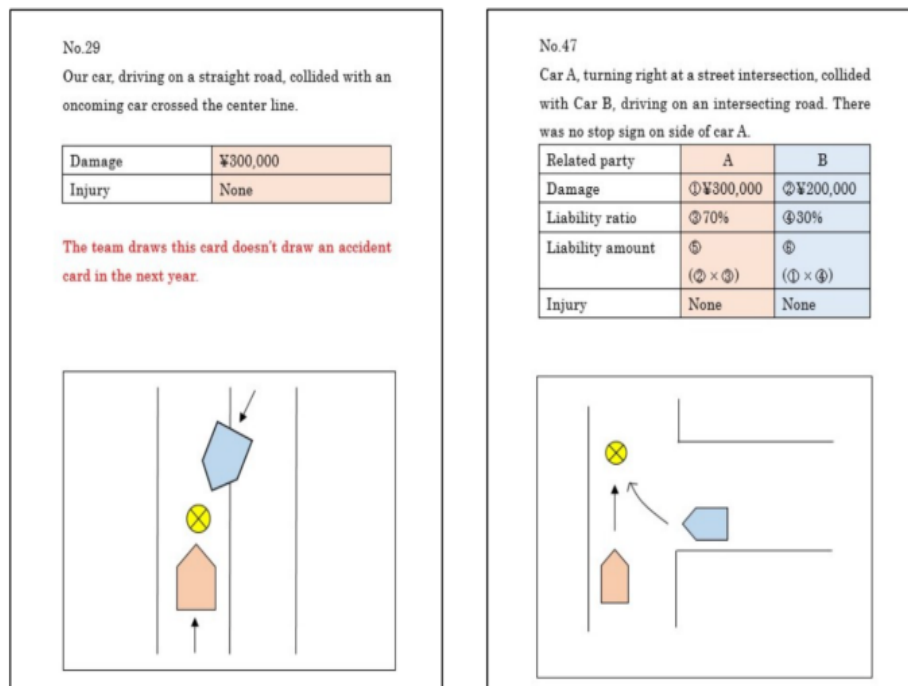


Fig. 2. Samples of accident cards

Google Spreadsheets moderated for the game

The authors designed CIG as an online facilitated simulation. The authors adopted "ZOOM" and "Google Spreadsheets." If players use papers individually, then it is difficult for the facilitator to manage if the player makes a wrong calculation. CIG's purpose is to learn the characteristics of the Japanese automobile insurance system. Calculations are necessary, but they are not a major objective.

11 How to play CIG

11.1 Preparation

The facilitator prepares the Zoom Meeting. Four to six players gather on the players' computers with dice.

11.2 Share Capital

Players receive share capital for the following decade with automobiles (5,000,000 JPY). Those obligations or expenses are recognized as negative numbers, but treating negative numbers complicates the game. Therefore, CIG provides an initial amount of money.

11.3 Buying Cars

Players can purchase cars of three types: small cars, standard cars, and electric cars. The vehicle price at the moment of the accident is an important factor in the damage calculation. The repair cost never exceeds the current value of the vehicle.

11.4 Subscription for insurance

All players can purchase insurance. If a player does not purchase insurance, then they need not pay any premium during the game. However, the player must repair and compensate for all damage occurring in the event of an accident. At the initial stage, all players are ranked as Grade 6 (without a prior contract). They can attach a vehicle warranty option. In this case, the premium will be approximately 40% up.

11.5 Playing Process in the Year

CIG covers up to ten years of simulation.

First step (Accident Determination)

- 1) Confirm the current cash, vehicle, and insurance status and report to the facilitator. The player records all number-related actions on Google Spreadsheets.
- 2) Throw a Die.
Rolling a 1: The player had an accident (-> 6.)
Rolling 2–6: The player did not have an accident (-> 3), but there is a possibility to be involved in bilateral accident later.

Second Step (Accident Resolution)

- 3) The facilitator draws an "Accident Card" on behalf of the player who caused the incident and shows it to the camera lens.
- 4) Depending on the accident status, the insurance company estimates the card descriptions. They are added automatically to the player's sheet when the player records the accident ID.
- 5) In the case of a single-car incident, the player rolls the die. Depends on the situation, compensation might not be covered 100% by insurance. For example, when the player was strongly at fault, the insurance company might decrease the payment made under

the vehicle warrantee. To model that mode of payment determination, we use die rolling. The Player throw a die and follows a result shown in Table 6.

Rolling a 1: 20% of all damage is not acknowledged as damage eligible for compensation.

Rolling a 2–6: No damage is acknowledged as damage eligible for compensation.

Table 6. Correspondence Table of Spot and Appraisal Results

Dice spot	1	2	3	4	5	6
Result	20% of all damages are not allowed as damages.	All damages are allowable as damages.	All damages are allowable as damages.	All damages are allowable as damages.	All damages are allowable as damages.	All damages are allowable as damages.

Bilateral Accident Resolution

It is in the nature of traffic accidents that the driver might be an offender or a victim. CIG is intended to help participants to learn how to act, negotiate, and make a decision. Therefore, the game has a rule about involving the player randomly in an accident caused by other players. In reality, there are many cases in which people involved in accidents are not satisfied with the percentage of fault. To express such negotiations, CIG adopts the process described below.

- I. The basic percentage of fault refers to the amount stated in “The Case Book,” which derives from cases that have been heard in the courts.
- II. The insurance companies notify both the offender and the victim.
- III. If either of the parties has an objection or demand for decreasing RR, then they roll a die.
 - (a) When only one party is not satisfied, the person rolls a die. If a “6” appears, then the player can adjust the player’s own RR downward by 10%. The rule means that the other party adjusts RR upward by 10%.
 - (b) If both players are not satisfied, then players roll a die once. Then, depending on the result, RR is adjusted, as shown in Table 7.

Table 7. How to Modify the RRs in a Bilateral Accident

	1	2	3	4	5	6
1	All	+10%			+10%	+20%
2	-10%	All			+20%	+10%
3			All	+20%		
4			-20%	All		
5	-10%	-20%			All	-10%
6	-20%	-10%			-10%	All

The numbers represent the die roll result: The left column is that of the offender. The top row is that of the victim. The modified percentages in Table 8 are from the offender's perspective, who drew the card; the opponents' percentages are reversed. "All" means that one must pay for all repairs. The player must repair all the damage personally, irrespective of the base percentage. In this case, holding a vehicle warranty will be extremely important.

Final Calculation Step

- 6) The player records all information using Google Spreadsheets. Most related parameters are calculated automatically.
- 7) Contracts are renewed every year-end. The price is determined on a sliding scale: three grades down if the player used insurance, or one grade up if the player does not.
- 8) The player pays a maintenance fee for the player's vehicle (10% of the new car).
- 9) The player can change the car. For example, if the next premium becomes expensive, then the player can use a smaller vehicle to save money.
- 10) Go back to (1).

12 Game Practice in ISGC2022 and Findings for a Future

The authors chose CIG for application at the ISAGA Simulation and Gaming Competition (ISGC2022). From August 22–25, 2022, all authors gathered at Asahikawa National Institute of Technology, Asahikawa College. The author specifically examined test play and finalized the game parameters and sheet settings. During the period, three students with game development experience and attendance at ISAGA Summer School 2021 joined CIG via ZOOM and provided the authors much advice and requests for amendments.

In the competition, we entered as a Japanese team and competed against two groups, including students of Thammasat University and Chulalongkorn University, Thailand. ISGC provided two hours for each team to explain, facilitate, and debrief the game to the same reviewers.

On September 3, ISGC2022 was held on ZOOM. Although some difficulties were apparent when communicating in English, and although the network connection was sometimes interrupted because of the communication environment, we were able to conduct a two-hour presentation by mutually compensating for those difficulties.

However, the insurance systems in Japan and Thailand differ. It was not easy to understand the difference for Thai reviewers because Thailand has no an obvious grading system for automobile insurance.

Another crucially important point they described is that CIG does not mention criminal liability. In actual accident cases, if the driver or passenger of the victim had been driving under the influence of alcohol, then the driver or passenger would be punished. The police handle these penalties while the handling of accidents and insurance procedures are ongoing. However, the reviewers needed to understand the distinction. They misunderstood that a driver would be free from any punishment if the driver had purchased an insurance contract.

As a result, the overall quality was appreciated by the judges. The CIG team received an "Award for Simulation Special Works". Although the production period was not long, it was an excellent experience for the authors to have their results of collaborative work on a game recognized worldwide.

13 Conclusion

The authors did not develop CIG only for ISGC2022. To retain the game as a valuable invention in the future, we would like to make proposals for its implementation at car dealerships, at non-life insurance companies, and by other people where it could be effective. Furthermore, when an opportunity arises, we would like to use the game at educational institutions such as universities and technical colleges, including the use of pre-questionnaires and post-questionnaires, to verify changes in each player's awareness of car insurance and CIG's learning effectiveness.

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Technology Transfer SIG
Board Game in Region SIG

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M&A gamification scheme for acknowledging value of digital operation know-how as human capital intangibles

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Abstract. The digital revolution has created many intangible assets that are difficult to value. Human capital includes the skills, knowledge and experience that employees possess. However, the attribution of human capital to employees is ambiguous, leading to accounting distortions. This paper makes people aware of intangible human capital such as digital know-how, and proposes an M&A gamification tool as a stand-alone human capital valuation method. It is a quasi-negotiation of a business debate in which the sell-side and the buy-side each present a "strategic FCF" that is advantageous to their own side, claiming and disproving it. You can learn how to change to a negotiation axis that is advantageous to your own team. Stage 1 uses a business plan simulator to develop negotiation strategies, and Stage 2 plays an M&A negotiation game. More than 50 negotiation cards will help you spark a bargaining idea. We aim to improve M&A negotiating power by repeating pseudo-M&A negotiations. Finally, use the scorecard to analyze your negotiation skills. You can clarify the strengths and weaknesses of your bargaining power and improve it. In addition, it is possible to calculate the single value of specific human capital using the green field method, and it is possible to propose a method for evaluating digital intangibles in the Web 3.0 era. In this research, we applied a gamification approach that provides "learning that never gets boring," "enjoyable learning," "exciting learning," and "acquisition of living knowledge," even for difficult themes.

Keywords: Human capital, Digital Intangibles, Valuation, M&A Gamification

1 Introduction:

In recent years, the issue of human capital has become increasingly important in accounting. Human capital refers to the skills, knowledge, and experience possessed by employees, which are critical to the success of a company. However, the attribution of human capital to individual employees is often ambiguous, leading to accounting distortions. In this paper, we focus on the impact of this ambiguity on the fairness valuation of companies and propose a novel approach for M&A in the Web 3.0 era.

The fairness valuation of human capital relevant to employees' digital know-how has become a critical element of modern accounting. However, the lack of clear guidelines for measuring the value of human capital has led to ambiguity and inconsistency in the accounting treatment of this important asset, and it has placed the fairness valuation of companies in a game-like situation. Companies are forced to negotiate with auditors and other stakeholders over the value of their human capital, often resulting in distorted accounting figures. This situation is particularly challenging in the context of M&A, where the fair value of a company's assets is a critical element of the negotiation process.

To address this issue, we design a negotiation game that incorporates the value method of digital intangible assets. This game enables companies to negotiate with potential acquirers in a transparent and standardized manner, using a common set of metrics for measuring the value of their human capital. By incorporating the value method of digital intangibles, we aim to provide a more accurate and consistent measurement of the value of human capital, thereby reducing accounting distortions.

We believe that this approach will provide a more accurate and consistent measurement of the value of human capital, thereby reducing accounting distortions and improving the transparency of M&A transactions.

2 Background

Digital intangibles and human capital. The digital revolution has introduced numerous intangible assets that are complex to value accurately. NFTs by blockchain, and financial functions, such as settlement creditworthiness by virtual currency, is challenging to realize, even though they are exploring the fairness valuation method. On the other hand, the digital intangibles which are relevant to human capital e.g. operational know-how are difficult to quantify in financial terms. Such inability to keep up with the changes in accounting regulations has led to BEPS (base erosion and profit shifting) from an international perspective and the accounting distortions from a corporate perspective[1]. The primary reason is the absence of social consensus on recording invisible digital intangibles as the human capital and amortizing them. On the other hand, BEPS results from companies shifting their profits to low-tax jurisdictions, causing revenue losses for high-tax countries[2].

Need for a Suitable Valuation Method. The traditional valuation methods, such as the Discounted Cash Flow (DCF) method, are no longer sufficient for valuing digitally advanced companies. There is a need for a suitable valuation method for the era of the digital revolution[3]. The new method should be able to capture the value of operational know-how, digital assets ownership, and financial functions. Moreover, the method should be flexible enough to accommodate the dynamic changes in digital assets[4].

What is Accounting Distortion? Accounting distortions refer to information reported in financial statements that differs from actual business reality. This distortion arises from the nature of accrual accounting. Sources of distortion include accounting standards, estimation errors, and conservatism. Distortions from accounting standards include political processes, specific accounting principles, double-entry bookkeeping, and conservatism. Sources of estimation error distortion include forecasting future cash flows and other estimates. Conservatism tends to bring a pessimistic bias to financial statements[5].

What is relationship between accounting distortion and digital intangibles? The current accounting standards treat tangible and intangible investments differently, which can lead to distortions in financial metrics and misrepresentations of a company's value. Digital companies are not allowed to capitalize their intangible investments, leading to the exclusion of their value from financial reports. Research has shown a difference in value relevance between tangible and intangible investments[6].

Valuation of intangible assets. Intangible assets such as patents and software are increasingly important in corporate value, which poses challenges to accounting rules and disclosure practices. The Accounting Value of Intangible Assets and the greenfield method of Intangible Assets Valuation by IVS 210 can be used to value intangible assets. Common techniques for valuing intangible assets include the excess earnings approach and the purchase price allocation method. However, these techniques may not be sufficient for valuing digital intangibles, which require new methods such as multifaceted digital platforms and value co-creation patterns. This paper explores various methods proposed for valuing digital intangibles, which are essential for accurately assessing the value of a digital enterprise.

Why is the debate of Digital Intangibles required? The relevance and reliability of intangible assets in accounting and financial reports have been questioned due to their exclusion from the balance sheet. The literature on the consequences of lack of accounting recognition of intangibles for their value relevance has been critically reviewed. However, the relationship between the accounting choices of intangibles and their value relevance, and the mitigating effects of the firm's life cycle, should be considered[7]. More empirical evidence is needed to understand the effect of accounting choice for intangibles on value relevance, given the

differences in firms' economic attributes and life cycle stages. Current accounting practice treats many investments in intangible assets as expenses, which can confuse earnings from current revenues. Historical episodes have provided solutions for intangible asset accounting that contrast with current practice under IFRS. It is crucial to acknowledge that accounting produces both an income statement and a balance sheet. The distinction between tangible and intangible assets in accounting practice is conceptually misguided and creates challenges for accounting intangibles. Therefore, debates remain on how to present digital intangibles valuation in accounting. Value relevance depends on how well accounting captures firms' digital intangibles and how they are valued, as well as the trustworthiness of the assessed value[8].

Digital Operation value as human capital. In order to capitalize on advanced digital operations as a source of revenue, we focus on the progress of DevOps as a quantitative index (KPI) for the human capitalization of digital human resources. DevOps includes various operational methodologies and represents a new structuring method that makes digital operation know-how in-house as a new revenue source, as the concept of CI/CD spreads [9]. However, the trend of SaaS cannot be effectively handled with conventional accounting rules. The quantitative value of an employee's personal knowledge, experience, originality, and know-how is the element of personal disclosure, and this paper aims to present the rationale for capitalizing on these assets in the balance sheet. With the digital revolution creating diverse intangible assets that are difficult to value, there is a need to move beyond traditional valuation methods such as the DCF method and develop a new framework suitable for the era of digital transformation. The lack of social consensus on how to record and depreciate these intangible assets has led to accounting distortions, which has resulted in BEPS from an international perspective and accounting distortions from a corporate perspective. This paper calls for further research to address these challenges and provide a more comprehensive framework for valuing digital intangible assets[10].

3 Gamification Methodology

3.1 Purpose

M&A negotiation game is a practical teaching material that provides a simulated M&A negotiation experience using a gamification approach. It will focus on how you can create rules that are advantageous from various M&A relevant legal materials e.g. accounting, taxation relevant to corporate law, antitrust law, transfer pricing and digital intangibles. Clear rules for M&A negotiations have not been finalized. Therefore, if you understand the accounting distortions and become a game changer yourself, you will have an advantage in negotiations[11].

Accounting distortions are deviations from reality in the information reported in financial statements. We will focus on the game-changing negotiating perspective brought about by accounting distortions. First, accounting standards influence the political process in management decision-making. Various decision makers conduct M&A negotiations on the premise of protecting their own interests. Second, a game situation arises from the interpretation of the materiality of a particular accounting principle. For example, the historical cost principle does not reflect the current market value of assets and liabilities, which can reduce the relevance of the balance sheet. Third is conservatism in the intangible asset valuation. Going-concern conservatism creates a pessimistic bias in financial statements.

Such skills will be accumulated as an "original negotiation card" named by yourself in this gamification process. This is a pseudo-negotiation training where you lead the deal as a deal maker and acquire the skills to make rules where there are none. This program targets corporate executives, M&A practitioners, M&A advisors for investment banks, securities companies, and consulting firms. Through this pseudo-M&A negotiation experience, you can cultivate actual game-changer negotiator's M&A skills. By extracting the difference between EBITDA and FCF, it is possible to extract the standalone value of the target intangible asset. The purpose is to make

people recognize the accounting property of intangible assets, and to learn the rational method of calculating the standalone value.

3.2 Process of the M&A negotiation game

The M&A negotiation game is a game that simulates M&A negotiations by dividing into two teams, sell-side and buy-side. Based on the negotiation strategy created in Stage1, we will play the M&A negotiation game in Stage2. The sell side goes first and presents the negotiation card and presents the price. The buy side goes second and presents the negotiation card and price. A negotiation card may include terms other than price, such as payment terms and warranty terms. There is no limit to the number of negotiation cards that can be presented at once, but there is limit to the number of modulation cards and session break cards. Modulation cards can change the negotiation axis to your advantage. Session break cards can be used to suspend or resume negotiations. Final negotiations will take place after a total of two rounds have been completed. At this time, the buy-side makes the final price offer. After final negotiations, the sell-side will decide on a price or deal break. Below are the details of the two stages.

Stage 1, Negotiation strategy planning by business plan simulator

Stage 1 presents case studies and business plans. Based on this, they are divided into a sell-side team and a buy-side team, and work out negotiation strategies by manipulating simulator. Hold a negotiation strategy meeting, formulate a fair price range from the business plan from the standpoint of your own team and the other team, and build a strategy for the negotiation issues with "5 negotiation axes" and "negotiation cards". At the end of meeting, determine a football chart showing your fair value range.

By manipulating the business plan simulator, you can try various of profit structure data and the cost structure data. It can simulate the marginal profit ratio from the procurement cost (variable & fixed). By changing sales costs (variable & direct) such as facility maintenance and advertising, it can simulate the SG&A structure. In addition, it can simulate incidental operator costs such as the cost of securing personnel necessary for operation. Finally, you can simulate the working capital position with CCC (cash conversion cycle) and FCF to determine the cost structure and profit structure of the business plan. The simulator will also complete the foot-ball chart and you will start initial price negotiations.

A "football chart" is a chart that visually expresses various valuation methods. The chart is an effective tool for achieving "fair price range visibility" and plays a key role in valuation conflicts. A good football chart is one where the DCF method, the multiples method, and the net worth method have overlapping ranges, showing a clear fairness price range for everyone. This allows us to clearly express our own claims and derive valuation results based on objective evaluations. Simplified valuation excel simulator is used to calculate the value of M&A targets. This tool provides simple simulations to calculate enterprise value based on financial metrics such as sales, operating profit and EBITDA. The football chart is then used to organize the requirements and terms of both sides in the negotiation. By arranging requirements on the horizontal axis and conditions on the vertical axis and setting priorities for each item, this tool can visualize which requirements and conditions are the most important. With this method, you can accurately grasp the profit structure in your business plan and build a favorable negotiation strategy. As a result, we believe that more appropriate valuations can be made in M&A negotiations.

Cost structure simulation

Focusing on the cost structure of the business plan presented by the sell side, the items belonging to the sales plan, manufacturing plan, fixed cost plan, and working capital plan are set as variables. The buy-side team simulates risk cases and the sell-side team simulates stretch cases.

Profit structure simulation

Focusing on the profit structure of the business plan presented by the sell side, the items belonging to investment plan (e.g. Building, land) and Financing plan (e.g. borrowed money) are set as variables.

Challenge Human capital listing as CAPEX and OPEX

Historically, the cost of hiring and retaining a workforce with advanced digital operations skills has been classified as OPEX and incurred in the normal course of business operations. This means that human capital was only shown as an expense on the income statement and had a negative impact on profitability and FCF.

However, if human capital is recorded as an asset on the balance sheet, it will impact a company's CAPEX. This could have a negative effect on the company's financial ratios as it would increase the company's total assets. However, if the CAPEX impact is offset by its amortization over time, it could increase FCF. Nevertheless, investing in human capital can create a revenue source in the form of digital intangible assets such as employee know-how and skills.

As shown in Fig.1, in the simulation of the fair price range, this gamification tool aims at recognizing human capital as an asset with an evolving concept and may change how companies view their workforce. By investing in employees and recognizing their value as important assets, companies can build a skilled and innovative workforce that promotes long-term growth and sustainability. However, the impact of recording human capital on the balance sheet as CAPEX and financial ratios will vary depending on the specific circumstances of the company and how they account for human capital.

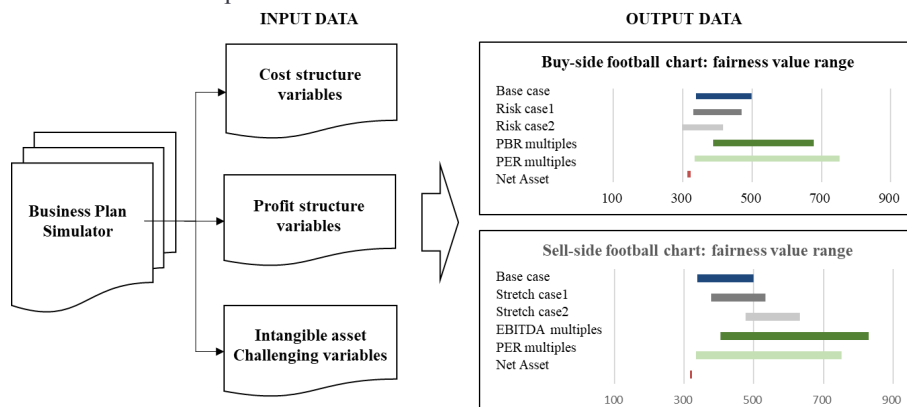


Fig. 3. Stage1 proceed using input data by simulator into football chart as output data

Stage 2, M&A negotiation game

The football chart determined in stage1 is essential to ensure the success of the actual negotiation in stage2. We use the negotiation board which represents five negotiation axes as shown in Fig.2.

Negotiation axis1 is "Determination of acquisition target" that clarifies the investment plan target. Negotiation axis2 discusses "Determination of valuation method" such as Discounted Cash Flow method, Multiple comparison with competitors, and net asset value. Negotiation axis3 is "Reality of earning power" that focuses on the appropriateness and risk assessment of the items that make up the profit structure. For example, price cuts and rebates, taxable provision risk, point provision will be the focused. Negotiation axis4 is "Reality of Assets" that focuses on the income generating capacity of the investment project and its risks. For example, depreciation risk for depreciable assets and impairment risk for non-depreciable assets. If it is difficult to determine where to negotiate, it will be the FCF adjustment item in Negotiation axis5 of "Actuality of FCF."



Fig. 2. M&A negotiation board presents five negotiation axes

As well, we use the negotiation cards which include buy-side card, sell-side card, blank card with naming rights, modulation card, session break card as shown in Fig.3.



Fig. 3. M&A negotiation card

Conduct pseudo-M&A negotiations divided into sell-side and buy-side teams in stage2. The rule is that the sell-side team goes first and presents the negotiation card and price as shown in Fig.4.

Image of negotiation screen: Sell-side first round

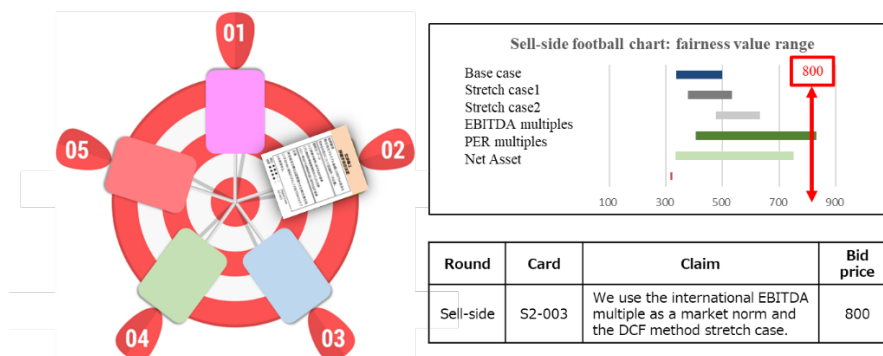


Fig. 4. Sell-side first round image

Then, the buy-side team goes second and presents the negotiation card and price as shown in Fig.5.

Image of negotiation screen: Buy-side first round

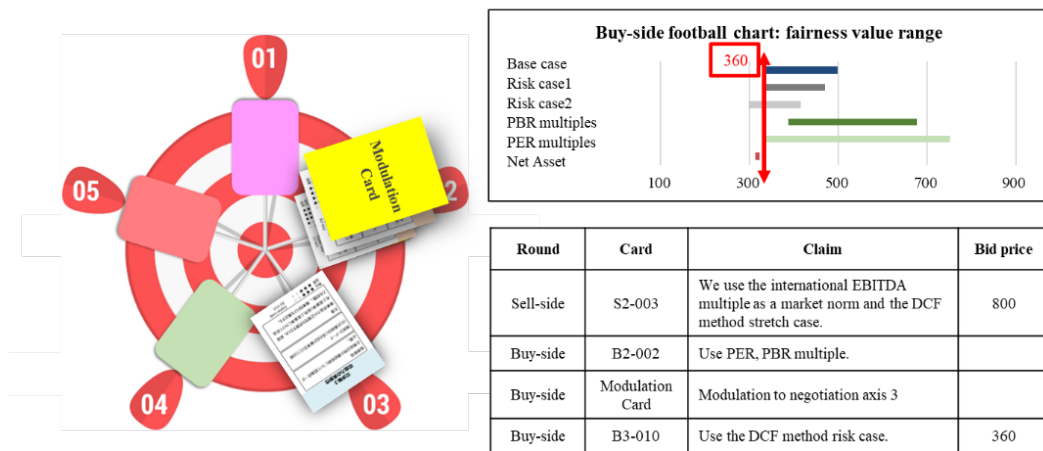


Fig. 5. Buy-side first round image

How to create the original cards utilizing ChatGPT?

Buy-side and sell-side negotiators implement negotiating strategies in their favor. 50 negotiation cards are preset for each. Furthermore, it is characterized by being able to create original cards flexibly. The original card can drop the negotiation strategy from macro to micro utilizing ChatGPT with the following prompts.

#Prompt for obtaining big picture of negotiation strategy##

1. Negotiation axis: M&A negotiation game has 5 negotiation axes. The negotiation axis1 focuses on identifying the target entity that best aligns with the acquiring company's strategic goals. The negotiation axis2 pertains to the selection of an appropriate valuation method using DCF, multiples or NAV. The negotiation axis3 examines the reality of the target entity profitability. The negotiation axis4 addresses the reality of the target company's assets, including tangible and intangible assets. The negotiation axis5 explores the reality of FCF, which is a critical measure of an ability to generate cash and its future growth prospects.
2. Role: I want to buy a target company as cheaply as possible within the fair price
3. Point out: I find the target company has a liability with a change-of-control clause.
4. Claim and Evidence: Show the negotiation issues for each negotiation axis with the evidence source, and construct a series of negotiation strategies that connect issues of each negotiation axis.

#Prompt for obtaining pin-pointed of negotiation strategy##

1. Role: I want to buy the target company as cheaply as possible within the fair price
2. Point out: I find the target company has a liability with a change-of-control clause.
3. Claim and Evidence: Show the contract clauses necessary to completely eliminate the liability risk of the subsidiary of the target company before the acquisition, and the underlying laws and regulations.

Summary of negotiation games: Evaluation of negotiator's ability

After a total of 2 rounds, final negotiations will be held and the buy-side team presents the final price. The sell-side team then declares to accept the offer or deal break. Team-based competitions provide a simulated M&A experience that requires mastery of football charts and problem-

solving skills of rational compromise. The purpose of this gamification approach is to explore the valuation method of digital intangibles and to increase the number of ideas that can be drawn out and to pursue advantageous to one's own team. Furthermore, it is designed as a negotiation tool to pursue maximization of corporate value through the materialization of human capital such as digital intangible assets.

Each of these negotiation axes requires careful consideration and analysis to ensure a successful M&A transaction. By addressing these negotiation axes, the acquiring company can better assess the target company's value and identify potential risks and opportunities. M&A negotiation game provides these negotiation axes and cards in order to maximize the value of the M&A transaction.

Finally, the scorecard is used to analyze your negotiation skills. Negotiation Dynamics is used to analyze your negotiation style, typifying your ability to find negotiating issues and thoughtfulness to Negotiating Agreements. The ability to find negotiating issues is measured on (1) Potential risk, (2) Rationality of valuation methods, (3) Defects in profit sources and cost structure, (4) Asset defect, (5) Business plan defect. Also, thoughtfulness to Negotiating Agreements is measured on (1) Cautious risk elimination type, (2) Moderate risk elimination type, (3) Defect warranty focused type, (4) Risk-taking new theory challenge type, (5) Game changer type.

By quantifying these negotiating abilities, we clarify what strengths and weaknesses there are in negotiations, and provide feedback on what kind of negotiation style it is. M&A negotiation game data performed in accordance with such a process is saved, and individual negotiation ability evaluation is performed. Give feedback on negotiating ability shared by the buy-side and sell-side based on the tendency of each case study, the ability to discover negotiating points, and the ability to think about negotiating agreements. Based on the distribution of cards in the five negotiation axes, the strengths and weaknesses are presented in comparison with the overall average value as shown in Fig.6.

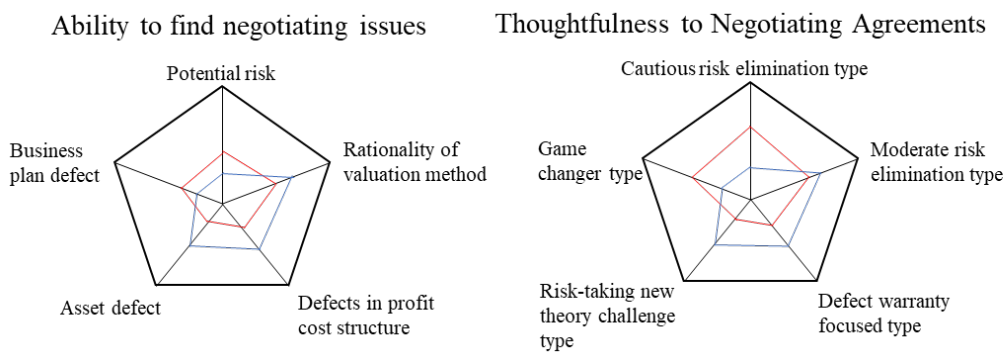


Fig. 6. Feedback score card by quantifying various negotiating abilities

4 Consideration

We consider the feature of the M&A negotiation game. Can it make people recognize the accounting property of intangible human capital, and can it work for a method of calculating their single value?

With the advancement of digital technology, many assets owned by companies have been converted into digital intangible assets, but the number of intangible fixed assets recognized in accounting is limited, and human capital is not recognized. This is one of the causes of accounting distortion. In the M&A negotiation game, you will learn about the mechanism by which accounting distortions caused by digital intangible assets affect valuations. Consider the

impact on sell-side and buy-side game situations or valuations by including non-financially recognized intangibles in the negotiation card.

Focusing on the sell-side and buy-side game situation, for example, in calculating FCF, is it customary to only focus on fixed asset depreciation? There are other items that require time smoothing, so the buy side has room to claim the risk of provisions, write-downs, loss carryforwards and deferred tax assets. The sell-side, on the other hand, must deny those risks. Similarly, why is only capital expenditure customarily counted as tangible assets? There are many other capital expenditures, so the buy side has room to claim non-capex items of CAPEX. On the other hand, the sell side needs to deny CAPEX items other than capital expenditures and claim them as OPEX items. In addition, the amortization expense of intangible assets is largely unrecognized. However, the M&A negotiating game insists on the capitality of human capital and digital intangible assets. In response to this problem, the buy side will compare Japanese accounting standards and international accounting standards, claim impairment risk, and argue that even if it is capitalized, it will be discounted. On the other hand, it is reasonable for the sell-side to deny amortization of human capital based on the continuity of audited financial statements. Finally, why are differences in effective tax rates across countries not taken into account? EBITDA, which is a pseudo FCF, is valid for resolution. On this issue, the buy-side must deny EBITDA because EBITDA includes taxes and utilities, and the sell-side must claim EBITDA as pseudo-FCF[12].

In addition, by taking the difference between EBITDA when human capital and digital intangible assets are included and when they are not included, intangible assets here are employee know-how and digital skills that have not been recognized as assets until now. It is possible to calculate a single value such as, and it may be possible to record human capital in BS. At this time, the green field method is used for the valuation of intangible assets[13]. It is a method to quantify the unit value of intangible assets from the difference between "before and after the existence of intangible assets". written as a formula,

Future value of EBITDA including intangible assets - Future value of EBITDA not including intangible assets = Value of specified intangible assets

Comparing the difference between business plans with and without digital intangibles can be very useful in calculating the stand-alone value of specific digital intangibles, human capital, organizational operational functions, etc. Intangible assets not only diversify the valuation negotiation card, but also enable quantitative valuation.

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Interaction for Participation – The hybrid threshold experience as a participatory transformation process in the citizen participation game

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Abstract.. The idea of translating citizen participation processes into hybrid games is ubiquitous. This decision is usually justified by the possibility of simplifying complex issues and using real data. However, hybridization as a combination digital and physical space offers another advantage that has not been highlighted so far: By creating a digital threshold, it enables a highly accessible transformation from participants to players. In citizen participation processes, a wide range of social groups encounter, thus the reduction of (social and gaming) inhibition is even more important for broad participation. While these benefits of the digital space are of great relevance, especially for the start of a game, the physical space creates an equally large opportunity of transparency and direct exchange. Particularly in mobility transformation, there is a need to sensitize citizens for the topic and make sure that they are engaged to get honest and thoughtful responses, so creating transparency is especially important. Based on the development of the citizen participation game *UTurn*, the authors took a closer look at the problem of participation as well as its solution by establishing a threshold. The following article therefore aims to shed light on this very establishment of a threshold experience in hybrid citizen participation processes and to debate its potentials and hurdles.

Keywords: Board Game, Policy Game, Citizen Participation, UTurn

1 Introduction

To ensure the possibility of co-determination for different social groups, more and more citizen participation processes have already been translated into the game format. While an important synergy is exploited with the approach of linking self-efficacy and fun for the players as well as didactic mediation and data generation for the topics, the success of this principle continues to depend significantly on the participation of the players. Particularly important is the moment of entering the game, in which the social situation of the participation process changes into a game situation - the participants are transformed into players. Due to the required breadth of data, the playgroups are very diversely composed. The confluence of these diverse life situations and perceptions can make it difficult for everyone to get started participating. In the creation of the game *UTurn*, the authors encountered a similar problem. The game from the beginning on was planned as a hybrid game. Hybrid in this sense means a combination of digital and physical [1] components that are interdependent. The digital elements, implemented as an app, are integrated into the game instead of merely augmenting or adapting it. [2] This concept has already been used for several years in the area of board games (so-called hybrid digital board games [3]) as well as in simulation games. The most frequent arguments for hybridization are the combination of digital and physical components as well as use real data [4].

The game *UTurn* uses these approaches as well: The goal of *UTurn* is for a group of residents to reduce their CO₂ emissions for their personal, daily mobility behavior by 10% within 2 game rounds. The core of the game is an app that facilitates the participants' personal calculations and finally adds up the figures of all group members per round. At the end of the second round, it compares the numbers from both rounds and immediately indicates whether the game goal has

been reached. Since the game is largely concerned with the *willingness* of citizens to use environmentally friendly means of transport, active and honest participation is central to the data evaluation. To reduce the hurdle to participation, the idea of hybridizing the simulation game is therefore to be taken further by using its digital threshold to simplify entering the game without losing complexity and transparency for the players.

2 Participative simulation games as borderline experiences

The use of simulation games as a citizen participation procedure differs fundamentally from the systematics of modern parlor games and their game formats. Even if there are analogies in the materiality of the games as well as the game forms used, the public participation procedure is nevertheless a very specific experience, significantly differentiated from the situation of the entertainment game: In anthropological game theory, modern parlor games are described as "delimited, inconsequential and repeatable". [5] While the demarcation from the real world is explicitly intended in this form of escapism, it is almost unavoidable to use real-world themes and artifacts in the citizen participation game. Based on its performance character and its specific experiential nature, simulation games require that certain information are withheld from the players up to a certain point in the game. Thus, it is not likely that games are played repeatedly by the same players. In addition, it is rather improbable (and a hindrance for data collection) to have the same person participate twice in the process. Most simulation games follow a didactic approach parallel to their data collection, which is why they should leave some kind of consequence for the players. Concurrently, the players gain self-efficacy from the game, which can be named as one of the main motivations to play games.

In addition to the more theoretical dimensions, the game situations differ greatly from each other. The players of a parlor game either play together with known people in a private setting or in a context that has been clearly established around the game (e.g. board game cafes). The players have "gaming capital" [6], as well as the "lusory attitude" [7], which maintenance is additionally supported by the external circumstances. In the context of a citizen participation process, participants of different social groups act together in public space with people unknown to them. Often, neither the space itself is tuned to the mode of play, nor do the participants possess a broad gaming capital that can be drawn upon. The attunement to the game as a ritual form [8] postulated in anthropological game theory – taking the game box out of the shelf, opening and setting it up together, reading the rules and negotiating who starts – is (almost) completely absent in this setting. Accordingly, the participants are mostly thrown directly into a situation that does not coincide with their expectations of a 'game' or a game situation. If a public participation process is advertised with the term "game", most participants are likely to trigger associations that relate primarily to modern parlor games such as Monopoly or Uno. [9] This is not only due to the term itself, but also to the identification of established 'play-forms'. [10] Game materials such as dice or playing cards entail so-called 'affordances' as intuitively recognizable game objects. Affordance describes the propositional character of an object, which is inscribed in its materiality through repeated experiences and evokes implicit knowledge about its use. [11] In this sense, dice, due to their shape and design, have the affordance to be thrown to randomly generate numerical values, that are somehow implemented in the game. [12] In game practice, different play-forms merge, and form complex 'game-formats'. [13] Accordingly, individual play-forms are already associated with the expectations of game-formats (esp. classic parlor game materials) in which they repeatedly appear.

As soon as the participants of a citizen participation game are expected to enter the game, they often experience a discrepancy between their expectations based on these game-formats and the materials they are confronted with. In *UTurn*, the basis of the game is a map of the specific district in which the game is played. Extended by markers, which represent landmarks of that district, the map is not connected to any play-forms whatsoever and thus contradicts the expectation of the participants, who might have awaited cards, dice and meeples.

The entry-phase is particularly important in the time-critical environment of the public participation process since the associated establishment of a game agency is fundamental for productive participation and thus secure data collection. To absorb this discrepancy directly at the beginning of the game, citizen participation games are often connected to a game leader – however, experience has shown that the gap between expectation and reality as well as the uncertainty caused by the unknown game situation is too large for the players to immediately participate in the social situation of the game even while being instructed.

This hurdle makes the entry into the Magic Circle more difficult – some participants can only cross the barrier after a certain period, while others cannot or do not want to cross it at all. An efficient first step to help the participants overcome this hurdle is by actively using play-forms such as cards or dice in the game. This step brings two benefits: First, the participants recognize something familiar and might feel safer about the situation. Second, by using the implicit knowledge associated with the play-forms for the game, the rules can be kept uncomplicated which results in the game being more inclusive overall. Using the example of *UTurn*, this is archived by using specifically designed playing cards that mime the aesthetic and simple logic of “Quartet”. This step considerably lowers the hurdle in terms of uncertainty towards the game itself. However, to lower the insecurities towards the game situation and the other players, a threshold is necessary, which can be achieved with the help of the digital component of the game in cooperation with these very play-forms.

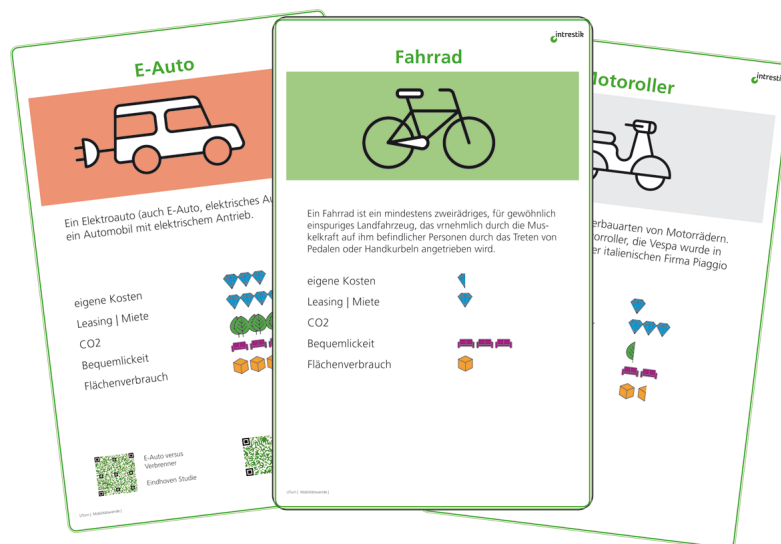


Fig 1: Three examples of the UTurn Quartet Cards

3 Using the digital threshold as a mediator

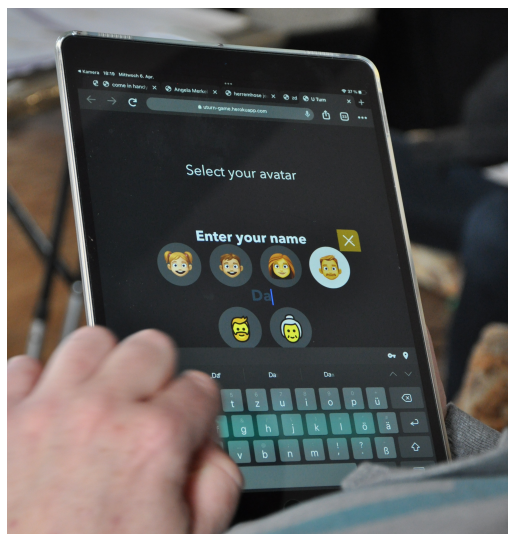
According to the previous thoughts, the aim is to create a zone connected to the play-forms that bridges the game entry and thus links the entry situation and the game, without hindering the course of the game and its data collection.

The threshold represents just such a zone. Based on Saeverin [14], it is a transition that contains the outside as well as and the inside and represents a transit space, i.e. through a "tension immanent to the transition" [15] that urges to cross it. "Only the transgression of the threshold opens access to a new space; at the same time, in the act of transgression, a transformation of the transgressors takes place." [16] The rituals underlying the parlor game can be grasped as such a threshold experience: Actions such as the set up create zones that contain the outside (the social situation) and the inside (the game) in equal measure, creating a *transition* from the real-world situation to the game situation. In doing so, they transform not only the table into a playing field,

but also the people into players. As already discussed in the previous chapter, it is not possible to use rituals analogous to the parlor game in a citizen participation. However, thinking about the citizen participation game as a hybrid between a collective physical and a personal digital space, it can adopt the concept of a digital threshold. This phenomenon can be observed in the field of digital games: Initial processes such as turning on the PC, starting the game, and especially creating avatars or setting preferences are as well described as threshold experiences. [17] In this case, they prepare the entry into the game through a one-on-one interaction.

With the integration of digital elements (e.g., a smartphone app) there is a possibility of creating such a digital threshold. By establishing the app directly at the start of the game, participants can be prepared for the following participation in a one-on-one-interaction with the app, instead of having to act directly in the collective game situation. Within this interaction, the players appropriate the game – analogous to the threshold experience of a video game. This appropriation (in the sense of a threshold phase) happens mostly through customization: entering a name, choosing an avatar, or deciding on a game color. Parallel to this, there are constant references to the physical game elements and game logics, for example by naming the resources relevant in the game and a first interaction with them. In the example of *UTurn*, the players must put in their names, choose an avatar, and estimate their own CO₂ consumption based on their day-to-day routes, which they are able to track through the physical map and translate by using the “Quartet”-cards. Through these references, the digital space is not only getting connected to the physical space, but the used play-forms are unfolding as the participants enter the game and the materials, that are reluctant to the participants expectations are getting introduced. Within the threshold phase, the participants inscribe themselves further and further into the game, while getting more and more information about the game. The goal is to enable the participants to develop their own game agency by lowering the boundary to participation through the private interaction with the digital. Subsequently as soon as everyone entered their data, the one-on-one-interaction with the device shifts into the shared room and becomes a collective participation in the game, as the names, avatars and generated data of the players are displayed on a monitor. In addition to the introduction to the game situation, the merging and disclosure of the information generated in the threshold situation creates an overview of the fellow players. It is important to note that the established threshold does not correspond to the interface of the application – rather, the interaction with its contents is to be regarded as a threshold experience. [18] Therefore, what is most interesting is *what* is controlled in the threshold rather than *how* it is controlled. In the case of *UTurn*, the app relocates the extradiegetic controls [19] – the administration level – to the digital space by making the players manage personal and game data exclusively in the app. The threshold experience in this case consists beside the customization mainly of the regulation of game parameters (such as the individual CO₂ consumption), which will have an impact on the game mechanism on the gameplay level. By trying different CO₂ scenarios in different rounds, the players do not only get a feeling of impact but are enabled to understand the connection between abstract parameters and game mechanics. By separating the extradiegetic controls from the gameplay, the players are allowed to understand the game structure in their own individual pace, before playing with them on the level of intradiegetic controls. In addition to this, possible meta-discussions triggered by the transparency are moved out of the gameplay level.

Fig. 2: starting page of the UTurn App



4 Connecting digital thresholds to physical forms

Beyond the pragmatic level the question arises as to why the citizen participation game is not moved completely into the digital space. In the context of a citizen participation, the players should be enabled to form a well-founded opinion on the topic of the procedure – on the one hand as a didactic approach, and on the other hand to generate differentiated data sets. With the connection to the physical space the game becomes more transparent to the players, as they can understand its logics and processes to a certain degree. By receiving feedback on how real-world phenomena are represented in the game, players can more easily transfer approaches back to the real world to be able to judge situations on a broader level and find applicable solutions. Thus, the use of hybridity between physical and digital as well as personal and collective space empowers gamers to not only *be a part* of the game but to *take part in it* by giving the players the opportunity to build their own agency *before* participating in the game with others. Accordingly, it is significant that the players are given the option to exchange views, opinions and actions with their fellow players. While the digital component has a decisive influence on the construction of a game agency, it only becomes significant in the context of joint action. This is hardly possible within the purely digital space, especially if a smartphone app is assumed as the basis: In this case, there may be a complexity reduction of the dialogue resulting from the lack of facial expressions and gestures. One way of dealing with this would be to separate the game space from the negotiation space by detaching the game physically or thematically from the main topic – in this case, however, the play agency developed in the game would play only a secondary role in the negotiation process. The linkage of the analog and digital space is also important for using the play-forms profitably. While phenomena like those of play-forms and game-formats can certainly be identified in the field of digital games, their affordances are also strongly linked to experience. This experience cannot be learned within a short time, but only results from frequent playing. To a high degree, this experience is also connected to a question of media competencies. Due to the breadth of the target group addressed, it cannot automatically be assumed that the participants can control a purely digital game. By using the digital space mainly as a threshold as well as extradiegetic controls, the participants can be offered help for controlling the digital space without destroying a broadly built involvement situation. The game is just being established in the threshold experience, which makes the players more receptive to external influences without breaking any involvements for them. In any case it makes sense to work with established forms of interactions [20], thus the concept of affordances can be used again to make the interaction easier. If the interface of the digital space refers to symbols that are already familiar from a wide variety of media origins (fillable blanks, multiple choice concepts, etc.), the players can draw on implicit knowledge from a wide variety of media fields, which the game more accessible for people with lower media skills.

5 Conclusion

The hybridity in the citizen participation game as an integrative combination of digital and physical elements enables an interplay of negotiation and empowerment that would not be possible in either a purely physical or a purely digital simulation. The digital space can be used to establish a threshold experience that allows participants to enter the Magic Circle in their individual pace. Within the threshold, the players can appropriate the game by individualizing it. By giving the participants the opportunity of a one-on-one interaction in the digital space rather than directly interacting with the game and the other attendees, the threshold simplifies the transformation from participant to player by enabling the more intimate establishment of a game agency. This game agency, however, only becomes productive in the physical space in which the players can perceive the possibility of exchange. By making the individual actions available to the other players as data, the process has a group-building effect at the same time, which makes a collective participation even easier.

The interplay between the threshold and the material allows to use the associated play-forms productively. By negotiating the partly unconventional materials of the citizen participation game already in the threshold, the expectation of the participants towards the game is adjusted. Thus, the irritation connected to those components can be solved, to make room for the usage of the implicit knowledge connected to the play-forms and interfaces of the game. By utilizing this knowledge, the game's controls and ruleset can be kept much less complex. In the same course, the game becomes more transparent for the players through its materiality and the linked implicit knowledge. The merge of these aspects enables the players to form well-founded opinions about the topics negotiated in the citizen participation procedure, which will result in complex data sets.

The functionality of the threshold experience depends on the competencies of the participants – using both physical and digital forms, a broad field of possible points of contact is available, but the associated competencies must be present to benefit from them. Based on experiences with *UTurn*, most players find it easy to handle the digital devices with a little help. However, it must always be kept in mind that a functional threshold experience should equally be created for digitally illiterate people, which is why the complexity of the digital elements must be kept low.

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4. Cf. e.g. TopSim (<https://www.topsim.com/blog/in-kuerze-erklart-was-sind-eigentlich-hybride-planspiele/>)
5. Clüver refers at this point, among others, to Huizinga, J.: *Homo Ludens. Vom Ursprung der Kultur im Spiel*. 26. Auflage. Rowohlt, Hamburg (1938), pp. 22 f.
6. Gaming Capital describes the metaknowledge of how rules are understood and games are played.
7. The concept of lusory attitude can be traced back to Salen and Zimmerman; it describes the willingness of those playing the game to commit to the rules, even if they demand real-world inefficient actions.
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15. Cf. Saeverin, P: *Zum Begriff der Schwelle. Philosophische Untersuchung von Übergängen*. Bis, Oldenburg (2002), p. 138
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Leading Change for Sustainability – Business: Preliminary Evaluation of a Sustainability Simulation for Management Education

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Abstract. Simulations are among the active learning strategies advocates have claimed as well-suited for teaching and learning about sustainability challenges and solutions. Recent reviews of research have, however, identified a need for simulations that address a broader range of sustainability issues. This is also the case in management education, where the predominant paradigm focuses on traditional shareholder value-based conceptions of corporate responsibility. This article presents the new sustainability-oriented, online computer simulation, Leading Change for Sustainability-Business. The authors present preliminary evaluation data from a study of 87 students who learned with the simulation in a Master of Management program in Thailand. Data analyses focus on student's engagement with the simulation and their perceptions of its efficacy as an online learning tool. The relevance of this research was enhanced due to the fact that the study was conducted during the COVID-19 pandemic when all university courses were executed in a fully online learning mode. Initial results support the efficacy of the Leading Change for Sustainability-Business simulation as a helpful tool for learning how to apply knowledge of change management to the challenges of corporate transformation for sustainability. More broadly, the results affirm the viability of simulation-based learning when used in a fully online mode of instruction at the university level.

Keywords: Leading Change for Sustainability, Simulation-based Learning, COVID-19, Online-learning

1 Introduction

Over the past several decades, the quest for corporate sustainability has gained increasing currency in Asia. For example, 'human capitalism,' with its strong employee focus, has enabled Japan to reach an advanced stage of capitalism [1]. Another variation comes from Southeast Asia, where governments have assumed a more proactive role in creating, shaping, and guiding markets. This has required firms to take greater responsibility for the social welfare of their employees [2]. Singapore is a successful example of this business model. In Thailand, the Sufficiency Economy Philosophy, which aims for the balanced development of a sustainable society, has been acclaimed as a viable approach to corporate sustainability [3,4]. However, even as research has begun to demonstrate the efficacy of these alternatives to prevailing corporate management models, managers continue to be mainly educated based on the prevailing paradigm of shareholder capitalism, which has contributed to the unsustainable exploitation of people and the planet [2,3]. Thus, current and future managers require education and training to successfully reorient companies towards the vision of sustainable progress encompassed in the United Nation's sustainable development goals.

An extensive body of literature has examined strategies used by managers to implement change successfully in organizations. Scholars conclude that leaders are 'facilitators' and

'gatekeepers' of change [5,6]. As gatekeepers, managers – at every level of the company – have the authority to open or close the door to change. However, research also affirms this does not guarantee successful change even when managers' open the door'. Facilitating changes adopted by the company -- even those that managers accept as priorities -- requires skillful managerial support to succeed. Thus, management education programs, whether at the corporate level or university degree programs, have made 'change management' a standard competency in the 21st-century management education curriculum [7].

However, the change to 'sustainability' presents an even more significant challenge than the usual 'internal organizational changes' that managers face. The change to sustainability involves complex, systemic changes at the individual, organizational, and social system levels [8,9]. Changes that fall under the rubric of sustainability are typically addressed through interaction with the organization's environment and under conditions of uncertainty [3,10-13]. This suggests a need for new and more powerful tools to assist managers and their teams understand how to succeed under these challenging conditions.

One approach that has emerged in efforts to learn how to 'make the change to sustainability' has been computer simulation [14-16]. Simulations have been developed on corporate social responsibility [16], climate change [15,17], and sustainable urban development [18]. Simulations have emerged as a 'tool of choice' among educators when addressing sustainability issues due to their superior ability to capture the complexity of systemic problems [15,19-22]. Simulations not only place learners in the situation of tackling complex problems and making decisions based on incomplete information, but they also provide feedback on those decisions, thereby enhancing capacities for problem-solving. Simulation-based learning is ideal for the subject matter and problems that require the ability to model and anticipate future scenarios [19,23,24].

A recent review of the literature on sustainability simulations and games identified a need for more simulations that can be used in management education and empirical research that sheds light on how much they achieve their stated goals. This includes high learner engagement, practical learning application, holistic, analytical thinking development, and learning transfer to the world outside the classroom [25].

This article addresses several, though not all, gaps in the research on using simulations and games in education for sustainability. More specifically, the goals of this article are to:

1. Elaborate on the instructional process used with the simulation,
2. Present preliminary evaluation data based on student perceptions of learning with the Leading Change for Sustainability – Business simulation.

This article is devoted to the instructional use of the LCS-B simulation and a preliminary empirical study. The empirical research included data collected from 87 part-time graduate students studying in a Master of Management degree program in Thailand. The 'treatment' consisted of a three-week, fully online learning module designed around the LCS-B simulation. Data analyses included data on student engagement with the simulation, student perceptions of the efficacy of the learning module based on end-of-course evaluations, and qualitative feedback obtained from open-ended questions answered by students during and following the module.

The significance of this article lies in three domains. First, the detailed instructional use of the LCS-B simulation may be of practical significance for educators interested in developing or using simulations. Second, the research highlights student perceptions of the effectiveness of the simulation in creating an active and engaging learning environment, enhancing their understanding of core concepts. Finally, since this research was conducted during the COVID-19 pandemic, the LCS-B simulation was delivered in a fully online synchronous learning mode. Thus, the findings also offer empirical insights into the efficacy of simulations as a mode of active learning when used in a fully online learning environment.

2 Instructional Process

The design features incorporated into the LCS-B simulation drew upon prior literature on experiential learning [27], simulation-based learning [28,29], and problem-based learning [26,30]. Thus, the LCS-B simulation design and instructional process emphasize the principle that 'learning should start with the problem,' a key tenet of problem-based learning [31]. Therefore, while the simulation is grounded in several different theories, these are not introduced to students ahead of time. Instead, the theories are elaborated to students in mini-lectures and readings as the students engage in solving the problem. This contrasts with case teaching, in which instructors typically teach a theory and provide a case for the application. Thus, for example, the Adopter Type theory is introduced to the students when they struggle to engage resistant stakeholders. Students can then apply the theory and see how it can help 'solve the problem.'

As indicated in Table 1, in the LCS-B module, students study in class for three three-hour sessions (a total of nine instructional hours). During class each week, the instructor divides the session into three parts (see Table 1). In the first 45 minutes, the instructor delivers a 'mini-lecture' on change management and sustainability concepts. For the next 90 minutes, teams consisting of three students take the 'project team' role and play the simulation in separate breakout rooms. The instructor periodically visits the breakout rooms to answer questions and offer consultation on change strategies. In the last half-hour of class, the instructor brings the whole class back together and leads a debriefing of the change obstacles and strategies they employ. Periodic debriefing of their simulation strategies accelerates learning, enhances the development of higher-order thinking, and clarifies the mental models essential to solving complex systemic problems [32,33].

In addition to learning in class, students are expected to complete a reading assignment each week, participate in an Online Discussion Forum (on Moodle), and play the simulation several times from home. The last two assignments are critical to learning with the simulation. Each week at the end of class, the instructor emphasizes that learning via simulation requires learners to play numerous times to see patterns associated with successful strategies. That is, the process of 'learning from experience' requires multiple cycles of planning, doing, reflecting, and adjusting [27].

Indeed, it would be impossible to obtain a passing grade on the simulation exam without playing multiple times at home. The amount of time spent playing the simulation in class is simply insufficient. In Week 1, when students were unfamiliar with the people, activities, and method of play, it could take up to two hours to play an entire three-year simulation session. However, students can complete the full three-year simulation in 30 to 45 minutes by the third or fourth iteration. Nonetheless, learning via simulation requires a substantial time commitment from the students. Playing the simulation at home is 'incentivized' by allocating 25% of the course grade to results on the individual simulation exam.

The Online Discussion Forum is designed to 'continue the conversations' started among students in class and to support individual problem-solving as they play the simulation at home. Each week, students are expected to post a response to the question in the Online Discussion Forum and also comment on each others' posts. For example, following the first class, three discussion questions are posted:

1. What was the most difficult problem that you encountered so far in implementing change for sustainability at the Best Company? How did you solve it?
2. What one piece of advice would you like to share with others?
3. What one problem would you like advice on from others?

Thus, the Online Discussion Forum is another form of 'student-centered learning' integrated into the module.

Table 1. Basic instructional sequence used with the LCS-B simulation.

Week	Activities in class	Individual Homework
1	Mini lecture: Sustainability concepts Resistance to change Introduction to LCS-B simulation Teams of 3 play simulation in breakout rooms Whole class debriefing	<ul style="list-style-type: none"> • Simulation practice • Post in Week 1 Online Discussion Forum discussion question • Reading assignment
2	Mini lecture: Sustainability concepts Stages in the change process Change Adopter Types Teams of 3 play simulation in breakout Whole class simulation debriefing	<ul style="list-style-type: none"> • Simulation practice • Post in Week 2 Online Discussion Forum Reading assignment
3	Mini lecture: Sustainability concepts Apply Kotter's 8-stage model of change Synthesize change models Teams of 3 play simulation in breakout Whole class simulation debriefing	<ul style="list-style-type: none"> • Simulation practice • Post in Week 3 Online Discussion Forum • Prepare for Simulation Exam in Week 4 • Reading assignment
4	Individual simulation exam	<ul style="list-style-type: none"> • Post in Week 4 Online Discussion Forum

3 Method

The main objective of this study is to preliminarily evaluate the simulation based on descriptive data, including student engagement and perception data. Future research of this study is to use additional quantitative and qualitative tools, including inferential analysis, to analyze students' simulation performances and discussion responses.

Participants. The participants in this study consisted of 87 students studying in a Master of Management degree program at a university in Thailand. The students averaged 28 years of age and five years of work experience, mainly in the corporate sector. Sixty-five percent of the students were female, and 35% male.

Instructional Treatment. The learning module that employed the simulation was an elective course in which enrolment was capped at 25 students to stimulate interaction. The simulation module was designed to draw upon and extend their prior learning of management theory. Students did not, however, have any prior coursework related to sustainability concepts. Therefore, the data presented in this analysis were collected from four classes over three trimesters between May 2021 and February 2022. The same instructor taught all four classes using the version of the simulation and support materials (i.e., lectures, readings, and discussion questions). The instructional process closely followed the description provided above. However, due to the COVID-19 pandemic, it should be noted that all instruction was delivered in a fully online mode. The weekly class sessions were delivered using the Zoom platform, supplemented by Moodle for storing materials and a link to the simulation.

Data collection. The research reported in this article is based on three data sources. First, student engagement was tracked by monitoring the frequency of simulation sessions played by individual students. Each time a student played, his/her 'strategy' (i.e., sequence of activities), results, and level achieved was saved on a server. Thus, the researchers were able to determine who played, when, for how long, how many times, and with what results.

The primary source of data for this report was an end-of-course evaluation used by the college. The course evaluation survey used by the college consisted of 16 questions answered on a five-point Likert scale (1 Not at All to 5 To a great extent). Students completed the survey online outside of class at their convenience. We extracted student responses to four questions deemed most relevant to our understanding of the impact of the LCS-B simulation. These were:

1. Rate how well this course developed your analytical ability;
2. Rate the instructor's ability to develop your understanding of the subject;
3. Rate the ability of the instructor to make the course content practical;
4. Rate the extent to which the course is actively involved in learning.

We chose to focus on these questions for several reasons. First, the challenge of delivering the module in a fully online mode presented a special challenge for engaging students actively in simulation-based learning. Second, prior research suggested that simulation-based learning is well suited to developing analytical ability and higher-order thinking. Thus, we were interested in whether students perceived this as the case. Third, simulation-based learning is also an explicit goal to enhance students' ability to apply theory to practical problems.

Finally, these quantitative data were supplemented by qualitative data from student feedback in the Online Discussion Board and responses to open-ended questions on the end-of-course evaluations.

Data Analysis. Preliminary statistical analysis confirmed that there were no significant differences in student characteristics across the four classes to age, college study duration, grade point average, or prior work experience. Thus, we treated the 87 students as a single group. Descriptive statistical analysis was conducted at the item level. Therefore, no reliability analysis was conducted. Data analysis reported the mean response of 87 students and the grand mean of students on the same items for all courses taught in the college during the same terms.

4 Results

This section presents qualitative and quantitative results concerning the efficacy of the LCS-B simulation in the context of a course offered in a graduate school of management in Thailand.

Before introducing the results of this study, however, we wish to highlight several features of the learners and the learning environment. First, although the students had learned Kotter's change model in an introductory course, they had no experience applying this or other change theories in practice. Second, a knowledge pre-test given in the first week of the module (not tabled) confirmed that the students had little or no baseline knowledge of basic sustainability concepts (e.g., triple bottom line, social sustainability, waste management, life cycle assessment). Thus, despite their work experience and prior coursework, the students came to the LCS-B module as 'novices' regarding change management and sustainability. Finally, we wish to reemphasize that all students in the four classes included in this research were working full-time and taking three classes concurrently. Consequently, their time for study outside of class was an ever-present constraint.

4.1 Impact of the Simulation on Student Engagement

The first result concerns the frequency with which students played the simulation. Table 2 shows the descriptive analysis of student engagement with the LCS-B simulation. The mean level of 22 game sessions per student per class was both consistent and 'high.' Using a low-end estimate of 30 minutes per game session as a standard, students spent an average of 3.7 hours per week playing the simulation at home. The data in Table 2 do, however, highlight considerable dispersion among students in their engagement with the simulation, as evidenced by the min/max counts in each class and the relatively high standard deviations.

Table 2. Frequency count of LCS-B simulation games played by students over the three weeks of the module (n=87 students in total).

LCS-B Class	Min	Max	Mean	SD
Class 1	1	73	20.8	18
Class 2	1	48	21.8	14.3
Class 3	4	49	19.9	13.7
Class 4	3	70	24.8	16.7
All four classes	1	73	22.2	15.8

When interpreting the data in Table 2, it is also useful to know that 82 of the 87 achieved the highest level, change Master, on the individual simulation exam. Thus, the Min counts shown in Table 2 were truly outliers both in terms of the number of times they played the simulation and their achievement on the 'exam.' Moreover, we believe it would be incorrect to interpret the high percentage of students achieving on the individual exam as indicating that the simulation was 'easy.' In fact, because students can 'see' the level of their success at the end of each three-year simulation session, they are motivated to continue playing until they can succeed. This is consistent with the principles of mastery learning.

These frequency data, which we interpret as a proxy for student motivation, were elaborated by quantitative data gathered on student participation in the Online Discussion Forum. More specifically, we assessed the level of student participation in the Online Discussion Forum for each of the four weeks. Analysis of the four classes found that 82 of the 87 students (94%) participated in all four Online Discussion Forum activities outside of class.

In addition, qualitative data was gathered from student responses in the Online Discussion Forum and open-ended questions in the course evaluation survey conducted at the conclusion of the module. Some relevant responses included the following.

- The simulation helps students enjoy playing together with learning how to make the company achieve sustainability.
- Too much homework, comments to post in the discussion forum and simulation practice.
- The simulation game is fun, challenging, and interesting.
- The class environment is very active, and students can participate a lot.
- Really love the simulation game. It is really fun to learn from the simulation, and it is helpful in real life as well.

4.2 Student perceptions of the efficacy of the LCS-B simulation

Table 3 shows the average ratings on the four survey questions for each LCS-B class and all college courses assessed in the same trimester. When interpreting the data in Table 3, two contextual factors deserve comment. First, it should be noted that the mean evaluation scores for 'all college courses' were consistently 'high' on the five-point

Likert scale during each of the terms during which data were collected for this study (i.e., M= 4.22; Min 4.13/Max 4.31). The college has long emphasized active learning methods, including implementing a problem-based learning track in the curriculum see [26]. Thus, the scores obtained for the LCS-B simulation in this study were measured against a 'high standard.'

Second, it should be reemphasized that data collection for this study began one year into the COVID-19 pandemic (i.e., May 2021). Prior to the onset of the pandemic a year earlier, no courses in the college had been offered in a fully online learning mode. Indeed, no instructors had used a synchronous learning platform such as Zoom, and relatively few had even used Moodle extensively. This is relevant because all college courses, not just the LCS-B module, were being delivered in a fully online learning mode during the entire data collection period.

Table 3. Comparison of student perceptions of the LCS-B module with all college courses.

Course	Class 1	Class 2	Class 3	Class 4	Grand Mean
<i>Rate how well this course developed your analytical ability</i>					
LCS-B Module	4.58	4.43	4.55	4.39	4.49
All courses for the term	4.23	4.13	4.13	4.19	4.17
% difference	+7.0%	+6.0%	+8.4%	+8.4%	+7%
<i>Rate the instructor's ability to develop your understanding of the subject</i>					
LCS-B Module	4.79	4.62	4.5	4.5	4.6
All courses for the term	4.26	4.2	4.2	4.16	4.21
% difference	+10.6%	+8.4%	+6.0%	+6.8%	+8%
<i>Rate the ability of the instructor to make the course content practical</i>					
LCS-B Module	4.63	4.52	4.55	4.56	4.57
All courses for the term	4.29	4.23	4.23	4.17	4.23
% difference	+6.8%	+5.8%	+6.4%	+7.8%	+6.7%
<i>Rate the instructor's ability to actively involve students in learning</i>					
LCS-B Module	4.74	4.71	4.6	4.5	4.64
All courses for the term	4.31	4.25	4.25	4.23	4.26
% difference	+8.6%	+9.2%	+7%	+5.4%	+7.5%
<i>Grand Mean 4 Items</i>					
LCS-B Module	4.69	4.57	4.55	4.49	4.58
All College Courses	4.27	4.20	4.20	4.19	4.22
% difference	+8.4%	+7.4%	+7%	+6%	+7.2%

Notes: courses were rated on a 5-point Likert scale. The LCS-B modules averaged an 86% student response rate to the course evaluation survey. + indicates the advantage of LCS-B mean compared with All College Courses

With these factors in mind, Table 3 shows very high grand scores for the LCS-B module on each of the four selected survey items (i.e., 4.49, 4.6, 4.57, 4.55). The grand mean across the four items was 4.55. These data provide perceptual evidence that learning through the LCS-B simulation developed student understanding of the subject (i.e., change management for sustainability), enhanced their analytical ability (i.e., change strategy), made the content practical, and provided an active and motivating learning environment.

The results of the course evaluation data provide clear, if somewhat limited, evidence that the LCS-B simulation provided an active, engaging, and challenging learning environment. The data also suggest that students experienced growth in their understanding of change management and sustainability concepts and increased interest in sustainability. Nonetheless, affirmation of these conclusions awaits further analysis of quasi-experimental data on actual learning gains and attitude change during the LCS-B module.

Comments extracted from the Online Discussion Forum and evaluation survey elaborated on these quantitative perceptions. With respect to developing an understanding of the content and enhancing their analytical ability, students made the following observations.

- I am very impressed with this simulation because it seems like you are in the organization. Actually, in real life, you cannot replay or redo everything, but in this simulation, you know that you could try to do it and redo it again. It inspires me to know exactly what is the process of change and the ways of embedding a sustainability attitude instead of just knowing the concepts.
- For me, at the beginning of this course, I had no knowledge about sustainability and questioned why sustainability can be beneficial to the company and industry. Now, I feel like there is a big surprise with many examples of sustainable practices that can be implemented. I don't feel like it is out of people's reach.

- I am surprised by the simulation. Sustainability turns out to be not only an environmental issue but also about impact on people at the individual, corporate, and society levels. The simulation was challenging but fun and gave me the whole sustainability concept.
- I learned that being a planned person but flexible to different circumstances is a good way to deal with problems. The simulation helped me learn how to think ahead and anticipate the consequences of my plan. I also learned to be prepared for unexpected situations in the future. In real life, we cannot expect everything to be predictable, and making any major change in the company is like that as well.

Students also emphasized ways in which the simulation made theories applicable in their corporate and personal lives.

- I was impressed by the simulation in class. The program helps to create the process of thinking about the sustainability concept in ways that can be used in real life.
- The simulation is similar to real life in my workplace. When a company wants to implement a new policy or make a change, it always faces resistance at first. At that point, the strategy we use is critical. We must determine who will be the first group to change and how to influence more people to support the change as time passes.
- To me, I think the problem of sustainability is big enough that we should have a course on it at the university. The fact that we have this class in the Master's program reflects the importance of the issue. Even though right now we know just only the tip of the iceberg, it is really useful because eventually, we will have to use this knowledge no matter where we are working or what we are doing.

Analysis of the LCS-B results against 'all college courses' offers additional insight into the meaning of these results. On each of the four items shown in Table 3, the mean scores for the LCS-B module evidenced a positive advantage when compared with the mean scores for all college courses (i.e., an average difference of 7%). Based on these data, we conclude that students perceived the fully online delivery of the LCS-B module to be successful at creating an active learning environment that enhanced their ability to think strategically and practically about the transformation of companies for sustainability.

5 Discussion and Conclusion

This article has described a project undertaken to design an online computer simulation focusing on leading change for sustainability in the corporate sector. The relevance of this research was unexpectedly enhanced by the onset of the COVID-19 pandemic, which intensified the need for identifying methods of active teaching and learning that could be employed in a fully online mode of instruction. In this final section of the article, we reflect on the limitations of the research method and interpret the meaning and implications of the findings.

5.1 Interpretation and implications

This article has focused on the initial evaluation of a fully online computer simulation intended to educate prospective and practicing managers. The LCS-B simulation offers a potent illustration of 'student-centered learning' delivered in a fully online learning mode. For example, our data offered insights into the extent of student engagement during the module. Frequency counts on the number of game sessions played by students represented objective data confirming the substantial amount of time students invested in learning outside class. Many students used words like 'fun,' 'stimulating,' 'engaging,' 'challenging,' 'frustrating,' and 'exciting' to describe their experience with the simulation. Notably, a few students objected to their time learning with the simulation, reading, and participating in the Online Discussion Forum. Nonetheless, from our perspective, even this negative assessment can be viewed as an affirmation that students were at the 'center' of learning, doing the hard work needed to make meaning from their 'simulated experience' gained through the game sessions.

Several implications follow from the findings presented in this article. First, this theory-driven simulation resulted from a multi-year, funded research and development project to enhance higher education for sustainability. The potential utility of this simulation as a resource for learning how to 'make the change to sustainability' is quite broad. The simulation could be used with undergraduate or graduate education students in various disciplines. Similarly, it could be used as part of a company's effort to raise staff awareness as it embraces sustainable practices. Finally, because the simulation is hosted 'online,' it could also be accessed and played outside of formal learning settings. Indeed, we repeatedly emphasize the learning gained from playing the simulation.

A second implication lies in the perceived efficacy of learning with the simulation in a fully online mode. The COVID-19 pandemic challenged educators to seek effective pedagogical models and tools that could be adapted to meet the constraints of 'distance learning' [36-38]. The preliminary analysis presented in this article lends credence to the potential that lies in simulations and games as a pedagogical framework for online learning. Our results highlight the motivational advantages inherent in well-designed simulations and their potential for reducing the gap between theory and practice.

Anecdotally, the authors wish to reference the perceptions of the instructors and students in this regard. As instructors, we observed a few disadvantages to using the simulation in a fully online mode compared with prior terms when it was used in a blended learning mode (i.e., meeting with students in a physical classroom). To our surprise, this perception was mirrored in student responses. For example, as our college began transitioning back to face-to-face instruction, the instructor gave students the option to hold the third and fourth class sessions online or face-to-face. Seventy-five percent of the class opted for online (i.e., via Zoom), and 25% expressed no preference. None opted explicitly for face-to-face instruction. Discussion with the students surfaced the perception that learning with the online simulation would be equally effective.

Third, positive student response to the LCS-B simulation has paved the way for the design of additional sustainability simulations. For example, the LCS-B simulation has been translated into Thai for a broader audience in Thailand. In addition, two new versions focusing on different organizational contexts for implementing sustainability are in the design and testing process: Leading Change for Sustainability - Schools [39] and Leading Change for Sustainability - Higher Education.

5.2 Limitations of the study

The key limitation of this research lies in the predominant reliance on student perception data to gain insights into the efficacy of the LCS-B simulation. In fact, the authors have been among those scholars who have criticized the use of 'weak research designs and methods in research on simulations and games in educating for sustainability' [19,25]. To be fair, this criticism also applies to the empirical research presented in this article which consisted of a descriptive analysis of student perceptions.

Our rationale for proceeding with the presentation of these admittedly preliminary results is based on two factors. First, the main purpose of this article was to provide a detailed description of the design features underlying a new sustainability-oriented computer simulation. Space limitations would preclude the inclusion of such detailed information on the LCS-B simulation in an article whose primary purpose was to report the results of an empirical study of student learning outcomes.

Thus, while not ideal, the analysis of student perceptions presented in this paper offers useful insights concerning the motivational impact of the simulation and its efficacy from the learners' perspective. Indeed, student perceptions of online learning became paramount during the COVID-19 pandemic when universities were challenged to adapt to a fully online instructional

environment [34,35]. Thus, we suggest that student perceptions in this preliminary study can be justified.

5.3 Further studies

Finally, we wish to emphasize that this report is just the first in a research program on the learning efficacy of the LCS-B simulation and its off-shoots. As future reports will elaborate, automatic data collection on a central server greatly facilitates research on online simulations. This data can be analyzed to gain insights into the thinking and decision-making of learners [40].

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Mirrors in Smog City – A serious game to assess collaboration potential

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Abstract. Collaboration is a critical factor for a team to be successful. Current practices to measure collaboration potential include methods that are outdated, cumbersome or error prone, and therefore often inapplicable in many settings. Games have been increasingly applied to assess a variety of skills and the popularity of multi-player games makes them a strong alternative for measuring the collaboration potential of a team. We propose Mirrors in Smog City, a novel serious game in which the final score is explicitly conceived as a proxy for the collaboration potential of the players. This multi-player collaborative game is designed for simplicity and accessibility, so that it can be used by very diverse teams in many settings, with minimal on boarding. Although the current prototype still needs a thorough evaluation, our preliminary assessment has concluded that the current design seems to be well-suited for assessing the collaboration potential of its players. Apart from the small sample size, a thorough evaluation will also need to include a benchmark with an objective and, if available, standardized method for assessing collaboration potential.

Keywords: Serious game · Team collaboration · Communication · Teamwork · Simple game controller

1 Introduction

In the last VUCA (Vision, Understanding, Clarity and Agility) World¹, managers of organizations stressed the need to adapt and improve to defeat challenges like Covid-19 and climate change. One efficient way to prepare for a rapidly changing world is Human Resource Development [10]. According to Dhillon et al., [6], organizational culture is an increasingly important topic, and for that, collaboration is essential. Moreover, they describe collaboration beyond the position in an organization, such as collaboration between managers and employees, leading to flexibility of thought, so that an organization can respond to fierce changes in its external environment.

According to Bedwell et al. [2], collaboration is a higher-level process that encompasses many frequently studied constructs such as *cooperation*, *teamwork* and *coordination*. Often collaboration is thought of as strongly correlated and/or connected with teamwork [3]. Driskell et al. [7] say that 'At a broad level, teamwork is the process through which team members collaborate to achieve task goals'. Teamwork refers to the activities through which team inputs translate into team outputs such as team effectiveness and satisfaction. These notions imply that collaboration is a kind of process for several people to achieve a common goal. We assume that there is a definition of 'good collaboration' based on some subjective and context-dependent criteria.

Collaboration potential, or the potential to collaborate, is the degree to which a group of people are skilled to perform group tasks together. These tasks, by definition, cannot be

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performed by an individual alone or would take more time. Quantifying collaboration potential within a group of people can enable the formation of the team that is best equipped to tackle a problem, be it strategic, commercial, military or in any other domain.

Despite abundant research effort, a single definition of collaboration has not yet emerged. Even today, a lot of research often depends on questionnaires to assess traits around collaboration, teamwork, communication skills, etc. These methodologies may often be affected by individual biases in the survey formulations, by bias among the participants answering the survey, and by the subjectivity of their answers. We posit that a carefully designed collaborative game can provide a much better means for efficiently assessing the collaboration potential within a team, in an immersive and compelling setting.

2 Related work

Tong and Chignell [14] showed that a serious game can be used to perform a cognitive assessment. Among others, they measured the 'working memory' of the participant. Tong et al. [15] performed a validation study to check if using a serious game to conduct a cognitive assessment is valid and they found that it was indeed a valid use case. Their work showed that a serious game can be used to quantify traits that are hard to measure by other means. It has also been shown that it is possible to measure the degree of a certain bias in a group of people, e.g. using the serious game *Stranded* [8]. In general, there is an increasing body of evidence that serious games, if properly designed, are a powerful and versatile instrument for skills and behavior assessment.

In 2011, Clayson and Haley [5] examined authenticity of student evaluation and found that students unintentionally falsify answers and sometimes intentionally give misleading answers. The disadvantage of paper questionnaires and interviews is the risk of 'favoring' socially desirable answers as shown in 2002 by Sjöström and Holst [13]. Accommodating assessment in a game can provide a richer, less repetitive and more immersive context in which players might act more naturally and intuitively. In order to design games for structured assessment existing methods do not sufficiently accommodate interactions between game, the player's mental state and decisions in the game.

Schneider et al. [11] discuss measuring collaboration between two individuals through techniques like computer vision, to identify facial expressions, but these can likely be fooled with a poker face or high-quality acting. The authors claim to measure collaboration, but in fact, what they measure is rather whether two people fit each other and would be comfortable working with each other.

Rousseau et al. [16] established a framework for a model of collaborative working. Their framework contains numerous factors like team building, goals, experience and communication. For example, they state that 'communication in collaborative work underpins how people understand each other and how knowledge is transferred. (...) The more that the right information is conveyed to the right people at the right time in the most appropriate way, the more effective collaboration will be.' Collaboration, they conclude, means cooperating with each other to achieve a common task/objective.

Mayer et al. [9] proposed a 3D multiplayer puzzle game *TeamUP* to assess team performance. Players collaborate to solve puzzles, and teamwork is measured by quantitative indicators like 'time needed to complete the task', 'speak time' and 'avoidable mistakes'. They observed that the teams in which team members had high cohesion were able to complete the game in less time. They suggest the time needed to complete the game, or the number of mistakes made, can be used to measure collaboration in a team.

Some collaborative serious games have gone a step further, attempting to improve rather than simply assess the conditions for collaboration in a team. The serious game *Grapplenauts* [1], for example, was designed to accelerate ideation conditions for newly formed teams, by progressively challenging its members, first individually, and then requiring from them

increasing collaboration. Similarly, the collaborative game *Maze Maestro* [12] aimed at helping break the ice within new teams, by spreading team members in a maze, with limited vision, and enforcing their collaboration to find the exit together.

Wang et al. [17] identified four game mechanic categories to promote collaboration and indicators to assess the effectiveness of collaboration. The first category is *Space*: by isolating players in their own space, they can be given individual tasks, while combining them within a shared space will foster collaboration. The second category relates to *Rules and Goals*, and it can include common goals, joint rewards and group victories. The third category is *Skills*, regarding the roles and abilities of individual players. Lastly, the category *Chance* refers to surprise elements that add fun to the game and create unexpected situations, which give the players additional opportunities to collaborate and thus, extra events where collaboration potential can be measured.

They also described two methods of measuring collaboration: *self-report*, where participants report how they felt collaborating, and *data mining* which uses collected gameplay data, like chatting logs, behavior logs, video footage or audio recordings. In the latter, researchers have to analyze the data after the game, which implies that conclusions or feedback are not derived in real time.

For so-called competitive-collaborative serious games, which include both competitive and collaborative gameplay elements, Buchinger et al. [4] identified various design features. They claim that games with the following elements tend to be more effective to promote knowledge acquisition:

- **Synchronization:** multiple players playing at the same time is better than turn-based
- **Roles:** players are often uniquely skilled
- **Score:** motivates players to do well and push themselves to do even better
- **Challenge:** gives an achievement feeling when the level/game was solved
- **Reward:** motivates players to finish the level/game and try to perform better for better rewards
- **Operationalization:** sufficient players/controllers/resources must be available

Finally, the authors also point out additional guidelines, two of which are most relevant to our research: (i) they suggest that gameplay should strongly induce *communication*, especially in a novel team, because otherwise individual characteristics might dominate over a united team's characteristics; (ii) they recommend that *assessments* should be neatly and cleanly integrated into gameplay; otherwise, if assessments are superimposed to the game, some players might get distracted from the game itself.

3 Game design

From the research work surveyed above, we have formulated the following Research Questions (RQ):

1. How could a game measure a team's collaboration potential with minimum dependence on player feelings, biases and skills?
2. How can we make that game into an expedite and very accessible measurement method?

In this section, we identify our set of design requirements for such a game, and introduce the main game loop and mechanics of *Mirrors in Smog City*, the game that we came up with as an answer to these questions.

3.1 Design requirements

Taking into account all recommendations from previous work, we identified a number of guidelines that we pose in the form of Game Requirements (GR):

1. To truly measure a team's collaboration potential, each player should have an equal and indispensable contribution, so that fewer than all players cannot succeed nor get a good score. (RQ 1)
2. The score for collaboration potential should be automatically derived from player data and performance, not from their answers to any survey. (RQ 2)
3. This score should be objectively and quickly given to the team. (RQ 1, 2)
4. The game mechanics should be very intuitive, so that most time is spent on collaborating, not on learning to play the game. (RQ 2)
5. For the same mechanics, the game should offer easy and hard difficulty modes, to tailor for various target groups. (RQ 1, 2)
6. The simplicity of the gameplay should make it accessible to a wide range of people, yet keep it challenging and fun for all teams. (RQ 2)



Fig.1: The polluted urban environment of Mirrors in Smog City

3.2 Game story and synopsis

A city is polluted by heavy, dense and filthy smog, which is pierced by just one ray of sunlight (see Figure 1). Players have to work together, using mirrors to direct that light ray onto a plant. Each player controls one mirror and, at each level, the team has to solve increasingly challenging puzzles. Upon each success, the plant grows and, as a result, the city air gets cleaner.

3.3 Main game loop

Rousseau et al. [16] identify three stages when a team tackles a common task (see Figure 2): (i) during the *preparation* stage, the team communicates to sketch their approach to solve the challenges at hand; (ii) at *execution* stage, the team

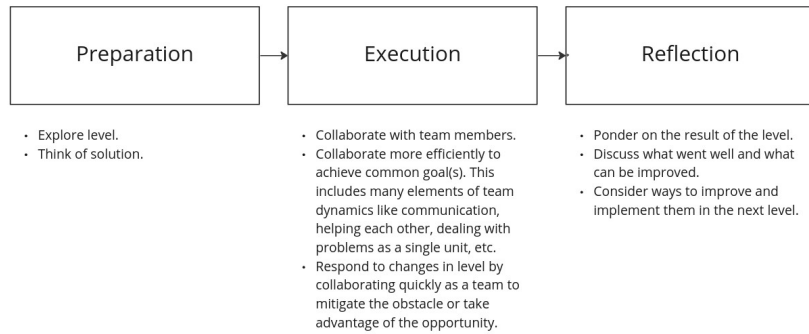


Fig.2: The three stages of tackling a common task

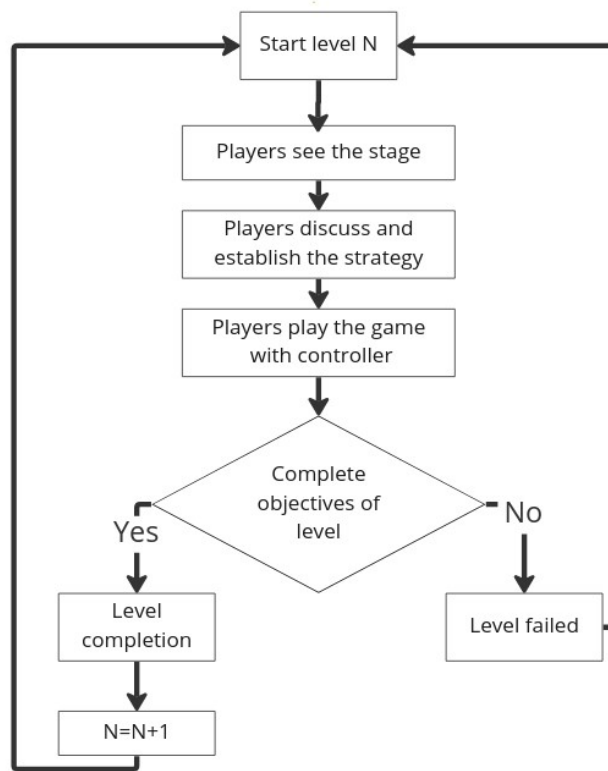


Fig.3: Detailed main game loop

implements what they planned and improvises along the way to deal with unplanned events; and (iii) at *reflection* stage, after completing the task, the team evaluates what went well and how to improve what did not go well for the next level.

We structured the core game loop of Mirrors in Smog City along these same stages, as indicated in Figure 3.

3.4 Core mechanics

To fulfill the game requirements in Subsection 3.1, we came up with the following core game mechanics:

1. Light, mirror reflection and rotation

First and foremost, the basic mechanics consists of leading a ray of sunlight by reflecting it with mirrors to a target. Each player is assigned a mirror they can rotate. Pointing the light at the back of another player's mirror will damage it. Such simple mechanics makes the game intuitive and accessible to almost everybody, so that the team can quickly learn to play the game. This levels the field for all players and reduces bias in estimating collaboration potential. (GR 1, 4, 6)

2. Simple one-button controller

We chose to use one-button controllers (see Figure 4) for each player to control the rotation of their mirror: pressing and holding the button will rotate the mirror. This control is just enough to play the game and it eliminates distractions caused by complex controllers with many buttons. Another advantage is that by having just a button, each player is actively limited in their capabilities, which gently pushes players to collaborate to achieve their joint objectives in the game. (GR 1, 4, 6)



Fig.4: Custom one-button controllers

3. Plant growth, healthy environment

The clear objective of each game level is a positive and attractive goal: to direct the sunlight ray to the plant and make it grow. This will purify the air and reduce the smog in the city. (GR 4, 6)

4. Scoring system

The scoring system estimates the collaboration potential among the team members. It is based on several parameters, reflecting the various aspects of collaboration, as described in Subsection 3.6. (GR 1, 2, 3)

5. Game level progression

The complexity of levels is increased by the inclusions of a variety of objects, so that players face more challenging obstacles as they progress in the game. Level 1 (Figure 1) shows simple obstacles to help players familiarize themselves with the basic mechanics, controllers and objectives. Level 2 (Figure 5) features a moving obstacle that blocks the

ray of light and forces a timeout on the game, while in Level 3 (Figure 6), the green mirror is placed ‘inconveniently’, blocking access to the plant with the risk of getting damaged. A switch workaround allows the team to change the level configuration. Level 4 (Figure 7) introduces static mirrors, which increase confusion so that the team must work together to steer the sunlight ray out of the maze of mirrors. Levels 1 to 4 address Game Requirements 1, 4, 5 and 6. Lastly, Level 5 is a dark level: to further increase the players’ dependency on each other, the scene is hidden behind thick dark smoke (Figure 8). The players must work together with their mirrors to first explore the level, learn the obstacles they face and then find a solution. Level 5 addresses Game Requirements 5 and 6.

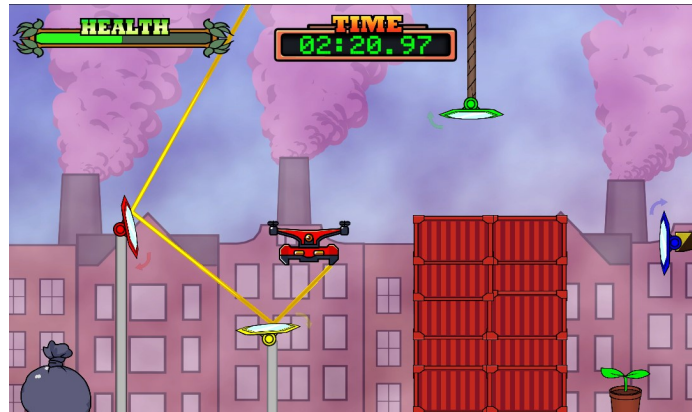


Fig.5: Level 2 – Moving drone gets in the way of light ray

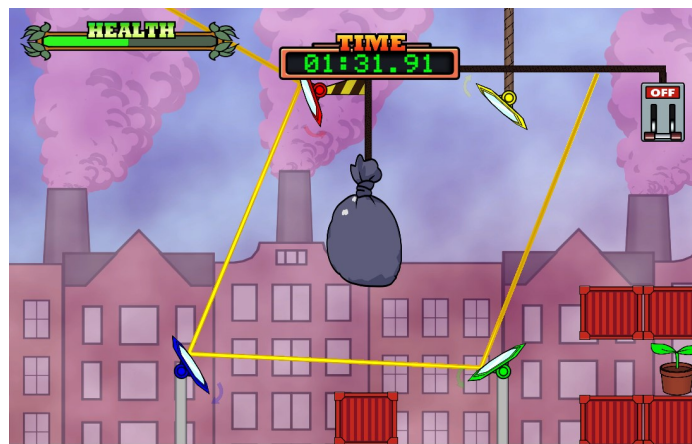


Fig.6: Level 3 – Use of a switch reconfigures the level, giving access to the plant

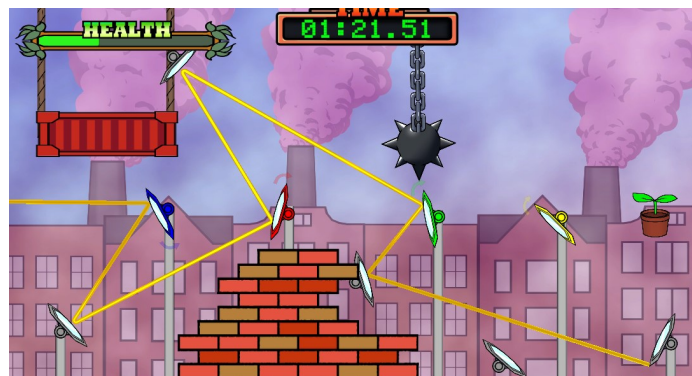


Fig.7: Level 4 – Inclusion of static mirrors (in gray) adds more possibilities and makes finding the correct sequence harder

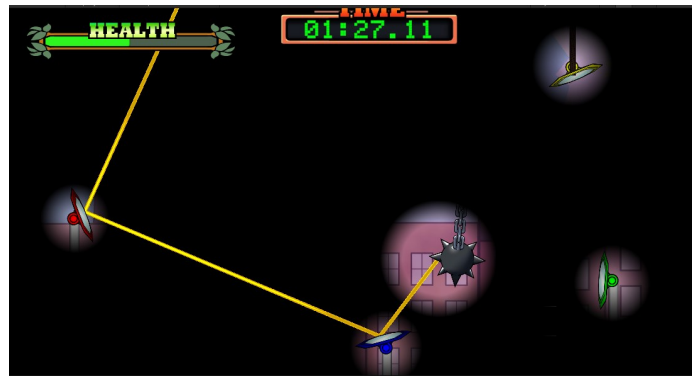


Fig.8: Level 5 – Inclusion of dark fog requires prior joint level exploration

3.5 Easy and hard difficulty modes

The easy mode offers mainly simple and straightforward gameplay, ideal for players who are less familiar with video games. The hard mode is better suited for players who are more experienced with video games and are insufficiently challenged in the easy mode. The hard mode gameplay requires more collaboration, as well as quicker and more precise response by each player. Firstly, the mirrors initially assigned to the players, get re-mapped over the controllers after some random period. The players then have to find a strategy to quickly discover the new mapping and rapidly resume solving the level before more random remaps are applied. Secondly, the time available for completing each level is shorter in the hard mode. Finally, in hard mode, the mirrors' health deteriorates faster, upon an incident ray, leaving the team less room for mistakes.

3.6 Scoring system

The score of a level is the weighted sum of Time Score (S_t), Friendly Damage Score (S_f) and Retry penalty for failing a level (S_r) between 0 and 100 (best score). Different components of the score can be given different weights and tailored to specific needs. Currently, the game uses equal weights, because it is simple and gives a broad picture of the various metrics measured. The final score of the game is the average of the scores obtained in all levels. A game is played in the same difficulty mode even though the scoring system is uniform across all levels and difficulty modes, because changing difficulty mode would introduce new variables and skew any comparisons among teams.

1. Time Score

Time Score expresses how fast players can solve the levels. Levels have time limits to create a sense of urgency, put pressure on players individually and the team as a whole. Team performance in adverse conditions is measured through time spent; naturally, teams with higher collaboration potential require less time. Higher Time Scores are better represent a faster level completion.

$$S_t = \lfloor \frac{T_l - T_u}{T_l} \times 100 \rfloor \quad (1)$$

S_t : Calculated Score.

T_l : Time Limit of a level.

T_u : Time taken to complete a level.

2. Friendly Damage Score

This score represents the damage a player does to team mates by pointing the light ray at the back of their mirror. A higher score can be earned by collaborating efficiently and is thus better. Mayer et al. [9] mention that the number of errors inversely correlates with the efficiency of information exchange, and hence of collaboration potential.

$$S_f = \max(0, \lfloor \frac{H_t - H_l}{H_t} \times 100 \rfloor) \quad (2)$$

S_f : Calculated Score.

H_l : Damage. H_t : Health.

H_t starts at 1000 in all levels and it is the collective health of the mirrors i.e. doing 250 points of damage to 4 mirrors will cause the team to fail the level. Pointing the light ray at the back of another mirror will start doing damage after 3 and 2 consecutive seconds in easy and hard modes respectively. Damage per second in easy mode is 25 and 50 for hard mode.

3. Retry penalty for failing a Level

The team can fail a level by losing all health to friendly damage (Eq. 2) or by exhausting all their time; in either case, they have to retry the level. Based on the above argument, stronger collaboration potential correlates with fewer retries. When a level is retried, a penalty of 20 is applied (Eq. 3) and the score of a successful attempt is taken. Retrying successfully solved levels to get a better score is not allowed because then the solution of the puzzle is known and finding the solution together is also a part of collaboration. The penalty value of 20 was empirically selected and should likely be adjusted after gaining more insights into the game, in particular by benchmarking it with other objective assessments.

$$S_r = -20 \times N_r \quad (3)$$

N_r : Number of failures

4 Evaluation

In order to evaluate Mirrors in Smog City, two experiments were conducted. In the first experiment, of subjective nature, a group of participants was asked about whether the game had a collaboration element in it. In the second, objective experiment, the game scores of two teams were compared in order to assess which of the two teams has a better collaboration potential.

4.1 Subjective experiment

20 participants (5 teams of 4 players) were introduced to the controls, objectives and backstory of the game. They were given a maximum of 10 minutes to play the game without any help or intervention from the research group and filled out a questionnaire immediately afterwards. All questions were answered on a scale of 1 (very little) to 5 (very much). The survey had the following three questions on collaboration potential:

- Q1: How much did you depend on other players?
- Q2: How much communication was required in your team?
- Q3: How much collaboration was required in your team?

Question	Average Response	Standard Deviation	Min	Max
Q1	3.78	1.11	1	5
Q2	4.11	0.83	2	5
Q3	4.39	0.78	3	5

Table 1: Result of the survey on perception of collaboration element

Table 1 summarizes the results of the survey. We posit that question **Q1**, about the "dependence on team mates", likely received a relatively low score because, for some participants, the first levels turned out to be easier than expected and, at the time the experiment was conducted, hard difficulty mode had not yet been developed.

4.2 Objective experiment

Two teams of four participants, with no prior knowledge of Mirrors in Smog City, volunteered for this experiment. Team A has worked together on a project for 3 months and claims to have good team dynamics. On the other hand, Team B consists of four random participants who met each other for the first time when they started playing the game. so, Team A has prior experience collaborating and Team B does not. This is expected to be reflected in the objective outcome of the experiment, namely in the game scores of both teams, as defined in the previous section.

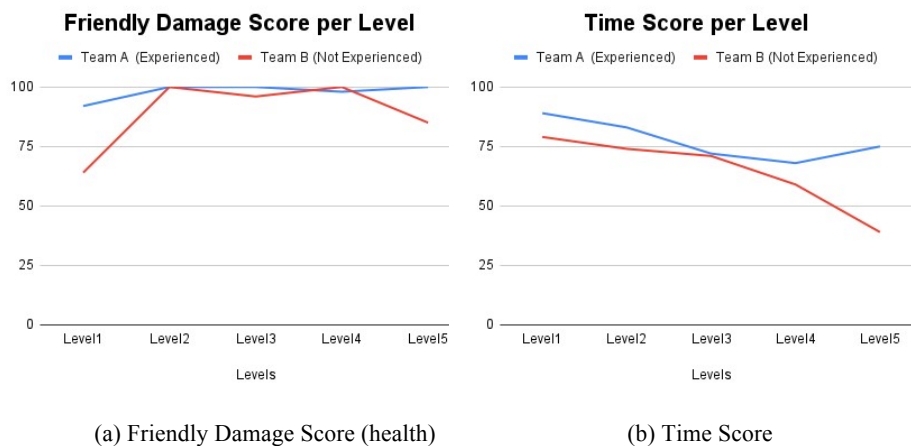


Fig.9: Scores per level, for Team A (Experienced) vs Team B (Not Experienced)

Figure 9a shows the Friendly Damage Score for each team. Clearly Team A (average score 98) does much better than Team B (average score 89). Team B also had to retry a level because they destroyed one of their mirrors due to poor collaboration (deciding who and how to deal with the situation). This failed attempt resulted in a deduction in the final score. Note that Figure 9a shows the damage done in the following successful try. Interestingly, Team B quickly learns how to collaborate successfully, although that does not go without struggle, as seen in the drop of the score at Level 5.

Team B has an average time score of 64.4 and shows a consistent drop in time taken to complete a level (see Figure 9b), because level complexity increases requiring stronger and more efficient collaboration among team members. Team A has an average time score of 77.4 and shows smaller drops in Time Score as the complexity of the levels increases, possibly indicating good collaboration potential.

The final score is calculated as the sum of the two previous scores (see Figure 10) and, as hypothesized, Team A does better on all levels. In the easiest and hardest level, Team A strongly outperforms Team B. Teams A and B got a final score of 87.7 and 76.7, respectively, which is not surprising. Of course, this experiment only gives anecdotal evidence that Mirrors in Smog City can be used to assess collaboration potential. Apart from a larger sample size, a thorough evaluation will also need to include a benchmark with an objective and, if possible, standardized method for assessing collaboration potential.

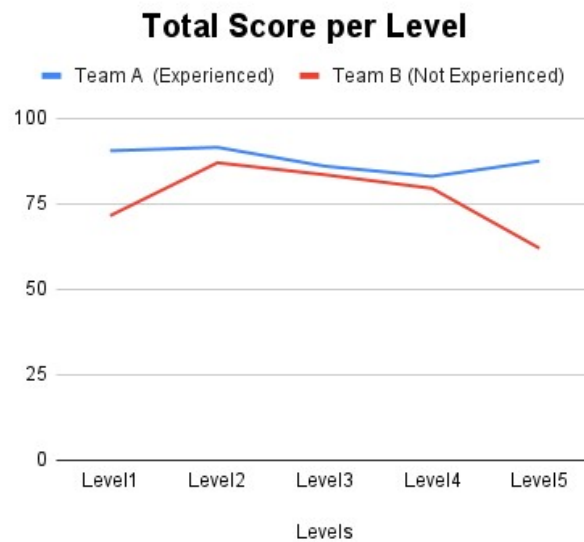


Fig.10: Total Score per level

5 Conclusion and future work

Mirrors in Smog City estimates collaboration potential in a team of 4 players and also answers our Research Questions (see Section 3). The process is independent of surveyor bias and individual feelings of players, because surveys are not used. Instead, results are given immediately after playing the game. The game is also accessible to most age groups by reducing dependence on complex controllers and using simple intuitive game elements.

So far, we performed a preliminary evaluation of Mirrors in Smog City. A first experiment (see Subsection 4.1) measured the perception of collaboration elements present in the game: its participants overwhelmingly confirmed it. Another experiment (see Subsection 4.2) focused on the score, and involved two teams: one that had prior experience working together and another team that had never met before. The scores obtained by the first team were all higher than those of the second team. This outcome, although based on just two teams, indeed hints at evidence that the game can be used to assess collaboration potential.

The current version of the game, however, is still just a proof of concept, and as such does not yet guarantee an accurate assessment of collaboration potential of a team. More experiments with larger sample sizes need to be conducted to guarantee the effectiveness of the game. A possible limitation is that the game does not measure what happens outside of the game (e.g. the quality/quantity of verbal/non-verbal communication), nor does it track how individual players evolve through the game, because its goal is to focus on team dynamics. Precision in the estimation of the degree of collaboration potential could likely be increased by analyzing communication, facial expressions, and other means to evaluate the atmosphere, emotions and interactions of the players. Naturally, a thorough evaluation will also need to include a benchmark with an objective existing method for assessing collaboration potential.

Mirrors in Smog City can further be extended by adding more levels and interactive elements. Many building blocks already exist in the game. Their use is very flexible and with a few more elements, many more unique levels can be created. Complex elements like a chaos moment where the scene is randomly rearranged (objects are moved, mirrors are rotated, switches are reset, etc) or dependent mirrors (moving a mirror will also move other mirrors) can be added. This will likely add more surprise, increase difficulty and, hopefully, allow for a better estimation of the collaboration potential of the team.

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Playing with flows in transition territories

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Abstract. These environmental and social challenges of the Anthropocene require us to imagine and implement alternatives to the current global economic organization. Accounting in biophysical flows (material, energy, land use, ...) is one grid of analysis providing insights on the alternatives' sustainability (strong sustainability and ecological economics frameworks). These tools are indeed relevant to highlight systemic effects (interdisciplinary understandings, spatial and temporal scales) on resources and important pressures to consider for the transformation of territories. If this biophysical flow vision may be very useful, it however remains for expert use only. However, one of the challenges of transition territories is to involve the populations in participatory processes in order to put their knowledge, wishes and specific capacities for action in synergy. Among the several participatory tools, serious games have long since proven their ability to sensitize to sustainability issues, facilitate learning and support changes. This paper presents an exploratory work to get insights on how playing with material and energy flows, fostering biophysical accounting and systemic vision learning to support stakeholders in territories' transitions. A first work on literature aims at understanding how resource flows are involved in existing sustainability games. We then present three experiments we made to play with material and energy flows analysis: one first game focusing on biophysical accounting, two games aimed at pointing out systemic effects on resources and three workshops in which an energy flow analysis diagram was discussed with stakeholders in a territory involved in resource management participatory process.

Keywords: biophysical accounting, material flow analysis, participation, serious game, transition

Introduction

Transitions of territories (cities and/or rural areas) require multiple forms of engagement and adaptation from stakeholders [20, 22, 25], under several biophysical and socio-institutional constraints. In this research, we focus on two groups of stakeholders: the first one comprises policy makers, public engineers and public administrators, and the second one citizens, private operators, and representatives of citizens. The first group has to cope with policy design, implementation and adaptation, while the second one may consider engaging in behavioral changes at the levels of businesses, households, and daily activities. New dialogue processes may be required for both. Transitioning toward alternative socio-technical organizations is their common challenge, if they endorse it. This requires coordination and compliance with various constraints in terms of resource availability and use patterns, balanced satisfaction of stakeholders' expectations, and social or institutional norms. The challenge problem could be formulated as: "how can we restructure our activities to cope now and later with bounded or declining resources (natural or socio-technical), considering the diversity of our needs and uses, the prevalent power structure and the current social and institutional situation?" This induces the following methodological research issue: "what are the related stakeholders' needs in terms of learning, adapting social norms, social relationships and practices?"

Methods for accounting biophysical flows (material, energy, land use, ...) provide one grid of analysis conveying insights on the alternatives' sustainability (along strong sustainability and

ecological economics frameworks) [6, 8, 13]. These tools are relevant to highlight systemic effects (interdisciplinary understandings, spatial and temporal scales) on resources and important pressures to consider for territorial transformations. Their transformative role can be strengthened by including them in game based processes – “playing with flows” – whereby players can explore and eventually commit to new resource and flow management strategies [2].

Playing with flows in and for transition territories requires new hypotheses related to the following needs of stakeholders:

- [Systemic learning] Discovering and endorsing systemic dependencies between multiple resources and activities in their living areas,
- [Assessing alternatives] Assessing possible technical and social alternatives, by testing and discussing their social and ecological impacts,
- [Social assessment] Reflecting on social beliefs, preferences, and their consequences,
- [Engagement] Engaging all stakeholders in an informed deliberation and decision process, leading to actual commitments and actions.

This paper presents an exploratory work on getting insights on how playing with material and energy flows, fostering biophysical accounting and systemic vision learning, may support stakeholders (especially citizens, private operators, and representatives of the civil society, who are not used to these accounting tools) in territorial transitions. Section 1 assesses the usefulness of biophysical tools in supporting transitions. Section 2 explores existing flow-based games. Section 3 describes an iterative test of simplified “flow-games”. The results are discussed in Section 5, leading to the introduction of the “TransKey” formalism and apparatus (Section 6).

1 Biophysical flows as a tool to evaluate sustainability

Biophysical accounting tools aim at representing the society’s functioning, analyzed through the biophysical (material and energy) flows caused by human activities. They highlight human-nature interactions and their evolution over time [10, 13]. Among these tools (environmental assessment methods such as life cycle analysis, input-output analysis, footprints, ...), we focus here on material and energy flow analysis (MFA). MFAs track extraction, production, transformation, trade, waste flows and related pressures in territories [6, 8, 10]. They provide insights for resource management and, depending on data availability, can be done at company, local, regional and national scales [3, 13].

Because they are based on biophysical coherence (thermodynamics laws on mass and energy), these tools track all flows thus reducing blind spots [10] and revealing linkages between resources, organization and pressures. They ease systemic learning and thinking, pointing out specific effects: competition for the use of resources (different uses requiring the same resource), geographical pressure transfer (externalization of pressures from consumers to producers), transfer between pressures (a production alternative shifts the pressure on the environment from one type to another), etc. [4]. They also constitute alternative assessment tools for scenarios of socio-economic development, to evaluate their impact on resources and to identify the resulting pressures [3, 8]. Finally, these tools are already used to support decisions. Companies and supply-chains use them to optimize material flows and waste streams in production processes (industrial ecology). Regions use them as a diagnosis tool to set up monitoring programs aimed at designing suitable strategies (e.g., regional bioeconomy strategies, regional biomass plans...). An extensive survey of their uses in decision support can be found in [13].

Yet, these models remain limited. Setting up their quantitative description requires data and expertise, often implying substantial data gathering costs and dependencies on data gathering methods (data availability does not always match decision scale, especially for local problems) [3, 10]. They are mostly static (describing the current state of a system, with no information on its evolution) and cannot easily support dynamic simulation or show flows’ evolution over time (requiring even more data). Moreover, they lack social assessment and engagement. Indeed, they only provide biophysical information, without any insights on the decision framework nor the

social control underneath. Yet, these insights could help users to go beyond flow description and discussion, and couplesocial considerations to the biophysical constraints.

To support decisions coping with social beliefs, preferences, constraints and to engage stakeholders in an informed deliberation and decision process, these biophysical models should be coupled with social models (endogenous social integration), be included explicitly in collective decision processes through participatory modeling [30] or in simulations like role-playing games (procedural social integration). In the literature, despite several efforts [13], there still exists a gap regarding the involvement of a larger diversity of stakeholders in the use of these models, especially in participatory processes aiming at the co-construction of a territory's transformations [15]. Such an involvement could be an opportunity to better understand the use and impact of MFA models for public decisions: do they really facilitate systemic thinking? Are they a good boundary object, fostering debate and deliberation (see [18] for example)? What could be a good decision framework to be coupled with these tools?

2 How are flows dealt with in games in the literature?

Games have long since proven their ability to foster territorial transformations [2]. In this section, we explore some examples involving flows and biophysical coherence, and discuss their relevance for systemic learning, assessing socio-technical alternatives, social assessment and engagement.

2.1 Choosing the games

We conducted a literature search based on key-words related to sustainability fields involving MFA, used together with “serious game”: “material flow analysis”, “territorial metabolism”, “territorial ecology”, “urban metabolism”, “social metabolism” and “socio-economic metabolism”. We have chosen to present here only the games that seemed to involve biophysical flows or had an intention to sensitize to a systemic analysis of the biophysical structure. To this first category, some nexus games and games related to circular economy or industrial symbiosis have been added to the study, as well as a few resource management games involving biophysical flows without focusing on them [12, 14, 16, 17, 19, 21, 23, 24, 26]. A large part of our research being inspired by the Wat-A-Game toolkit [1,11], a versatile modeling and game toolkit for water and other resource dynamics, we have included it too for comparison's sake. This literature survey is not exhaustive and is only aimed towards future game and experimentation perspectives.

2.2 Game analysis framework

The objectives here are to get insights on how to involve flows in sustainability games and to evaluate whether these games fulfill the four stakeholders needs, namely systemic learning, assessment of alternatives, social assessment and player engagement. Our analysis is split into three different parts: game description, flow representation, and fulfillment of needs. Letters and terms in *italics* refer to ones used in Table 1.

Game description. This category covers

- the *game name*,
- the *game support* (*online*: numeric interface, *board*: physical interface, *hybrid*: physical and numeric interfaces),
- the *game environment* (description of the situation played (*S.*) and the stakeholder roles involved (*P.*)),
- the *game objectives* in terms of target players (*P.*) and learning objectives (*L.*). We have identified 8 specific learning goals (*L.*) in these games. Three of them are related to systemic learning: *interdependencies* (between sectors, along a supply chain, ...), *time interdependencies* (short and long term consequences) and *space interdependencies*. We

add to them *circularity* learning (to optimize a supply chain by introducing flows, using systemic learning). Three goals are related to sustainability-related characteristics: *sustainability* learning (raising awareness of environmental disruptions), *stress* (urgency and stake in the decisions) and *uncertainty* (on the information about the present and the future). Finally, *relational* learning (discovering stakeholders' representations of reality) is related to the decision framework.

Biophysical flows. This category covers

- the *biophysical representation* to detail what resources and pressures are involved and how (*res. rep.*: tokens, indicators, cards, ...), as well as what *flows* are involved and how.
- the link to *data* that qualifies data involved in a game, with respect to intelligibility (people can imagine the data), accuracy (the data chosen allow a correct simulation of the phenomena at stake) and playability. Games can use *real* data (automatically chosen for online games unless otherwise stated), discretized data (*disc*) (automatically chosen for board games unless otherwise stated). The use of abstract data (no direct link with reality) has not been observed here.

Stakeholders' needs. If the systemic learning, explicitly mentioned in some games' objectives, has been kept apart, assessment of socio-technical alternatives, social assessment and engagement have been gathered as a decision framework.

- *Systemic learning* aims at pointing out systemic effects related to resources that might otherwise remain blind spots. The games thus highlight interdependencies (*I.*) that can hold between sectors, spatial or temporal scales (short and long term). These interdependencies can be pointed out (*H.*) through the *game structure* (that constrains the actions a player can take, thus pointing out dependencies), *trade-offs* (between indicators, since improving one requires decreasing others) and *relational* aspects (discussions to realize dependencies, conflicts and shared interests).
- The *decision framework* is composed of the available actions as well as the interactions between players' decisions and the biophysical structure of the game. In most of the games, players were entitled to individual actions with collective consequences. These actions mainly depend on roles and could be *controlling the biophysical flows* (transport, production, transformation, trade, consumption and waste), *controlling the technology and infrastructures related to these flows* (infrastructures and technology investments, infrastructures buildings), *controlling the social structure of these flows* (resource allocation policies, resource management policies, life-style policies). Note that in each of the studied games, players are allowed to talk with each other and can thus collectively decide which individual actions each of them will take. Most physical (board) games disclose and share all information, whereas digital games can keep secret some flows, processes or individual capitals. Information concealment is a well known key factor in decision patterns.

2.3 Insights from the literature

In each of these games, material and energy resources are involved but represented through different strategies. Some games hide the flows and the underlying models from the players (black-box effects) and let them discover the system functioning through the consequences of their decisions. Among the games that materialize biophysical resources, only the ones explicitly focusing on "supply chain" or "circularity" (CircusSChain focuses on making a supply chain circular [17], Sanitation planning game focuses on the circularity of wastes, CAP'T'EN ValDech and CAP'T'EN Bois involve biomass and wood supply chains respectively [12]) involve resource transformations while the others only focus on resource circulation. As for the data involved in the games, three strategies appear. Real data (in online games only) allow for a quantitative description of the biophysical system. They can however be difficult to apprehend

and indicators are often added to help players to imagine the data and make their trade-offs. Playing with discrete data allows for the use of tokens but requires hard work to remain accurate while reducing different data (types and orders of magnitude) to small integers. Finally, abstract data have not been chosen in these games. If this could highly simplify a game, debriefing to help players to relate the game experience to reality is harder.

Each of these games (besides CircusSChain [17]) aims at proving how systemic thinking is important (consistent with the stated learning objectives), by putting the system under stress and forcing players to compromise. Yet, different strategies are used: some games directly use the flow structure, constraining players' choices by resource availability (tokens left) or pressure levels. A similar strategy is used through indicators: the constraint is not directly on the availability of tokens but on the extent of sliders allowing to reach a chosen alternative in the remaining space of feasible solutions. Finally, and often used as the main strategy in nexus games, systemic learning is based upon the relationships between players: different roles involve different interests. Negotiations to improve one's interests lead to highlighting links between sectors and scales (links explicitly shown in the game or hidden in a computer code).

In most of the games, socio-economic indicators have been added to force the integration of the biophysical structure in socio-environmental systems. Once again, the case of CircusSChain must be treated separately. The objective here is to optimize the supply chain by allowing its circularity, and is thus decorrelated from a real socio-environmental system.

3 Testing assumptions in simplified iterative games

Based on the literature analysis, we have conducted in this work three iterative experiments to explore MFA and systemics based games, as well as the use and impact of such models in participatory processes. It was not intended at this stage to produce comprehensive analytical results on each game, but to feed a critical review of design principles, leading to the generic apparatus described in section 4.

3.1 Can players explore systemic effects?

Our first assumption while playing with flows is that it could foster systemic learning. Based on biophysical accounting, we chose to design resource management games focusing on two chosen systemic effects. Playing them, we aimed at assessing social agents' interests into systemic thinking and at gaining insights on designing flow games.

The "Chicken Game" [4, 27] (see figure 1) focuses on the geographic transfer of pressures. From the cultivation of soybeans in Brazil to the French supermarket, each "industry" player represents a step (industry and location) of making a roasted chicken. Each step induces pressures (land use, energy and water needs, and greenhouse gas emissions) only known by the corresponding player. One person plays the consumer who, in the first phase of the game, climbs up the production chain, and then goes back, collecting pressure tokens at each step, finally ending up in the supermarket with all the pressures induced along the chain. Meanwhile, the "industry" players make a drawing with their understanding of the situation. In this game, pressures are represented by tokens and we focus on resource transformations (from soy to chicken) represented by magic cards. The flows are revealed throughout the consumer's journey. Resource transformation data are obtained from Life Cycle Analyses, rounded to small integers for the purpose of this game. The decision framework is very limited. A systemic learning effect is expected through the surprise of the amount of pressure tokens collected along the chain as well as by the discussions related to players' drawings.

"Cooperate or compete" [4, 28] (see figure 2) focuses on resource usage competition. Three players must collectively create, in each round, six products (two each of three different types). For each product, two recipes, consuming different resources, can be applied. These resources are obtained by exploiting a territory. Some of them are renewable, others not: the latter allow more efficient recipes, but they are depleting. Gradually deprived of these efficient recipes,

players must fall back on renewable resources, leading to competition in their usage. In this game, the resources are tokens but the flows are not represented. The focus is indeed more on the systemic effect of resource usage competition than on flows. Abstract data have been chosen. While the decision framework was not an objective in this game’s design, different types of strong power relations and associated decision schemes were observed in practice. We aim at fostering systemic learning by creating a real surprise at the end of the game when players realize that because of depletion of non-renewable resources, competition in the creation of two product types arises.

These games have been tested (twice for the first and six times for the second), following [9] to analyze the sessions (see [4] for further details), giving insights on their design’s relevance for systemic learning. The main conclusion concerns data management. In the first game, we chose to discretize real data. Yet, the process of transforming real data to small integers is a critical point. Indeed, the players couldn’t project themselves in the game and discussed the realism of the settings instead of experiencing the pressure transfer effect. In MFA, flow data with various orders of magnitude are involved but cannot be neglected because of their relevance in the biophysical structure or their meaning in the socio-economic system. On the other hand, if abstract data avoid this barrier, they complicate the way back to reality (thus the learning), making the debriefing phase crucial but delicate. Thus, players can indeed explore systemic effects through games. However, the game balancing process must be carefully chosen to engage players and foster learning by playing.

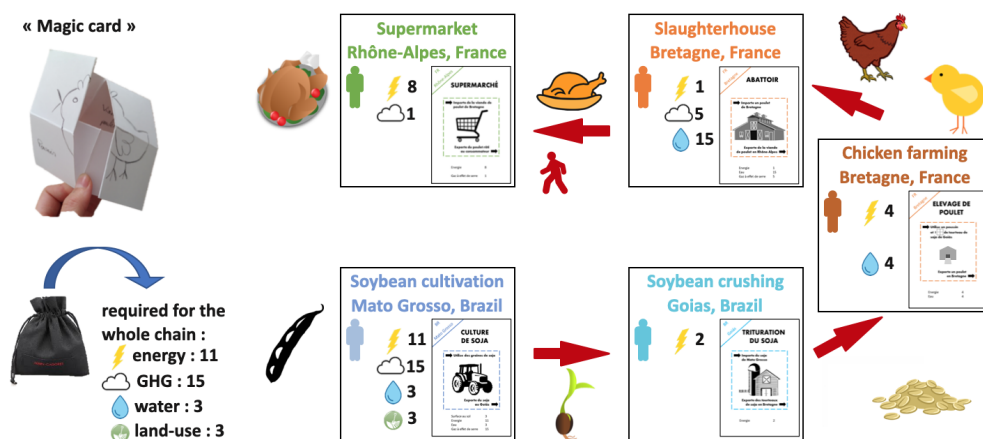


Fig. 1. Chicken game, going back the production-consumption chain.



Fig. 2. Cooperate or compete.

3.2 Can players control biophysical flows?

Besides systemic learning, we assumed that playing with flows could facilitate sustainability assessments, social assessments and engage stakeholders in transitions. However, since MFAs do not explicitly involve a decision framework, games must create one. In most games in the literature, flows are not controlled directly but through indicators. We chose to explore how players could control flows.

To this end, we copied an MFA structure with circulation and transformation of biophysical resources only, without any money. This game (see figure 3) is composed of territories sharing water and energy production, producing food (agriculture) and housing (wood and metals) and related with each other through biophysical flows. Each territory has a limited number of slots to set up production or transformation industries, that transform resources into other resources, GHG and pollution. Finally, each territory has work force units that must be fed and housed to be able to keep the facilities running. Each energy and material resource is represented by tokens, transformed along the “supply chains”. Flows are materialized on the board. The data are abstract. The decision framework is mainly organizational: each player can decide what industry to set up in her or his territory and who to trade with. Socio-economic indicators are introduced: the ability of each player to provide food and housing to her or his working force determine a level of “social satisfaction”.

Flow circulations and transformations happen to become rapidly very complex. Whereas the initial situation allowed each player to fulfill her or his needs, changing this initialization required complex computations, similar to the reconciliation process¹ for computing missing data in real MFAs: the players have to solve a discrete optimization problem to fill the gaps adequately, given the admissible space left. This is a clear challenge in playing directly with flows, without focusing on indicators only and this has cut short our experimentations on this game design. This barrier might be overcome by introducing stocks and a better designed playing sequence. Following the literature, we could also think of introducing a calculation spreadsheet to help players (yet losing some transparency).

¹ Data reconciliation is used in MFA to translate incomplete and inconsistent data to flows respecting e.g., mass conservation [7].

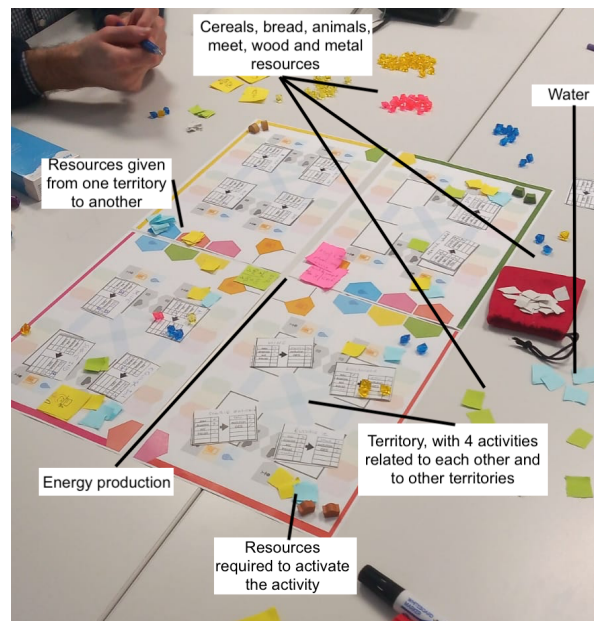


Fig. 3. First attempt to play with MFAs (the board shows four territories, each one possessing four slots for setting up activities).

3.3 Can players discuss flows in real field experiments?

In the literature, MFAs are mainly used by policy makers, public engineers and public administrators. To better understand the insights gained by "ordinary" citizens due to playing with flows, we performed three focus group workshops in the Pays Grand Briançonnais area in France, composed of three communities of municipalities (Pays du Briançonnais, Écrins, Guillestrois-Queyras), on which operates a so-called Pôle of Territorial and Rural Equilibrium (PETR). This territory will soon be involved in a participatory resource management process: it is the head of the Durance basin, with a strong hydroelectric potential and contains biodiversity reserves (Parc Naturel des Écrins, Regional Park of Queyras, Natura 2000 zones). The tourist economy is strong, summer and winter (mountain territory). We have been asked by the president of the PETR to structure an "upstream" debate between the various stakeholders, aimed at reducing contentious blockages (in particular between energeticists and environmentalists)

After performing individual interviews with some of the crucial stakeholders, we realized an energy flow analysis based on a diagnosis realized for the Plan Climat Air Énergie Territoire (PCAET). This flow analysis, adapted to the territory, was then discussed during three focus group workshops (11 people in total). The objective was first to clarify the context of the participatory process to come, but also to put to the test a work with flows. During these workshops and while reading the flow diagrams (see figure 4), people pointed out interdependencies, thus showing a systemic thinking. While people explicitly stated their interest for this type of flow representation, they mainly asked for further information: on specific sectors, on different space scales (where do the flows exactly come from or go to, when imported to or exported from the territory, what is their own contribution in this analysis), time scales (the diagram was for a year, but what about individual months, weeks, or seasons). The decision framework based on these flows was also discussed but once again, through their request of an actor network analysis showing who controls what. These first tests have therefore confirmed the ability of MFAs to enable systemic analysis but also the lack of a decision framework to really make the knowledge operable.



Fig. 4. Workshop session, presenting an energy flow analysis (December 2022).

4 Analysis

Based on the literature and these exploratory experiments, we infer the following insights about playing with biophysical flows, regarding transitions towards sustainability.

First of all, from the literature and from the Chicken Game and Cooperate or Compete, it seems that games are adapted to foster systemic learning, with several game design possibilities. However, the decision framework, gathering alternative assessment, social preferences and engagement seems a lot harder to include.

- A direct control of flows induces complexity. Playing with indicators can be an alternative. Another lead may also be to relate biophysical flow control to information flow. Indeed, to avoid a complicated discrete data reconciliation, players must pre-decide and share options for resource flows. Actuation comes only after the use decisions were taken “downstream” by the “consumers”. Negotiation can occur, as in real life. It requires a clear time sequence regulating an information cycle before action.
- The accuracy of data is crucial to engage people and have them express their preferences. Indeed, abstract data complicates the way back from the game to reality, real data are only available on numeric games thus requiring specific transparency efforts whereas discrete data suffer in accuracy.

Yet, there is a critical relationship between the biophysical structure representation and the social decision framework, materialized in the players’ actions:

- As for the biophysical structure, players can control various resource flows’ intensities directly (through stock controls) or indirectly through the transformation processes (infrastructures, technology). This control can be individual and thus distributed between players, or collective, requiring players to negotiate and decide together.
- Concerning the social and institutional structure, players choose regulation and rules, restricting or enabling the actions they can make on the biophysical structure. Once again, this control can be individual (one player can control distribution policies related to one resource) but it is usually collective.
- Finally, there are drivers on which the players cannot act. In sustainability contexts especially, the complex dynamics due to systemic effects can counterbalance the players’ intention.

Toward a relevant game design, regarding the goals categorized in [5], the users would need to visualize stocks and flows, to decide and control them, under explicit social norms, to elicit and combine constraints related to various resources, to project future transformations, to relate this to various scales starting from their individual level. Therefore we propose the following

alternative apparatus including the key useful features of MFA, but extended to support transitions.

5 Toward TransKey: a prototype model and game for transition support

After this analysis, we have designed a generic model to support new transition game designs, adapted from the previous MFA games and goals. The target features are: representing multiple resource stocks and flows, their dynamics, stakeholders' constraints and control, exogeneous drivers, multi-scale representations, player friendliness, data fitting when required, connecting material and digital versions. The resulting structure is the following.

TransKey model and game

TransKey = {*Resources, Stocks, Processes, Taps, Network, Tapholders, Control Matrix, Control Rules, Payoff, Activation Scheme*}

- *Resources* are any consumable and transferable resource, good or product.
- *Stocks* are specified for each resource (many stocks can exist per resource).
- *Processes* carry, consume and produce various resources, for which a Process Function specifies the transformations and their conditions.
- *Taps* control the outflows of stocks and the activation ratio of processes.
- The *Network* is the overall structure of interaction between components.
- *Tapholders* are social actors (persons or groups) animated by players or the game manager, who “own” some stocks, control the taps and discuss rules.

Figure 5 shows this structure and colored arrows only show the topology of connections. The process WWW is a “pure transport flow”, moving one resource from stock P2 to stock P1, at no extra cost in terms of other resources. Figure 6 adds the tapholders.

The process functions *pf* should be of the form:

$$O_{pf}(t) = pf(I_{pf}(t-\Delta t), t, c_{pf}(t))$$

where *t* is time, $O_{pf}(t)$ is the (discrete or continuous) vector of produced resources at discrete time *t* (round), $I_{pf}(t-\Delta t)$ the vector of the input resource at time $(t-\Delta t)$ with Δt a delay (equals 0, 1 or 2: a delay of 0 to 2 rounds), and $c_{pf}(t)$ the control over this process at time *t*. Autonomous processes without control exist.

Social actuation and regulation: Stocks' and processes' taps are controlled by zero to many tapholders defined in a *control matrix*. For any “tap group”, the “*control rules*” are specified, as mandatory rules (from the model settings) or as players' choices (dynamic: mean rule, vote, random, deliberation, etc).

Each tapholder or group has a *payoff function* depending on some stocks, single- or multi-valued (e.g. current state of one stock, set of values of 2 stocks, weighted sum of 3 stocks, growth, etc).

Tapholders' Activity & Dynamics:

1. Deciding or adjusting each “tap control rule”, or keeping it as it is
2. Deciding and sharing stock's output “offers” by each stock tap group
3. By process tap, tapholders propose individually their control preference for the tap, based on the upstream flow information.
4. The process tap group applies the “tap control rule” to set the process ratio, and the outputs. It computes the input resource actually consumed.
5. The new stocks are updated (subtracting and adding).
6. The tapholders evaluate their payoff.
7. Tap groups assess and express “demands” for incoming resource flows.
8. (option) A tapholder can ask to enter any tap group, which accepts or not.

9. (option) Tapholders can activate new processes chosen in a set. A creation cost has to be “paid” out of the tapholder’ controlled stocks.

The game ends after some rounds or when a given payoff is reached.

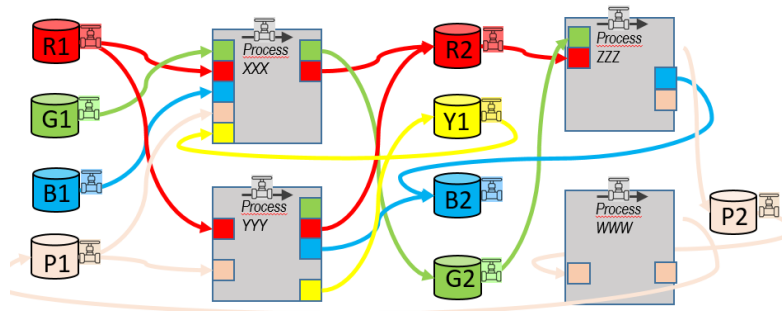


Fig. 5. Transkey model and game structure.

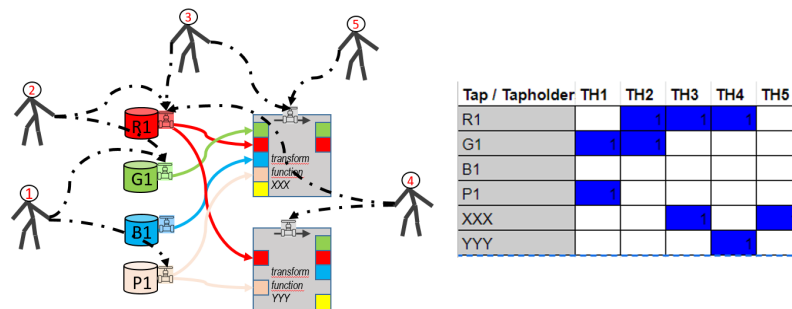


Fig. 6. Transkey structure including stakeholders' tap control.

6 Conclusion

If biophysical accounting and especially MFAs are undoubtedly useful to design transitions, they remain expert tools that cannot be manipulated easily by stakeholders transforming their territories. One way to better understand the use and impact of these models would be to make people play with them during games. The literature gives various insights on how to play with biophysical flows, and especially about how to represent them and which control players have on them. We supplemented this work by three field experiments which pointed out the importance of data, its accuracy and its transformation from real data to small integers. They also confirmed the importance of carefully designing the decision framework. Indeed, to make sure players can build biophysically consistent transition scenarios, the playing sequence involving actions and information flows is crucial. Based on this study, a new game structure has been sketched and further work will include a fully implemented design, putting them to the test and analyzing people’s reactions to better understand how MFAs could be used to support stakeholders in transition territories.

Acknowledgments.

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Table 1. Game literature analysis (“abst”: abstract, “coll.”: collective, “disc.”: discrete, “ind.”: individual, “interdep.”: interdependency, “res.”: resource, “rep.”: representation, “SE”.: socio-economic, “spatial.”: spatialized, “stkh.”: stakeholder)

Game/projet (and support)	Goal	Game environment and roles	Biophysical flows representation	Systemic mechanisms	Decision framework	Link to data
Wat-A-Game toolkit + 180 offsprings games [1, 11] (board, multiplayer)	L. interdep., relational. sustain. P. everyone	S. directed graph with places and actions - any discrete resource dynamic & sharing R. any type	Res. rep.: colored tokens for representation of each resource Flows: movable card connectors on which the tokens circulate	I. Multi-functional exchange and production system H. Relational, trade-off	Ind. actuation of “action cards” transforming res. Coll. decision on res. management and sharing. SE indicators (with and without money).	Disc.
The Nexus Game [19] (board) (multiplayer)	L. interdep., relational. P. policy makers, professionals, students.	S. 2 countries sharing a river. R. Ministers (decide) Journalists (observe).	Res. rep.: tokens (water, food, energy, pollution). Flows: only water flows between players. No focus on res. transformation.	I. Sectors (competition in the use of resources), space, time. H. Relational.	Ind. (sectorial) actions (res. allocation, infrastructures policies). SE indicators (with money).	Disc.
Sim4Nexus [26] (online) (multiplayer)	L. interdep., relational, time. P. everyone.	S. Abst. spatial territory. R. Managers of each sector.	Res. rep.: indicators (food, energy, water, climate, land use) Flows: hidden in the computer code (system dynamics). No focus on res. transformation.	I. Sectors, time. H. Relational, trade-off.	Ind. (sectorial) actions (policies). SE indicators (with money).	Real.
Magic nexus [24] (online) (one player / multiplayer)	L. interdep., sustainability. P. everyone.	S. 1 to 4 regions . R. Managers of each region.	Res. rep.: indicators (food, energy, footprints, water and land use limits). Flows: hidden in the computer code. No focus on res. transformation.	I. Sectors, spatial. H. Relational, trade-off.	Ind. (regional) actions (production, consumption, import of food and energy).	Real.
PostFossil Cities [21, 23] (hybrid) (multiplayer)	L. sustainability, stress. P. everyone.	S. City. R. 7 roles of relevant societal stkh (politicians, population, investors, ...)	Res. rep.: indicators. Flows: hidden in the computer code (based on an MFA model). No focus on res. transformation.	I. Sectors. H. Relational.	Ind. actions (technology or life-style on energy, building and transport sectors).	Real.

Table 1. (following)

Game/projet (and support)	Goal	Game environment and roles	Biophysical flows representation	Systemic mechanisms	Decision framework	Link to data
CircusChain (board, + calculation spreadsheet) (multiplayer)	L. interdep., sustainability, circularity. P. students and professionals.	S. generic supply chain. R. Different actors on the supply chain.	Res. rep.: tokens (material, GHG). Flows: tokens moving along the chain, with material transformation.	I. No (only one sector).	Control information flows. Decide loops to introduce in the supply chain (coll. or not). SE indicators (with money).	Disc.
Sanitation planning game [16] (board) (multiplayer)	L. interdep., relational. P. everyone.	S. Abst. spatial. territory. R. Various stkh. related to sanitation (roles translated at each round).	Res. rep.: cards (waste, food, NPK), indicators (water quality). Flows: dice allow material transformation.	I. Sectors. H. Relational.	Ind. (role) actions (build, transform resource) and coll. action (joint policy). SE indicators (with money).	Disc.
CAP'T'EN ValDech [12] (board) (multiplayer)	L. sustainability, relational. P. everyone.	S. Abst. spatial. territory R. farmers, institutions.	Res. rep.: tokens (biomass materials), indicators (GHG, energy, agronomy). Flows: material transformation and trade.	I. Sectors. H. Game structure, relational.	Ind. (roles) actions (transform resource, trade, manag. policies). SE indicators (with money).	Disc.
CAP'T'EN Bois [12] (board game) (multiplayer)	L. sustainability, relational. P. everyone.	S. Abst. spatial. territory R. craftsman, businessman, manager, park, transporter, builder, sawyer, operator.	Res. rep.: tokens (biomass materials), indicators (GHG, energy, forestry). Flows: material transformation and trade.	I. Sectors (along the supply chain). H. Game structure, relational.	Ind. (roles) actions (transform resource, trade, build, transport). SE indicators (with money).	Disc.
LIPTAKOR [13] (board game) (multiplayer)	L. sustainability, interdep., relational. P. inhab. of gold-digging villages in Niger.	S. Spatial. territory related to the test case. R. Various stkh.	Res. rep.: token (water, gold, wind, ... all resources), indicators (pollution). Flows: water flow and trade between players. No focus on res. transformation.	I. Sectors. H. Game structure, relational.	Ind. actions (get resource, trade, invest in technology) SE indicators (with money) and biodiversity.	Disc.

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Exploring the Pitfalls of Participatory Processes for a Just Energy Transition through Serious Gaming

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Abstract. Designing local energy transitions is becoming an important question for local governments all around Europe. Negative perceived impacts of energy projects on local communities have frequently sparked opposition. Citizen resistance is often fed by feelings of recognition, distributive or procedural injustice. To give policymakers insight into these, (hidden) injustices, we designed the “Just Solar Panels” serious game.

The game aims to make players experience how it feels to be participating in a participatory process from the perspective of different archetypes. The player are expected to balance daily personal tasks, needed to stay happy with processing and acting upon municipal information in a limited amount of time. The stated aim is to maximise points that represent general wellbeing. The roles and tasks are designed in a way that are unfair in a non-obvious way. This mimics reality where citizens with the same information and opportunities to participate may not be able to do so because of systemic injustices.

The game was played in three sessions with students, academics and industry and policy experts. The debrief was focused on eliciting experienced inequalities between players in the game and relating these to reality. The game successfully allowed players to experience injustices and relate these to reality, increasing their understanding of how seemingly just participatory processes can be unjust. In the future, the game should be further developed to enhance its use as a tool for learning and building capacity for change in organizations towards a more just local energy transition.

Keywords: energy justice, public participation, local energy transition, serious gaming, awareness creation

1 Introduction

How to design local energy transitions is becoming an increasingly important question for local governments all around Europe, as deadlines for lowering greenhouse gas emissions are getting closer. The current transition to renewable energy means that many local communities are directly affected by the construction and operation of energy projects. Due to, for example, perceived health and annoyance of wind turbines and solar panels and their impact on the local environment [1]. This has often sparked intense opposition from citizens, which may slow down the development of local energy projects [2–6].

Local opposition to renewable energy projects, despite the multitude of causes and reasons for resistance, is often still ascribed to a “NIMBY” (Not In My Back Yard) attitude in which citizens’ opposition is driven by their self-interest [7]. However, the term NIMBY has been critiqued for being too simplistic and neglectful of the hidden, perceived, and actual injustices that occur [8, 9]. Rather than citizens opposing a project because they do not want their landscape to change, opposition has more complex reasons and is often fed by feelings of injustice in three categories: distributive (unfair division of burdens and benefits), recognition (lack of inclusion of needs and values of citizens), and procedural (lack of agency in decision-making for energy projects) [10].

Nonetheless, even when project developers and policymakers aim to take these potential injustices into consideration through a participatory process, they often still struggle with getting

citizens involved in the decision-making procedure. Attendance to participatory processes is often low, with a low diversity of citizens being present [11]. Limited attendance is not always equivalent to a low motivation to join, as there are systemic injustices that prevent citizens from participating, even if it seems as if their chances to participate are equal as compared to other citizens.

To shed light on the complexity of citizen behaviour and these “hidden injustices” in participatory processes, we created a serious game for policymakers and project developers named “Just Solar Panels”. Serious games can be used as a tool to simulate realistic scenarios and induce discussions or exchanges of experiences and perspectives amongst players in a playful manner [12]. With “Just Solar Panels”, we aimed to do just that. The goal of this game is to have policymakers and project developers stand in the shoes of citizens who are faced with limited information and requests to think along on a solar energy project. In the game, players experience the difficulty of balancing time spent on daily responsibilities with sometimes complicated, incomplete, technical information on energy projects and a call to participate in decision-making. Not everyone is equal in the game, with different players having harder or easier tasks, representing different segments of the population.

The game was designed as a conversation-starter, in which participants first play the game and undergo an emotional experience, and subsequently engage in a debrief in which they share their experiences, feelings, and suggestions for future participatory decision-making processes. As the aim is to make players experience injustices, the game is not necessarily fun or fair for everyone. Design has accounted for that so the negative feelings do not go overboard and, so far, everyone leaves happy after the debrief. Rounds are short and limited in number and inequalities are non-obvious.

In the following sections, we first elaborate on the justice challenges that are of concern in participatory energy projects. After this, we elucidate our research approach. Then we explain the results of initial gameplays and relate this to perceived justice aspects. Finally we argue that the game achieved its aim well and highlight pathways and plans for future research.

2 Justice challenges of energy projects

To better understand the justice issues citizens may face in energy projects and their adhering participatory processes, we employ theories of energy justice. The energy justice field is concerned with granting every individual fair access to safe, affordable and sustainable energy through just energy policies; energy production; and consumption systems [10, 13–15]. Energy justice is commonly divided into distributive, procedural and recognition justice [10].

Distributive justice relates to the way in which the burdens and benefits of energy infrastructures are distributed over members of society, social groups and generations [10, 13, 16]. Procedural justice is concerned with the procedures of energy transition policy and energy projects and relates to the extent to which actors are able to participate in open and transparent decision-making processes [10, 13, 17, 18]. Finally, recognition justice is focused on the degree to which actors’ identities, needs, values and opinions are acknowledged and included in energy systems and policy [3, 10, 19].

Whether an actor perceives any type of injustice depends on their personal and cultural ideas of right and wrong and their normative framework [20]. Such a normative framework is influenced by the actors’ culture and factors such as their gender, socio-economic status and lived experiences with other actors. Each actor’s normative framework is uniquely applied to the specific time, context and location of the energy projects [4, 20]. These normative frameworks might not align with those of the developers of energy infrastructures and responsible governmental bodies. This often leads to citizens advocating for values and concerns that they feel are not included or underrepresented in the participation process [3]. The resulting conflicts often lead to delays or cancellations of energy projects [21].

Governmental bodies and project developers often assume that conflicts result from citizens experiencing a lack of options for participation, NIMBY feelings or citizens having incorrect knowledge about energy infrastructure [21, 22]. In some cases, governments compensate citizens for the damages done to their specific interests or they accommodate citizens' concerns. However, governments usually do not take diversified approaches for each unique group of citizens. Partially because of the burden such approaches would put on their limited capacities, governments instead regard all actors as equal. Therefore, in aiming to prevent and solve conflicts or creating a just energy transition, governments and project developers oftentimes employ general compensation schemes, change their procedures and employ measures such as expanding options for participation, educating the public, or instead restricting options for opposition and refuting citizens' claims [21].

Citizens, on the other hand, often seek recognition justice in the first place. They prefer their unique identity, feelings and concerns to be recognised [3, 4]. Official participatory processes, in which all actors are seemingly treated equally, are often of no use to them, as they experience difficulties in accessing these processes, making their voice be heard, and ultimately having their unique concerns taken into account [3, 4, 23, 24].

These dynamics of seemingly equal and just participatory processes that ultimately misalign with the diverse needs of various groups of citizens, were translated into the design of the game.

3 Research approach

In this section the game philosophy will be elaborated upon. Following this the game and the debrief will be discussed. The results of the debrief will be discussed in the following section.

3.1 Game design philosophy

The intended goal of the game was to help players, ideally municipal employees and project developers, experience the complexity of citizen behaviour resulting from hidden injustices in participatory processes. The game aims to simulate a situation wherein some citizens are not able to meaningfully participate in participatory processes for implementing renewable energy projects even if, at the outset, the processes appear to be procedurally just and inclusive. The game context was based on an exemplary solar energy case in the Netherlands in which initial participatory processes resulted in low attendance of citizens, whereas in later phases when certain choices had been made without citizen consultation, citizens opposed and delayed the project.

Initial analysis of the case study, in combination with a literature study on energy justice, resulted in identification of systemic injustices that could lead to citizens not being able to participate in the municipal participatory decision-making process. These included for example misunderstandings, language barriers, and verbose municipal communication that hindered citizens' understanding of the nature of the participatory process and their role within it. Furthermore, we found that participatory processes are often designed in such a manner that it is challenging for citizens with caretaking duties or other fulltime jobs to participate meaningfully. Such procedural and recognition injustices resulted in limited access to decision-making for many citizens, causing them to feel their needs unacknowledged. In addition, instances of perceived distributive injustice were also identified, in which some citizens experience the burdens of an energy project, whilst others experience the benefits. Eliciting a combination of such hidden procedural, distributive and recognition injustices which have implications on citizen perception of the justness of participatory processes, forms the basis of the game design.

The game aims to make players experience how it is to stand in the shoes of citizens who face the challenge of balancing various commitments in real life, whilst being invited to actively engage in these participatory processes which are also time consuming.

During the game development, we employed the phases and steps as defined by Duke & Geurts [25] using a Triadic game design philosophy [26]. This meant that the game was designed

based on three crucial worlds: meaning, reality, and play. All three worlds have to be present and enough in balance with the others: a game should be meaningful, relatable, and playable to its participants. Note that this balancing act can lead to a specific world being made less important to keep others intact, depending on the intentions of the game designers. In the case of this game in particular it is interesting to note that the game was made unfair and unbalanced on purpose. This, however, is severely limiting for the world of play and may risk players giving up during gameplay. Nonetheless, given the intended meaning of the game – having players experience the (hidden) injustices in participatory processes – this imbalance was deemed necessary as negative emotions are part of that. How negative emotions like stress and perceived (real) unfairness were taken into account will be discussed in the following sections.

3.2 The game

The game takes place in the fictional municipality of Zonedael. The game represents a situation in which six players from different neighbourhoods are invited to engage in a participatory process to help their municipality in deciding where to place a solar park. They need to balance participation with their daily responsibilities (tasks), representing activities that are required for someone's wellbeing, both emotional and otherwise. Having a solar park in the municipality reduces energy prices for everyone, increasing material wellbeing. People in neighbourhoods next to the solar park experience a hit to their wellbeing. The participatory process consists of information provision through letters and allowing players to vote for a preferred location for the solar park.

To represent the resources and wellbeing of people, each player has a certain number of "socio-economic fulfilment points" (SFPs). Each round a player loses a fixed number of these as 'taxes'. If someone is out of points it is assumed that they are overburdened and will not be able to participate in the municipal process because of stress or a lack of time. Players gain points by succeeding in their daily tasks. As SFPs represents social and economic wellbeing, tasks represent non-trivial matters that people do to keep happy. The stated aim for players is to maximise their SFPs by finishing tasks and taking part in the participation process. They are only able to do the latter if they have time for it in any of the rounds and a number of SFPs higher than zero.

There are three rounds which take 5 minutes. The rounds consist of the following actions:

1. Receiving and finishing tasks to obtain SFPs;
2. Receiving and processing municipal information letters (once a task has been finished);
3. Voting on a location for a solar park based on the information letters (if players are aware of this possibility after having processed the municipal information letter).

After three rounds, the game ends. Based on players' votes, the solar park is constructed in a certain location and SFPs are taken away from and handed out to players accordingly.

To simulate injustices we defined three archetypes of players:

- Type 1 players: Representing the upper-class citizen. This citizen is wealthy and has the time and resources to participate. They are positioned next to the nature area on the playing board (Fig.) and gain one additional SFP each round because of this convenience [16].
- Type 2 players: Representing the middle-class citizen. This citizen has an average income and moderate time to engage in participatory processes.
- Type 3 players: Representing the lower-class citizen. This citizen has a low income and less time and resources to participate. Additionally, this player loses two additional SFPs every round for being located near a coal-fired power plant and experiencing health issues and inconvenience from that.



Fig. 1. Final playing board. The Type 1 neighbourhood is white, Type 2 red and yellow, Type 3 black, blue and green. The hexagons with letters denote potential spots for the solar park.

Table 1. Implementation of injustices in the game.

Type	Injustice	Implementation
Distributive	Unequal distribution of benefits and burdens of energy projects	Municipal letters and role descriptions respectively state and implicitly imply that a solar park next to their house will lower their happiness (SFPs), but that a solar park in any location will lower electricity bills for all (increase SFPs). Type 1 players pay one less SFP each round as they live next to nature. Type 3 players pay two additional SFPs each round as they live next to a coal plant.
Procedural	Unequal access to decision-making	Daily tasks and time-restricted rounds: quick tasks for type 1, medium-length for type 2, full round tasks for type 3.
Procedural	Unclear governmental communication (language barriers, miscommunication)	Letters: Written wordy and fuzzy with jargon.

Table 2. Examples of daily tasks for each of the three player types

Type 1 player	Type 2 player	Type 3 player
Starting page: wind turbine	Starting page: wind turbine	Starting page: wind turbine
1. What does WPD stand for?	1. What is another word for an eggbeater turbine?	1. In which era did wind power first appear in Europe?
2. The strongest observed winds on a planet in the solar system occur on Saturn and...?	2. What is the official word for an "egg-beater shape"?	2. Which battle happened in 1389?
3. What was the discovery year of the planet?	3. To what shape is the shape similar?	3. What is the name of the heir of Murad?
	4. When was the AMJRF founded?	4. What is the name of his wife?
		5. Who wrote Tamburlaine?
		6. As a child, where did he study?
		7. When was the school established?

Assuming a player manages to complete their task for the round, they are able to read municipal information letters and act on them. Here, we adopted another identified injustice, namely language barriers and miscommunication. We intentionally wrote the letters wordy and fuzzy, to simulate how governmental communication oftentimes does not match with the ability to process these letters by the target group: they tend to contain jargon or are written in a language that is not or only partially understood by the target group. Some of the letters provide information on the impact of a future solar park on citizens' SFPs, whereas others call for citizens to vote for a location of the solar park by placing their token on a lettered plot. A side-note is that spots A and D require more than half of the votes to get passed as the municipality states that B or C are preferred in their perspective (limiting impact of participation). In case of a draw, the municipality will always choose the location closest to the existing power-plant. If people fail in their tasks they will not see the letter. If they are out of time they will not be able to read the letter well (and may be misinformed by other players) and if they are out of SFPs they are not allowed to vote on a location as it is assumed they are too busy with their personal life.

Initial designs also included letters that were less legible for specific players and actual municipal discussion rounds. These ideas were scrapped to limit stress levels and complexity as this caused disengagement during testing. Moreover, the game already explicitly allows for discussions among players. Like stated, the intention was to cause negative feelings, but not to the extent that players quit the game.

3.3 Debrief

To confirm that the meaning of the game was conveyed well and reflected upon, a debrief was designed around three questions:

1. How did you feel during the game in one word?
2. Did anyone have an unfair advantage?
3. In which ways is the situation of the game representative of real life?

The aim of the first question was to make it clear to all players that there were pre-set differences and inequalities in the possibilities of the different archetypes of players. We expected that in general the type 3 players would feel most stressed and the type 1 player the most relaxed.

The aim of the second question was to open up a discussion on how a process that by design is 'equal', with citizens having the same rights to participate and the same information, may not be fair in reality. Additionally, it served as a test to see if task inequalities were observed and reflected upon. We expected here that participants would in most cases not realise this during actual gameplay as the game itself was designed in a way that would not allow for much reflection. However, we expected that during the debrief, they would realise that certain players had more SFPs and understand that the tasks between players and the initial set-up had not been fair.

The intent of the third question was to see the extent to which players were able to come up with real-life reasons for failing participatory processes. We expected to see the causes that were found in literature come back in the discussions.

As part of the third question the facilitators explain how these processes often happen in reality in broad terms, followed by a discussion with the players on the breadth of mechanisms that can cause inequalities. This question thereby served to allow players (policymakers) to translate their in-game experiences to their real-life experiences. This aimed to make them aware of hidden injustices and spur them to take these into account in their design of energy projects and the accompanying participatory processes.

3.4 Gameplay

The game was played three times with different target groups to test the game mechanics and to check whether the game outcomes corresponded with the intended aim of the game.

The participants per round were as follows:

1. 24 graduate students;
2. 6 scientists;
3. 12 industry and policy professionals from the energy field.

4 Results

In this section the answers to each debrief question will be discussed over the different sessions. Where possible the responses will be linked to justice aspects.

4.1 Debrief Question 1: Describe your feelings during the game in one word.

During game sessions 1 and 2, type 1 players noted feeling “privileged” and “content” and on some occasions “guilty” and “confused”. This made sense, as type 1 players smoothly completed their tasks, while observing their fellow players struggling with a supposedly similar game. While some type 1 players proceeded with the assumption that they were quick because they were simply quick at the game, others felt guilty at having it so easy and were wondering if they had an unfair advantage in the game. The type 2 and 3 players expressed feelings of confusion, stress, annoyance, frustration and unfair treatment.

In the third game session with policy practitioners, the feelings of “frustration”, “confusion” and “stress” were uniformly expressed across all three player types to differing degrees. This was because, unlike the first two game sessions, players here faced unexpected technical difficulties in using their devices. There were significant differences in age and digital savviness between players, in addition to challenges such as dyslexia when consuming verbose information in the form of letters. This resulted in some of the type 1 players who struggled with navigating Wikipedia seeking extra time and support, thereby slowing them down considerably. Players (irrespective of their role type), who were better at navigating Wikipedia and their devices, performed well in the game, even if they had the most challenging tasks. This has led to a more detailed explanation of the task that has yet to be tested.

4.2 Debrief Question 2: Did you feel anyone had an unfair (dis)-advantage in the game?

In the first two game sessions, several observations were made such as: “People living next to nature seemed happier. They didn’t have to pay much at the end of every round” and “People who were less stressed, had more time, influenced the municipality more”. Some type 3 players discovered that living next to coal was bad only at the very end of the game, with many of them expressing the feeling that the game was “set up for them to lose”.

Although the task was designed such that players had to balance time between doing the daily task and reading the information letters, it was not intended to induce extreme frustration that could lead the player to give up on the game. For example, during the first gameplay session, the game consisted of five rounds, with each round lasting five minutes. Some players (mainly type 3) were disengaged by the third round. Their frustration worsened when a) they had no more SFPs left to pay the facilitator their taxes through the distributive injustices in the game, b) they had yet to complete a single task, and c) the procedural injustices allowed other players who had finished their tasks to begin discussing about where to place their vote, whereas the frustrated players did not understand any of this, due to lack of information. Whereas this was effective in eliciting feelings of distributive and procedural injustice, it led to too much frustration. In an attempt to prevent further cases of extreme frustration, the number of rounds per game was reduced to three and the duration of rounds shortened to four minutes from five. This reduction of round duration however resulted in increasing frustration levels for all player types because, the voting round came quickly and did not give the players time to acclimatize themselves to how the game worked. Therefore, the round duration was again increased to five minutes, which effectively removed most disengagement.

Some players from the first two game sessions noticed that the positioning of the players in the game board were the source of inherent inequalities. Some players in session one noticed that players located next to the nature area consistently finished tasks early and accumulated more points. Because these players also had more time, they were able to read the information letters and make informed voting decisions to maximise their benefits. In some cases, type 1 players traded their SFPs with type 2/3 players for a vote that benefited them. Players located next to a coal plant noticed they were not only unable to finish their tasks in any round, but they also saw their points declining more rapidly than others. The feelings of distributive injustice were thereby the first injustices to be effectively experienced and recognised by the players during gameplay.

4.3 Debrief Question 3: In what ways is this situation representative of real-life?

After only a brief explanation of the aim of the game and energy justice players were able to identify causes for all types of injustice in reality well without priming.

Players of all types across all three game sessions agreed that the municipal letters are too verbose and difficult to read, albeit a slightly exaggerated version of real-life letters. One player noted: “Especially when you are coming home after a long day of work and you see so much text– you don’t want to read that.” Migrant players remarked that real municipal letters were even harder to understand for them, as they did not speak the Dutch language. This recognition of injustice, whereby policies and processes are not tailored to the needs of uniquely abled groups, was thus missing from the game but recognized. Other players recognized in-game recognition of injustice in their struggle to read the letters (caused by dyslexia) or difficulties to finish tasks, related to limited digital skills.

Some other observations were: “People who were already in a good situation, got in an even better one”, with a person in the third gameplay recognizing this from their work where certain kinds of people are participating more than others. “People who really wanted to change the situation couldn’t change their life, nor influence anything to improve themselves”. There were reflections on how the game closely simulated reality in terms of ‘rich getting richer’, not just because of the distributive injustice of inherently unequal starting points, but also because of the procedural injustice of more access to municipal information due to greater time availability and a improved ability to bring about policies that benefit their lives. Players noted that although all the information was shared equally and transparently by the municipality via the letters, this actually worsened the situations of certain demographics, because the participatory processes were not tailored to accommodate their needs. This removed these groups’ ability to participate.

It is worth noting that despite game outcomes and experiences differing across game sessions, the reflections and parallels to reality that were drawn during the debriefs were similar across groups, ages and player backgrounds.

Finally it was notable how particularly the type three players, with the hardest role, in each session noted to be impressed with the game. By discussing how negative emotions were elicited on purpose, players seemed content rather than negative. With regards to this final point we would claim that negative emotions, as long as they do not go overboard, can add to a game experience if they are implemented on purpose.

5 Discussion and conclusion

The goal of the “Just Solar Panels” game was to enable policymakers and project developers to gain insights into and experience first-hand the complexities of citizen behaviour in participatory processes as a result of experienced (hidden) injustices in the underlying socio-economic and technical systems in which actors operate. We aimed to make participants aware that even if a process seems just from a municipal point of view, there might be complexities involved that cause the process to be perceived as unjust by some citizens. The game is therefore intended to serve as a conversation starter on justice not only amongst the participants during the debrief, but

also with their colleagues back in their organisations. These aims were tested in three gameplay sessions with graduate-school students, scientists, and industry and policy professionals.

Overall, the design of the three player types and seemingly “equal” individual tasks succeeded in conveying to players that current-day participatory practices, which aim to involve all stakeholders equally in the process, are not necessarily perceived by citizens as being just. The game enabled players to conclude that equal and detailed information provision and options for participation are experienced by citizens differently. Several factors such as socio-economic status in society, time constraints, preoccupations, and language barriers may result in unequal access to participatory decision-making and information. The game allowed players to emotionally experience these injustices and therewith successfully sparked discussion on perceived justice of participatory processes. Players concluded that these systemic injustices, if not addressed properly, can be serious hindrances to effective implementations of regional participatory energy initiatives. Different levels of access to participatory processes would result in only a limited group of citizens being included in the design and planning phase, with the consequences and impact of the project being distributed unfairly to citizens whose voices are not accounted for during the planning phases. By communicating and making players experience how these hidden injustices impact citizens’ access to participatory processes, the game thus aids as a conversation starter on energy justice concepts and their implications.

This game can be further developed to enhance its use as a tool for learning and building capacity for change in organisations. We envision this to be achieved by drawing a comparison between perceptions of justice of participants of the game, and such perceptions of a control group that has not played the game, to test the use of serious gaming in creating awareness for energy justice issues. Furthermore, future research should be directed at observing participants during the gameplay and the debrief and by interviewing them after a certain amount of time. This would help test whether and how participants’ perceptions on justice have changed and whether they saw the contribution of the game in starting a discussion within their organisation on justice perspectives and how these inform decision-making support tools. This allows for the proper assessment of the ultimate goal of the game development: to aid in creating a more just and effective energy transition.

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Pan Africa Business Simulation Games: The ITIS Case Study

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Abstract. Economists have demonstrated a positive correlation between management quality and the country's economic performance. In turn, business simulation games have shown their educational effectiveness in developing management skills crucial for African countries. However, its use is still nascent. Although they present different characteristics favorable to its implementation, for example, The African Continental Free Trade Area, the Digital Transformation Strategy Project for Africa (2020-2030), and The Pan-Africa Games Group, they also present singular characteristics such as the predominance of the informal sector, political instability, and high corruption rates. These factors influence the designing and adoption of the Pan-African Business Simulation Games Framework suitable for this specific context. This proposal aims to contribute a gaming framework to support collaborative development and appropriation by the end-users and Multi-User with content representative of their contextual diversity. The successful EVER project and Bootcamp created by the Mozambican firm ITIS, which adopted a lean startup methodology to add local content in Business Games, can inspire the Pan African Business Simulations Games - PABSG.

Keywords: Game-Based Learning, Business Simulation Game, Pan Africa, Game Design

1 Introduction

The use of Business Games or Business Simulation programmes is widely accepted in literature as having started 3,000 years before the Common Era, and became widespread around the 1950s with the development of computing. The process since that decade has been accompanied by the emergence of international associations such as ABSEL, ISAGA, and others dedicated to research publication and program proposals.

Despite the lack of companies and organisations in Africa providing internships and other practical activities for young people, who make up the majority of the population (Generation Z), [1]-[3] the use of business games, which have proven effectiveness at the didactic level, is not recorded on the continent. The specialised organisation Pan Africa Group Games was only formed in 2021. Projects based on simulations and virtual reality have been used not only because of their proven effectiveness, but also because they reduce risks, costs, and time if the activities had to be carried out in a real context [4]. It is from this perspective that the present article aims to propose the framework design of Pan-African business games. To do this, research was conducted based on literature review, qualitative and exploratory case study because the main question is "what can be learned from the study of startup businesses" [5]. This results from the experience of the author, who was the tutor/teacher/co-founder of the projects SPEE, EVER and Bootcamp promoted by the company ITIS in Mozambique. ITIS identified a problem that could be analysed on the basis of a lack of opportunities for Generation Z internships or a lack of organizations involved in practical learning based on management at international standards (see Fig 1).

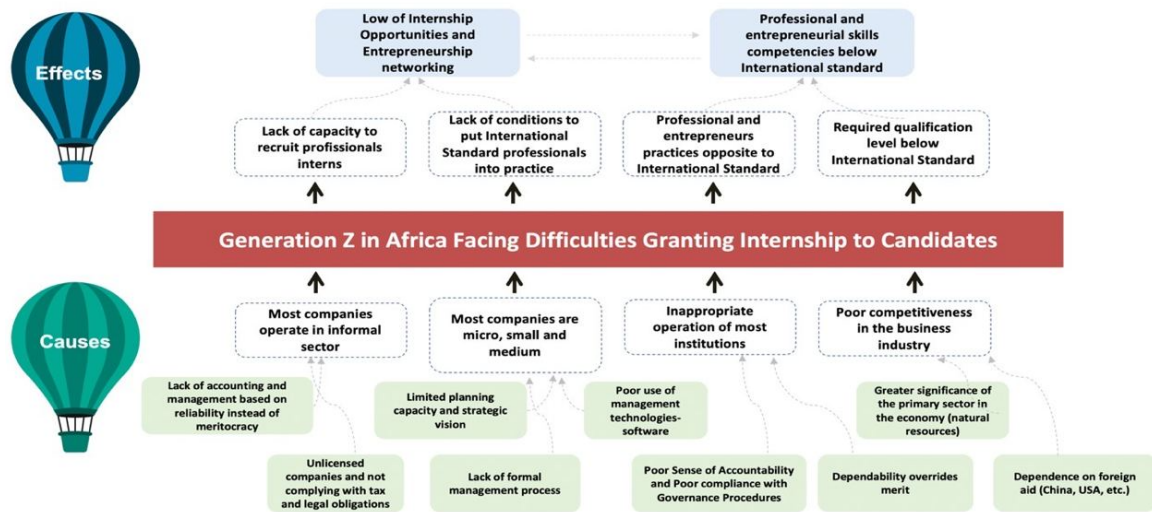


Fig. 1. Tree Problem

This article is part of a vast research project to develop the "framework of Pan Africa Business Simulation Games. This article discusses what can be learned from startups to develop the framework of Pan Africa Business Simulation.

2 Literature Review

Economists and social science researchers have demonstrated a positive correlation between management quality and the performance of people, companies, and the economy of a country [6], [7]. Business simulation games have also shown their effectiveness in developing management skills like communication, teamwork, and strategy definition since the 1950s [8]–[10]. These skills are crucial for developing countries [4]. Various approaches to the effectiveness of entrepreneur simulation games have been made in the context of game-based learning, serious games [11], gamification [12], [13], though the effectiveness of the latter is questionable [14], [15]. There are several empirical studies that support the effectiveness of business simulation games, in their different types (conceptual, top, functional) [16], and interventions at the publication level made by organisations specialised in learning games, most of which were created more than 60 years ago [17].

Despite the African continent having a higher prevalence of developing countries, the use of games is still nascent. However, awareness and opportunities for game adoption are increasing, with a majority of young people (15 years old) having access to technology [18], significant improvements in the business environment index [19], the African Continental Free Trade Area (AfCFTA) [20], and the Digital Transformation Strategy Project for Africa (2020-2030). The Pan-Africa Games Group (PAGG) is the first games organisation representing more than 10 African countries, with over 200 professionals and 8 different languages. PAGG aims to harness the power of gamification to create fun ways to solve some of Africa's challenges, including health, education, women's empowerment, and climate change. However, other characteristics common to most countries still persist, such as the predominance of the informal economy [3], [21], problems in statistics, such as overstated GDPs [1], corruption (Neo-Patrimonialism) [22]–[25], and political instability [22]–[24], [26], [27]. According to Lopes, the challenges in Africa include poor planning, design, and execution skills, macroeconomic volatility, weak institutional and human capabilities, limited investments in social and economic infrastructure, limited investments in technology and R&D, and political instability [1].

Business simulation games are defined as simulators that combine organizational context models with mathematical models to simulate administrative processes in an economic context that should be realistic [28]– [30]. With the increase in computing power and ease of use, students may be asked to create their own "better" versions of the business games, in addition to making decisions in the traditional ones [31]. It is possible to include functionalities that allow end users to appropriate and create content, for instance, wiki [32] or co-creation [33].

Business games may present some similarities; however, they can differ according to several elements such as purpose, target group, rules, among others (see Table 1).

Games Architecture			
Design Specifications	Client Purpose Subject Target Group (Intended Audience) Context of Use		
Social System	Syntactic (Form)	Semantics (Content)	Pragmatics (Use)
Players	Number of players. Number of positions of the participants in the game	Roles Composition of roles in the social organisation.	Context of learning: types of targeting; purpose of learning, Types of knowledge;
Rules	Rules of interaction with the game; Rules of preparation; Rules for starting and stopping; Rigid rules; Rules governed by the principles of the game; Free form; Starting positions; Permitted moves; End positions in the game;	Relationships between roles, communication, rules, procedures Evaluation of destinations/places for resource allocation and relative position between players	Teams of facilitators Format and instructions for strict rules versus free form. Evaluation functions
Resources	Space of the game; Set of positions in the game; Set of pieces;	Positioning of the pieces; significance of the cultural and socio-economic situation Set of occupied and available positions	Materials; Equipment; Accessory or paraphernalia Installations

Table 1 - Klabbers Simulation Game Analysis Framework [17]

The proposed design process should follow similar stages to scientific research, beginning with a clear definition of the objective intended to be achieved with the game, followed by researching existing solutions on the market, their characteristics, and surveying existing research on the topic (see Table 2). The game proposal's conception must undergo successive validation tests. After the validation tests, it will be possible to train the participants responsible for using the system to train others.

Step	Summary Description
Definition of specific objective	Define a set of specific objectives that must be achieved.
Review of previous work	Review previous research to detect and correct deficiencies
Elaboration	Develop the product that achieves the intended objectives
Tests and evaluations	Test on a group that can be used and eventually assess its suitability for the objectives.
Revision	Revise the product
Re-testing	Repeat the testing and review to optimise the product.
Training	Produce a teacher training programme.

Table 2- Steps to Produce Business Simulation Games [41]

2.1 Methodology

For the present article, research was developed based on a literature review, qualitative and exploratory case study, because the main question is "what can be learned from the study of startup businesses" [5]. The qualitative research does not present a diary or chronicle about the case study, but explains through existing concepts around startups and serious games [34]. The paper discusses how the startup achieved scalability during 11 years. Some authors, such as Yin and Creswell, recommend six types of information to collect or multiple sources of data: documents, archival records, interviews, direct observations, participant-observations, and physical artefacts [5], [34].

The group which was selected for research can be called theoretical sampling, the participants interviewed are theoretically chosen to support the best way to form the theory [34]. In this case study, the selection of the group was based on the participants of the bootcamp program who managed to establish a formal company (see Table 3). The information for the study was collected from a wide range of sources, namely: documents such as magazines, strategic plans; videos from YouTube of the EVER program and Bootcamp; physical artefacts such as tax files, accountability reports, and commercial law documents; interviews with the CEO of ITIS and also the 8 participants who successfully completed the EVER program; direct observations (participation in the programs as a trainer), participant-observations (interaction with the participants of the program).


Source	Link	Date
Bootcamp Newsletter 1st Edition	 Newsletter - BSBC_PT 2.pdf	August 2022
Videos about EVER	https://www.youtube.com/@canalitis4096	August 2022
Video about Bootcamp	https://www.facebook.com/itis.ac.mz/videos/751386389403128	August 2022
Xonguile Magazine	https://xonguila.co.mz/rubrics/Oe3L_0B4iHZYOUZCa3gag%3D%3D%2BOutros/cBGjIUntB7rej3DUvxhn0Q%3D%3D%2BTechsolutions	January 2022
Blessking Photography Company	https://www.instagram.com/blessking_photography/	August 2022
Lionesses of Africa Magazine	https://www.lionessesofafrica.com/blog/2022/2/13/startup-story-of-sofia-maquile	February 2022
Softcode Company	https://www.softcode.co.mz/contact/	September 2022
MLDC Company	https://www.instagram.com/lamaisondechoix/?igshid=YmMyMTA2M2Y	September 2022
ITIS Company	https://itis.ac.mz/en/home/	September 2022
ITIS strategy Plan 2018-24	restricted access	September 2022
Accountability Reports	(hard coy)	December 2022

Table 3 - Source of Data

In Africa, although this is a new phenomenon, there are quite a significant number of countries that have already started using gamified solutions and are members of the Pan Africa Games Group¹ (PAGG), which represents 10 African countries. These countries even have centres/studios for the development of Business Simulation games, such as South Africa, Senegal, Cameroon, Ghana, Tunisia, Ethiopia, Kenya, and Rwanda. Additionally, countries like Angola, Namibia, and Mozambique have already conducted studies in the field of BGS.

¹ <https://pagg.group/>

2.2 ITIS CASE

Instituto de Tecnologia, Inovação e Serviços (ITIS) was created in 2010 in Mozambique, with the slogan "*Innovation as Continuous Requirement*" initially having Business Simulation Games - SPEE (*Sistema de Práticas Empresariais e Empreendedorismo*) as their main product. The Business Simulation Games started in Mozambique in 2005 with the Instituto Superior de Ciências e Tecnologias de Mozambique (ISCTEM) with a platform acquired from the Expandindustria² company based in Portugal, followed by UEM being acquired by Aveiro University³, Portugal in 2009. In 2010, ITIS launched the first Business Simulation Game called System of Business Practices and Entrepreneurship - SPEE, becoming the first and only startup in Mozambique in the serious games sector. "A startup is a temporary organization in search of a scalable, repeatable, profitable business model" [35]. The ITIS achieved scalability with a new business model. First of all, it is based on subscriptions that could be acquired semi-annually, annually, or by getting an unlimited license. Second, SPEE was designed based on local reality and feedback ("appropriate, guiding, and significant") [30] from potential customers (players), business stakeholder's environment such as the stock exchange, banks, revenue authorities, universities, business associations, etc. from an iteration perspective, i.e., a lean start-up approach [36] and "because great ideas come from networks, not individuals" [37]. According to [1], local realities:

"Any approach aimed at understanding Africa's development and related challenges that ignores the roles of local actors but privileges large actors such as the World Bank misses the reality of development as a homogeneous activity. To block out any sterile theoretical excess, we must take into consideration the roles of different actors in society and consider how each defines its own reality of development."

The majority of business games in Africa (Mozambique Case) is similar to the World Bank and International Monetary Fund program in Africa (Structural Adjustment Programs - SAPs), i.e., policy prescriptions that are applied without proper context. "*Too often, these conventional policy recommendations focus on one-size-all and business-as-usual models that do not accommodate Africa's diverse and fast-changing realities nor do they allow for local agency*" [1]. Additionally, the player (student) will not be able to develop a mental model that is congruent with the real phenomenon if the game model does not accurately represent the genuine reality [30].

Third, SPEE adopted a model similar to the one developed by Henry Mintzberg (experiencing management by action) [38], in which students are not forced to simulate in one sector or company but to create a company according to their dreams, expectations, or previous professional experience.

The scalable recurring model can be noted by the growth (see Figure 2), where between 2010 and 2017, 10 higher education institutions started using SPEE. By 2019, bootcamp Business Simulation was tested for adolescents between 11 and 17 years of age, and in 2020, an internationalisation process began with the EVER project (virtual internships) involving Portuguese-speaking countries, namely Brazil, Angola, Mozambique, Cape Verde, São Tomé and Príncipe. Over the 12 years of SPEE, trainees have created successful companies, such as Edilson Alberto (18 years old), Prince Chone (17 years old), and others in table 3. It can be said that the product fits the concept "Job To be Done - (JTBD)" [39] by promoting the spirit of entrepreneurial attitude and good management practices for which it was designed.

² <http://www.expandindustria.pt/>

³ <https://www.ua.pt/pt/uc/10115>

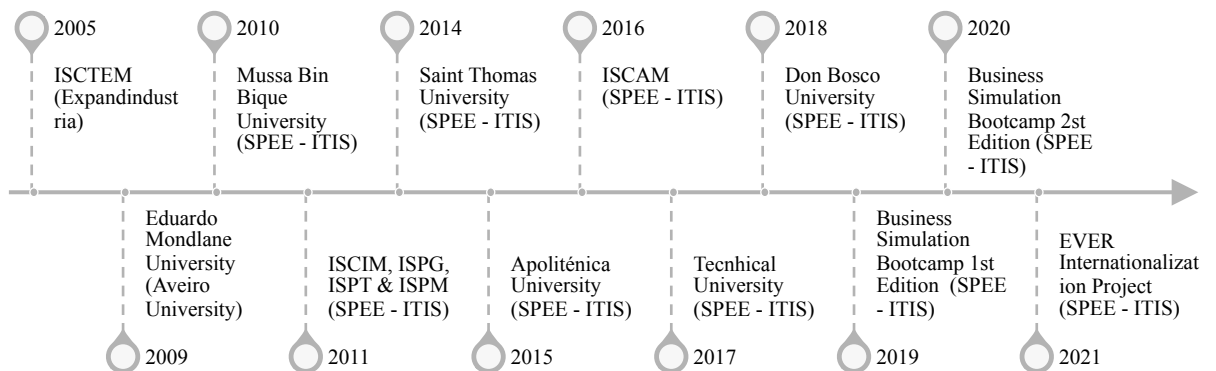


Fig. 2 - Chronology of the Implementation of Business Simulation Games in Mozambique

The EVER experience involved students from five Portuguese-speaking countries, where four virtual companies were created in Mozambique. The participants showed enthusiasm for the e-learning project, and despite not knowing Mozambican legislation and having their first contact with SPEE in EVER, it was possible to see that young Africans are "native speakers" in digital tools [11]. Participants noted that business games are key to developing skills such as professionalism, leadership, teamwork, critical thinking, assertiveness, time management, diversity, and responsibility [40]. In the experiment, it was possible to see that African countries with few resources to acquire laboratories can benefit from gaming technologies to simulate various scenarios [4]. The purpose of SPEE is to develop management and entrepreneurial skills, and currently, it is not known whether the participants of the EVER project created companies in their respective countries, as happened in the Bootcamp and in the Universities in Mozambique. Nevertheless, research has shown that business simulation players were successful in their professional careers [41].

3 Conclusion

The design of the Pan Africa Business Simulation Game Framework can be inspired by various theoretical approaches and the ITIS experience with EVER and Bootcamp. However, the success of EVER and Bootcamp was due to the target group being young, familiar with information technologies, and the design taking into consideration local content (Glocal) based on "the lean startup" development and "experiencing management by action" by Mintzberg.

However, ITIS Software's SPEE has several limitations that prevent it from becoming a PABSG. Firstly, it only caters to one business environment (Mozambique), and it does not allow to configure for simultaneous simulation of the several of context business (different countries). Secondly, it is only available in Portuguese. Lastly, end-users do not allow to contribute creating new content.

Given the predominant characteristics of the African context, including informality, corruption (neopatrimonialism/patronage), and political instability, it is possible to ensure inclusive (lean) development by including functionalities that allow end-users to appropriate and create content, and Multi-User functionalities that enable virtual interaction and collaboration without travel expenses. This is a global trend in participatory cultures that supports the design of interactive technologies for appropriation and reconfiguration by end-users and multi-users. Additionally, artificial intelligence can be used to capture the local experiences of diverse African contexts.

Acknowledgments

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Allyship: The Key to Diversity Management in an Organization

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Abstract. This study aims to understand how to effectively manage diverse human resources in an organization. Companies pursue "Talented Employees" who perform highly and contribute to companies' sales and profit. However, some "Associated Talented Employees" perform highly but need individual support to continue working, such as child-rearing and nursing care. Selecting employees who do not require individualized support is more reasonable based on improving corporate productivity and growth. However, every human has risks that will need such individual care in the future due to illness, change of life stage, or other reasons. Therefore, companies have required a transformation to utilize diverse human resources because of the perspective of the risks. This study focuses on the person with "Allyship" who belongs to the majority but raises questions and takes specific actions toward the minority's detriment and barrier in the organization. Verifying "Allyship" is difficult; therefore, this study develops a gaming simulation to recognize "Allyship" and how it has affected the organization. The analysis shows that the number of occurrences of "Allyship" is rare but significant; furthermore, the examinee's personality and gaming environment influences the occurrence of Allyship. These results suggest that Allyship's generation and persistence are crucial for diverse human resource management.

Keywords: Diversity Human Resource Management, Allyship, Work-life balance, Texting.

1 Introduction

1.1 Situation in Japan

Japan faces a seriously declining birth rate and an aging population. In 2020, the total percentage of Japan's working-age population, aged 15 to 64, was 59.4%, and the G20 countries' average was 67.3%. Moreover, Japan has an apparent decreasing trend in the working-age population [1]. Compared with other countries, we know that this fact is impending an agenda for Japanese companies to secure a labor force for sustainable corporate management. Companies pursue "Talented Employees (TE)" who perform highly and contribute to companies' sales or profit. However, some "Associated Talented Employees (ATE)" perform highly but need individual support to continue working, such as child-rearing and nursing care in the labor market, and already might exist in companies. In other words, ATE is the person who requires work-life balance (WLB) policies in the company. Selecting employees who do not require individualized support is more reasonable based on improving corporate productivity and growth. However, TE has risks that will need such care in the future due to unexpected accidents, illness, or other reasons. Similarly, ATE may change from a situation requiring WLB. Considering the possibility of transforming TE into an ATE that everyone would have, homogeneous corporate management by only TE is challenging.

Companies are only a part of an organization, and there are also non-profit organizations such as NPOs and educational institutions. However, the effective utilization of both types of human resources is a common issue for all organizations. Moreover, diversity management is a global challenge, not only Japan's unique issue. However, each country has different challenges toward diversity since the present internal situation or cultural/historical backgrounds are different. These are the profoundly related identity of each country and have different main target agendas

for diversity which each country have. Based on what we mentioned, in this study, we focus on the organization's primary target, a company; since companies are required to generate profit desperately, this study focuses on companies in Japan.

We identify severe population decline, but other issues are relevant to why Japanese companies are required to change. The utilization of ATE is the same as encouraging diversity management, and there is a limit to maintaining corporate growth through traditional homogeneous management; management by TE resources only. Diversity management is also needed to capture diversified needs and create innovation because the external environment of companies changes rapidly. [2]. Furthermore, gender equality is recognized as an issue to solve as SDGs goals and requires concrete actions toward this. The Government Pension Investment Fund (GPIF), one of Japan's most significant funds, was announced to consider ESG investments [3]. Therefore Japanese companies face the necessity of utilization of women actively to a severe management issue due to GPIF's statement. Companies have to take responsibility for direct profits and global-scale problems.

Empirical research shows that organizational diversity has complex effects on organizational outcomes, both positive and negative [4]. Diversity has negative aspects, but we have no choice but to proceed to manage diversity. Then, what will be the key to accomplishing diverse human resource management to maximize the return? This study focuses on the Ally as a link between the minority and majority groups.

1.2 What is Allyship?

Ally is the person with "Allyship" who belongs to the majority but works for minority and marginalized groups (e.g., racial and sexual minorities) as allies in various ways. Furthermore, Ally raises questions and takes specific actions toward the minority's detriment and barrier in the organization [5]. Diversified organizations may create majority and minority because attributes are not uniform. Primarily corporate activities pursue rationality and expect to reduce inconvenience to the majority as much as possible. However, what is suitable for the majority is not equal for the minority, and it is difficult to eliminate the possibility of inconvenience for the minority. ATE are minorities in the organization since they need individualized care. However, they must continue working in the case of no care, such as flexible working hours or limiting overtime work; it is challenging to overcome through individual efforts, even if they are highly qualified. The majority has difficulty to aware of the barriers to minorities in the environment which structs for the majority because it is the expected standard for them not to have obstacles [6].

We believe that Ally will be critical to balancing diverse human resource management when we consider human resources TE and ATE. The majority has difficulty recognizing the benefits of being in the majority and does not strongly face the necessity for change. At the same time, the minority is not easy for raising issues to move the majority. The problem of majority and minority groups can create an antagonistic structure and cause division within the organization, which will be an obstacle to maximizing the effectiveness of human resources. Therefore, this study set as a core concept that Ally and Allyship, who stands in the middle and link between majority and minority, plays an essential role in diverse human resource management.

1.3 Purpose of this study

It is not easy to verify "Allyship" in the real world. Therefore, this study develops a gaming simulation to recognize how and why "Allyship" has occurred and how it has affected the organization for diverse human resource management.

2 Related Works

2.1 Cognitive Limitations

Humans are multifaced and complex, not easily recognizable information (e.g., biological sex and age) but internal characteristics (e.g., personality and experience). Therefore, ATE is necessary for WLB, and this is not targeting a specific sex or gender.

Kishino and Hirano (2018) stated that those needing WLB indicated "women." The reason was that women are inseparable from the possibility of experiencing pregnancy and childbirth, and these experiences led to the need to leave full-time employment for a certain period. In addition, there was a tendency not to allocate growth opportunities from their consideration toward "women" [7]. Bohnet (2018) insisted that humans evaluate others based on recognizable information from their appearance and past experiences. Therefore, their judgments were always made with bias [8]. Sex/Gender is a label that is easily recognized by others. It is difficult to escape from disclosing one's biological sex as basic information when belonging to a company in Japan, and it indicates that there is a label easily recognized by others.

Companies are making irrational decisions if the companies are currently making allocation decisions for the employee based on their sex/gender, regardless of whether they need WLB or not. As a result, it cannot accomplish effective human resource management and maximize the return the company is supposed to gain.

2.2 The reason for this study method using Gaming & Simulations

We state that ATE tends to be judged as "women," and there is a cultural influence of gender and paternalism in subsection 2.1. It is hard observing a situation in reality in which there is no influence of bias by labels due to human characteristics. Gaming simulation is the appropriate and effective way to observe how people think about, judge, and allocate to ATE in an abstract environment when "labels" recognition is difficult. It is hard to achieve except this approach; therefore, there should be findings to investigate through abstract gaming experiments.

2.3 Elements for this study's Gaming & Simulations

Three elements from related works referred to the design for this study's Game. First, Yamori et al. (2005) developed a game that simulated decision-making in which multiple options were under a trade-off relationship during a natural disaster. Players needed to discuss and decide on the absence of the correct answer. The Game was expected to simulate the experience of considering various positions from multiple perspectives with time limitations [9]. In this study, we referred to this game concept to encourage active discussion and construct a structure with dilemmas with various restrictions.

NIMBY (Not In My Back Yard) is a problem in the person who nears oneself is considered a burden even if a necessity socially, and consensus building is complex [10]. A typical example of NIMBY is an abatement facility, such as a garbage disposal facility. While recognizing the necessity of utilizing ATE, companies may hesitate to allocate significant work actively. The attitude toward ATE can be observed in the Game and referred to as an element of this study's game design.

M&A game which was a gaming simulation to examine the factors that increase the takeover premium in M&A. In this Game, the displayed news content affects the stock price [11]. Therefore, in this study, we referred to the news part to create a situation to encourage discussion and decision-making in the Game.

3 Gaming Method

3.1 Gaming Designs

This Game aimed to observe what kind of judgments toward ATE. This Game was designed ATE, whose concrete circumstances are challenging, but players could observe "the existence of some circumstances." We itemized lists of this game process.

- The players are a group of three.
- They are executive officers of a fictitious company in this Game.
- They are required to assign all employees to achieve the Game goal (KPI and budget).
- This company has 20 employees (20 people) and five departments.
- Each employee is assigned quantitative information (production volume and cost) and qualitative information (such as personality and areas of expertise).
- Each department is assigned KPI and budget targets.
- There is no initial allocation of human resources.
- At the end of the Game, the player's goal is to achieve their goals, fulfill KPI, and budget for all departments.
- Players will be assigned roles (General Manager of Sales, General Manager of Human Resources, General Manager of Corporate Planning), and each role's power is equal for all players.
- Events will be assigned during the Game, designed to encourage discussion and decision-making.
- Immediately after the Game is completed, players have time to debrief their Game with team members.

This Game was designed intentionally as an environment where players feel a substantial dilemma due to vague, strict goals, limitations, and time settings. Players have required a situation in which action and decision-making are necessary. Roles and events were made to activate the discussion to encourage self-discovery toward Allyship during a discussion in the Game. Kurahashi (2020) developed a game to capture the signs of severe but infrequent accidents that occur in a plant (i.e., equipment, machinery). Many incident cases were captured quickly based on discussions of decision-making dilemmas felt during the Game in the debriefing [12]. This study also considered that Allyship might confirm in the debriefing since players at the debriefing part are free from the limitations/pressures of the Game and can share their honest ideas/thoughts. Therefore, this study used debriefing data as the target data for analysis.

3.2 Experiments

We conducted a face-to-face experiment on August 20, 2022, with 15 graduate students who are full-time workers in Tokyo, Japan. Participants' age range is from the 20s to over 60s. Setting team refers to the results of the psychological scale measured before the Game started and gender, which the participants themselves answered. The gender answer column is male, female, or non-respondent. In this case, females were the minority; therefore, we adjusted not to the concentration of the number of females. Additionally, we adjusted specific age groups, and similar trends in psychometric results are not in the same team. This study analyzes the results of the Game and the transcribed data of the recordings of discussions during the Game and debriefing.

4 Results

4.1 Quantitative Game Result

This Game was designed intentionally to create dilemmas that make achieving the game goals challenging. Therefore all teams could not assign employees to achieve the Game's goals to fulfill KPI and cost. This result confirmed the difficulty of this Game and indicated the necessity of analyzing qualitative data to confirm Allyship.

4.2 Analysis by Text Mining Studio (TMS)

We analyzed to verify frequent words and co-occurrence networks using a text mining tool, TMS, the NTT DATA Mathematical Systems Inc software. This analysis showed two types of discussions.

1. Game-Related Discussions (GD): Discussions that aim to achieve "Gaming Goals."
10. Diversified Discussions (DD): Discussions that deviate from the perspective of achieving "Gaming Goals."

DD was a heterogeneous discussion from the perspective of a company's pursuit of rationality. DD had the potential to be Allyship and checked the words in the co-occurrence network. However, the amount of DD words was small, and they hardly appeared in the network.

4.3 Analysis of Contents of Discussions

Subsection 4.2 results clarified the difficulty of being observed the words of DD. We determined whether they were GD or DD in all discussions and analyzed their details. The definitions of DD were complicated because of various discussions. Therefore, we created a list of standard words, as shown in Table 1, which referred to the result of subsection 4.2. For labeling, we referred to Table 1 as criteria; all but those that included the word were considered in the discussion regarding this Gaming goal, GD. Others were considered diversity discussion, DD, and the author manually checked the context before and after. Ensuring objectivity, labeled data by the author was finalized after confirmation by other reviews, and this double-checked method's essence was referred from Miura et al. (2016) [13]. This analysis could be classified into two groups.

- Group 1 (Team A/C/D): The ratio of DD during the Game is high.
- Group 2 (Team B/E): The ratio of DD during the Game is less than Group 1, and the ratio of GD is high.

Table 1. Word list: Game Indicator Discussions (GD) flag words

Category	Words
Quantitative words	KPI/ Cost/ Output/ Cost performance/ Labor costs
Event cards	Talent cards / Talent list
Calculate	Calculation/ Mathematical

4.4 Allyship

Not all labeled DD could be categorically identified as statements with Allyship. We identified only a few discussions with Allyship or Ally-oriented viewpoints from Group 1, the high-diversity group. There were two groups where positive and negative attitudes accept in Allyship discussions.

- Group Positive (Team A/C): Team members accepted opinions with Allyship positively even though the opinions derailed from the main discussions.

- Group Negative (Team D): Team members rejected opinions with Allyship since the opinions derailed from the main discussions.

In this paper, we present Team A from Group Positive, in which the Allyship statement was accepted, and Team D from Group Negative, in which the Allyship statement was generated but not accepted by other team members.

Team A's Allyship statement confirmed the situation; one of the employees left the company, and the player needed to erase the employee from a Talent list. This situation was made by an event card that expected to discuss reallocating employees to achieve the Game's goals under the Game's structure. It was the "Correct answer" to transfer Employees to other departments to match the KPI and cost of the Game goal from the perspective of achieving the goals. In this situation, Ally-the player with Allyship, raised a question of whether this transfer was correct. One of the team members confirmed the reason, and because of this confirmation, Ally could explain why s/he raised the question even though it derailed from the main discussion under the quantitative goal was achieved. Furthermore, Ally could provide specific examples of transfer risks as a real-world problem expanding from the game framework. This question did not lead to new actions, such as reassigning employees. However, other team members could take a new perspective and are confirmed to be accepted with positive attitudes, such as listening actively.

Team D was a severe environment for Ally. Ally suggested increasing the number of employees in a specific department because the number of employees was minimal compared to other departments. This suggestion was that it would be challenging to achieve the game goal if they reassigned employees. Therefore other team members denied Ally's statement even though s/he stated that the small number of employees was risky. Ally could not convince other team members with a counterargument to the "Correct answer," and the discussion was settled. Ally intended to extend the framework of the Game. Hence, the balance of power within the team differed from Team A. Ally became a minority in Team D when s/he presented a discussion that differed from the axis set up in the Game. This structure explicitly showed that Ally's suggestion was not an immediate solution for achieving the game goal, and survival of Ally was inhibited.

4.5 Statistic test result

We took a statistic test toward the subsection 4.3 group's result. The data was confirmed non-parametric by the Shapiro test. According to Table 2, the p-value was under 3%. Therefore we confirmed that Group 1(ACD) and Group 2(BE) 's diversity has a difference statistically by the Wilcoxon rank sum test.

Table 2. Result: Wilcoxon rank sum test

Groups	Rank Sums	Means	P-Value	Cohens d	Null.Value
ACD/BE	221571	0.6702806	1.323533e-19 (p < .001)	-0.4874304	0

5 Discussions of Results

No direct effects were confirmed, such as the reallocation of employees, on the Game from the Allyship discussion. However, there are discussions during the debriefing part where Group 1 players reflect on the situation of Ally and share their thoughts within the team. The analysis shows that the number of occurrences of "Allyship" is rare but considered an essential contributor. Furthermore, the examinee's personality and gaming environment influences the occurrence. Based on the results, we describe conditions for generating Allyship, facilitators for Allyship, and implications from this Game in the following subsections.

5.1 Allyship conditions

There are differences in the occurrence of Allyship in teams and each player. These differences are influenced by personality and the environment in which Allyship exists.

In Team A, we observed a situation in which the team members listened to the opinions with an open mind and considered different opinions. The discussion of Allyship itself was positive. Team D's Allyship statement was rejected while at the same time. The more the team focuses on problem-solving in the Game, the more Ally is apart from the Game's framework. Ally's statement becomes heterogeneous opinions, bringing a point of view to the discussion that is not set directly in the Game. If there is substantial conformity, a heretical member is likely recognized as excluded from a group/team [14]. It will be the burden of raising an issue as a heretical opinion for a minority (in the case of Ally) if there is a structure of majority and minority. "Psychological safety" was defined by Edmondson as a culture where people feel free to express their opinions. Edmondson stated that team performance improves when psychological safety is high, and team performance declines when psychological safety is low when conflict arises [15]. In this study, it is impossible to say what the psychological safety conditions and impacts are within the team. However, it may hinder the generation of potential Allyship in a harsh environment to express one's opinion. Regardless of whether Allyship affects the final result, the environment of the discussion in which Allyship is accepted positively or not is essential for the generation of the Allyship. We state the environment for Allyship generation in the following subsection.

5.2 Facilitators for Allyship

A positive attitude toward Allyship is accepting without denying opposed or heterodox opinions and encouraging the speaker's opinions during the discussion. However, simply accepting an "Allyship" is not enough to create a discussion that leads to a seed of innovation or a new point of view. Kumada and Kurahashi (2022) indicated that the factors for diversified discussions are repeat expansion and convergence of discussions around a specific topic word. Moreover, a comprehensive facilitator encouraging discussion indicated leading to deep, diversified discussions [16].

There is a facilitator in Team A who encourages the person who raised questions to explain the reason or background of the statement of Allyship. As a result, this triggers Ally to explain their thoughts, and the other members can understand why Ally raises a heterodox statement. Although the game outcome does not change because of Allyship, it indicates that an environment supporting and sharing Allyship statements within the team is critical for survival.

In Team D debriefing part, we confirmed that the player who opposed Allyship's comments reflected on his comment that was insufficient for rejecting reason to answer the Allyship comments. This statement is considered a player's honest opinion, which is difficult to emerge from the discussion due to high game pressure and restrictions. The player who rejected Allyship was not playing the role of facilitator obviously but disclosed their own opinions, and this action was facilitator-oriented. This discussion could encourage Ally to explain the reason or background why s/he raised the issue in the Game as an additional explanation of Allyship's statement.

5.3 The implication of this Game

Based on the results and discussion, we itemized the implications of this Game.

1. The factors that influence the occurrence of an Allyship are players' personalities, experience, and the degree of dispersion of diversity within the organization.

In this study, the teaming is based on a psychological scale, and each team's diversity has no different. However, since emerging new ideas from a non-diverse environment are not easy, the significant variance in the diversity of players can be considered a factor in the generation of the Allyship.

2. The factors that cause and survive Allyship are influenced by the positive attitude of listening to others and the presence of a facilitator who encourages discussion.
3. Allyship presents the organization with a different perspective from the current situation. Allyship can make people aware of the importance of diverse human resources, such as in terms of maintenance/improvement of productivity, corporate social responsibility, and risk of talent outflow.

6 Conclusions

This study aims to verify the impact and how "Allyship" affect organizational behavior from a new perspective. We confirmed that Allyship is rare in terms of occurrence, but Allyship is a significant contributor. We also present a specific investigation and compelling analysis method for rare cases that do not surface with a large amount of data. This method is supposed to extend to problems with similar structures, which contribute academically and practically.

The future work is for other analytics of the environmental factors that may cause the Allyship generation and persistence. This study observed how Allyship is accepted in the discussion or not. The differences between the two groups are examined in terms of whether an environment makes it easy to accept the different points of view. In addition, this Game is developed for this study, and the number of obtained data is limited. Therefore, reviewing the experiment's results and improving the Game's operability based on players' feedback is necessary.

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The role of facilitators for learning and satisfaction of students in simulation game courses

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Abstract. Teachers play a central role for learning. This was confirmed often by scientific studies. Unlike in classical courses, where teachers are in the focus, the activity in simulation game courses is usually shifted to the learners and the simulation game played by the participants is of central importance for the course alongside the facilitators. Compared to ordinary teaching it remains unclear whether facilitators play a minor role in courses taught with simulations or a more prominent role because of the complexity of the learning method. With this study we highlight the influence of facilitators on learning success in courses using simulation games, based not only on one specific simulation game, but on data from different simulation games.

The present study includes data from over 2,750 students who participated in simulation game courses at the Duale Hochschule Baden-Württemberg (DHBW)¹ Stuttgart between May 2021 and December 2022. 31 different simulation games were used, covering a wide range of content (despite the focus on business administration) and methods (online, offline, board-based and computer-based simulation games). This broad range of games covered in this study is unique in simulation game research and allows to analyse the role of facilitators not only for one specific simulation game but for simulation games in general.

The results illustrate the important role that facilitators play for the satisfaction and learning success of students in simulation game courses. Furthermore, it is analyzed which factors have an influence on the successful work of simulation game facilitators.

Keywords: Business game, business simulation, simulation game, facilitator, learning success

1 Introduction

Simulation games represent a complex learning arrangement in which reality is represented in a modelled way. In the context of simulation games, the participants, who are usually divided into groups, take on roles and work on simulated problems while taking rules into account (Kriz, 2011). Simulation games thus combine elements of simulation, rule play and role play (Kriz, 2011). Characteristic is a sequence of briefing, game phase and debriefing.

At least since the groundbreaking work of Hattie (2011, 2012), the central importance of teachers for successful learning has been recognized. Hattie writes that the "greatest source of variance in our system relates to teachers" (2012, p. 190 and 2013, p. 27f.) and sums this up in the formula the "action of teachers make the difference" (2013, p. 27). Teachers have a significant influence on the learning process through the design of the learning environment and direct interaction as well as through the professional and personal relationship with the learners. In relation to the actions of the teachers, other factors are less important.

However, the extent to which Hattie's results also apply to simulation game courses and the facilitators of simulation game courses has so far only been partially scientifically analysed and discussed (cf. Alf 2022). In particular, there is a lack of studies that analyse the role of facilitators for the learning success of students beyond a single simulation game. Given the

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widespread use that simulation games have found in higher education (Meßner et al., 2018; Muno, 2020) and beyond, the current data situation is unsatisfactory.

This is especially true in light of the fact that data from other teaching formats can be transferred to simulation games lectures only to a very limited extent. In the context of simulation game courses, facilitators of the simulation games largely take on a different role than teachers in classic courses. Whereas in traditional courses teachers take on a very present role and are largely in control of the teaching process, the simulation game itself has a central role in simulation game courses and the facilitators are often in the role of coaches. Depending on the situation, they offer their support to the learners, set impulses and encourage learners to reflect independently. Essential parts of the learning process in simulation games often take place in group phases without the direct presence of the facilitators and in largely autonomous interaction among the group members. Several studies emphasize that teamwork has a significant influence on the learning process (van den Bossche et al. 2011, Siewiorek et al. 2013, Tao et al. 2012). The task of the facilitator is to design the framework conditions in connection with the simulation game in such a way that they optimally support the active acquisition and application of knowledge and competences. The management of this very open learning process places special demands on the facilitator, especially with regard to the change of briefing - game/group phase and debriefing. In round-based simulation games, this dynamic process must always be adapted to the situational conditions throughout the entire course of the simulation game. This is a process that places high demands on the simulation game facilitator due to the usually limited planning possibilities and often simultaneous time pressure. Several studies emphasize the importance of guided debriefing as central to learning with simulation games. In particular, the guided reflection of the simulation game content sets learning processes in motion (Dube 2015, Richards & Camuso 2015). In addition, the literature emphasizes that students are dependent on feedback and explanation from facilitator during the course of simulation games (Abdullah et al. 2013, Buil et al. 2018). Through more or less feedback, the difficulty/complexity of the simulation can be adapted to the learners.

In the simulation literature, different assessments of the importance of simulation game facilitators can be found. For example, Trautwein (cf. 2011, p. 218) states that facilitators contribute to a lesser extent to explaining learning success in simulation game courses than the simulation game TOPSIM General Management considered there. In contrast, in the opinion of Mayer et al (2013, p. 97) it is better to have good facilitators with a weak simulation game than vice versa (for further study results, see Alf 2022).

Based on this background, the aim of the present study is to shed light on the importance of facilitators for the learning success of students in simulation game courses on an empirical basis. It also analyses which factors have a positive effect on the evaluation of facilitators by students.

In detail the following research questions are addressed:

Research Question 1: How do facilitators influence learning and satisfaction of students?

Research Question 2: On which factors does the evaluation of simulation game facilitators depend?

Research Question 3: What is the relationship between students' assessment of facilitators and of simulation games courses?

Research Question 4: To what extent are there similarities in the evaluation of simulation game courses by facilitators and students?

2 Research design and methodology

The present study is part of a comprehensive research project that has been conducted by the Centre for Management Simulation (ZMS) at DHBW Stuttgart since 2020.² Following the

² The ZMS is a teaching and research centre focused on (business) simulation games in teaching and research (cf. <https://zms.dhbw-stuttgart.de/>).

theory-based model for the evaluation of simulation-game based courses (see Trautwein & Alf, 2022, for an overview of the model see <https://zms.dhbw-stuttgart.de/forschung/forschungsprojekte/>) the simulation game courses have been evaluated with a simulation-specific questionnaire (ZMS Inventory). The inventory exists of two questionnaires, one for students and one for facilitators. The questionnaire for the students essentially consists of 27 Likert-scaled items, five of which relate to the simulation game facilitators and six of which measure the learning success and satisfaction with the simulation game course. All questions are answered on a six-point Likert scale, which (apart from the question about overall satisfaction) ranges from "strongly disagree" (value = 1) to "strongly agree" (value = 6).³ In the questionnaire for facilitators mainly categorical data is collected (prior experience with the game, amount of theoretical input besides the game, length of debriefing) but also Likert-scaled items towards the satisfaction with the course from a facilitators perspective.

The following evaluation is based on 2,757 data records that were collected in the period from May 2021 to December 2022 in 157 simulation game courses with 31 different simulation games at the DHBW Stuttgart. The simulation games used are predominantly business simulation games.⁴ They include 21 computer-based simulation games and 10 haptic simulation games. The survey of the students is usually carried out towards the end, but still within the framework of the course, using the ZMS inventory. It takes about 5 minutes and is voluntary. Due to the fact that it is mostly carried out during the course, the participation of the students (response rate) is usually high and distorting effects due to self-selection during the answering process can be estimated as rather low. Of 2,757 data sets, 1,469 were collected in face-to-face classes and 1,244 in online classes.⁵ All evaluated simulation game courses are block courses (courses taking place on one day or consecutive days) in which the facilitators were present and approachable for the students throughout the entire course of the simulation game, on-site or online.

The quantitative study is mainly based on the (self-)perception of the students, added by the questionnaire for the facilitators (for more details cf. Trautwein/Alf 2022). Besides the fact, that such a large study wouldn't be possible on objective data or even a mixed-method research design, there are content factors that speak in favour of focusing on the participants' self-assessment (cf. Trautwein 2004, 57ff.): One aspect is, that participants perceive themselves in a more differentiated way than is possible for observers. Furthermore, a connection between self-assessment and assessment by others has been empirically confirmed many times, even though self-assessment is certainly not an objective picture of reality. In addition, there is another important aspect: even if the self-assessment were objectively wrong, it would be important because people's self-assessment is highly action-guiding (cf. Trautwein 2004, 58f.). With regard to the use of simulation games, Schwägele (cf. 2017, 59ff.) concludes that the subjective perspective of the students is of central importance for the success of simulation games. Therefore the self-perception of the students is put in middle of the research methodology, accompanied by data gathered from the facilitators.

The evaluations of the results follow scientific conventions (cf. below as an example Trautwein 2011, p. 155ff.). Depending on the probability of error (p), we report the results on the .05 significance level (*), on the .01 significance level (**) or on the .001 significance level (***). Correlations (r) are designated as weak ($r < |.30|$), medium ($|.30| \leq r < |.50|$) and strong ($r \geq |.50|$). For the Cronbach's α , values above 0.8 are considered very good, from 0.7 to 0.8 good and below still sufficient if above 0.6. With regard to the effect size d, we follow the suggestions of Cohen (1988, 25) and speak at .2 or .3 of a small effect, around .5 of a medium

³ When asked about overall satisfaction, the scale ranges from "very dissatisfied" to "very satisfied". The questionnaires for the students as well as for the facilitators are available at <https://zms.dhbw-stuttgart.de/forschung/forschungsprojekte/>.

⁴ Among the simulation games used are twelve TOPSIM and five BTI business games. In addition to simulation games on economic topics, simulation games on sustainability, for example, are also used. An overview of the simulation games used at the ZMS can be found at: <https://zms.dhbw-stuttgart.de/das-zms/unsere-planspiele/>.

⁵ The other 44 are missing data or courses in hybrid form.

effect and from .8 of a large effect. For factor analysis the principal component analysis is used as extraction method combined with varimax with Kaiser normalization as rotation method.

3 Results

In the following the results on research questions are described and discussed based on the empirical data.

The basis for the analysis are the scales on the simulation game facilitators and on the overall assessment. In both cases, a factor analysis shows that it is in each case a uniform factor without subscales.

Table 1. Results on the assessment of the Facilitators

Scale for Facilitator ($\alpha = .88$)		x	s
		5,35	0,80
P1	The instructor is very familiar with the simulation.	5,50	0,92
P2	The seminar was well structured.	5,20	1,03
P3	There was sufficient opportunity to consult with the instructor.	5,34	0,99
P4	Consultation with the instructor took place in a constructive atmosphere.	5,40	0,96
P5	Support of the instructor was professionally helpful.	5,30	0,99

With a mean value of 5.35 on a six-point scale from 1 to 6, the students are very satisfied with essential characteristics of the facilitators (cf. Table 1).

If the two theoretically derived subscales are formed, a subscale with a mean value of 5.35 and a standard deviation of 0.88 ($\alpha = 0.78$) results from the items P1 and P2 (competence of the facilitator), and the subscale communication/interaction of the facilitator with a mean value of 5.34 and a standard deviation of 0.86 ($\alpha = 0.85$) results from the items P3 to P5. The subscales are introduced here because they are used later for evaluation.

Table 2. Results on Overall Assessment of the simulation game courses

Scale for Overall Assessment ($\alpha = .94$)		x	s
		4,49	1,12
G1	I learned a lot in the simulation game.	4,40	1,22
G2	I learned something meaningful and important in this course.	4,58	1,23
G3	My understanding of my field of study has been enhanced by the course.	4,25	1,38
G4	All in all, attending the course was worth it for me.	4,64	1,34
G5	I found the simulation game very motivating.	4,28	1,36
G6	How satisfied are you with the course overall?	4,80	1,14

Table 2 shows an overview of the results on overall assessment (combining questions on learning and satisfaction). If we look at the two scales for the facilitator and overall assessment, it is striking that the students are far less satisfied with the simulation game course than with the facilitator. However, the present study cannot empirically clarify why this is the case.

Research Question 1: How do facilitators influence learning and satisfaction of students?

To answer this RQ we operationalize facilitators influence in three ways: We take the scales on facilitators from the student questionnaire into consideration, we look second at prior experience with the game and third on the confidence of the facilitator with the game.

There is a highly significant correlation of $r = .48^{***}$ between the assessment of the facilitators and the overall assessment of the simulation game courses. A positive assessment of the facilitators is therefore also associated to a considerable extent with a positive assessment of the course as a whole. In order to be able to analyze these facts in more detail, some aspects related to the facilitators will be examined more closely in the following.

First, the question of whether the overall assessment depends on how often the facilitators have conducted the simulation game in the past is considered. The overall success is significantly lower if the simulation game has not been conducted by any of the facilitators more than three times in the past three years ($x = 4.30$) compared to $x = 4.56$ for 4 to 9 courses and $x = 4.50$ for more than 9 courses (without the difference between 4 to 9 or more than 9 courses being significant). This seems quite understandable, since mastery of the simulation game is an important prerequisite for the successful implementation of simulation games and this generally improves with the frequency of use. This corresponds, at least in tendency, to the fact that the confidence of the facilitators in the implementation of the simulation game is accompanied by a better overall assessment of the students ($r = .11^{**}$)⁶. However, the correlation here is very low, as are the mean differences with regard to the frequency of implementation. If one assumes that the self-perception of the facilitators is adequate, at least in tendency, the analogous evaluation of the overall success by the students speaks for their judgement competence: the more confident the facilitators feel, the higher the learning success and the satisfaction of the students.

An essential element of teaching with simulation games is debriefing. Here it is noticeable that the duration of the debriefing based on the information provided by the facilitators has no significant influence on the overall evaluation of the course by the students. Also the number of facilitators has no significant effect on the overall assessment of the simulation game courses.

As expected, we see a significant influence of facilitation towards student satisfaction. Higher values on the facilitation scale correspondent with a higher value on the scale for learning and satisfaction. But also higher values for experience and confidence of facilitators lead to significant higher values on the learning and satisfaction scale.

Research Question 2: On which factors does the evaluation of simulation game facilitators depend?

To answer this question we take the facilitation scale as the dependent variable and measure various possibly influencing effects on it. These are online or face-to-face teaching, difficulty of the game, pace of the course, number of present lecturers, prior experience, length of debriefing.

In order to answer this research question, a whole series of aspects of the simulation game courses are examined more closely, which can have an influence on the evaluation of the facilitators.

In the evaluation of the facilitators, it makes no difference whether the simulation game courses were conducted in face-to-face or online. The facilitators thus succeeded in being convincing in terms of competence and communication even under the conditions of online teaching. In view of the high scores in the assessment of the facilitators (compare Table 1), this is a convincing result.

By far the majority of students judge the difficulty of the simulation game to be just right ($n = 2,179$), $n = 243$ judge the difficulty to be too low and about the same number ($n = 296$) judge it to be too high. Not entirely unexpectedly, those students for whom the simulation game had the right level of difficulty also rated the facilitators with $x = 5.40$ significantly better than if they rated the difficulty as rather too high ($x = 5.19$) or rather too low ($x = 5.13$).

⁶ To calculate the correlation, a scale was formed with the two items of the facilitator ("I would say that I am very familiar with the simulation game.") and ("I feel confident while leading the game."). This shows an excellent value of $\alpha = .92$ for only two items.

The differences are somewhat bigger if one relates the rating of the facilitators to the perceived speed of the course. While 1,718 students rated the pace as just right, for $n = 668$ the course was rather too slow and for $n = 309$ rather too fast. If the pace is perceived as just right, the facilitators are given a rating of $x = 5.52$. If the pace is rather too fast, the rating is only $x = 5.05$ and if the pace is rather too slow, the rating is $x = 5.06$. The fact that the pace was not optimal for about one in three participants illustrates the difficulty of finding a pace that is appropriate for everyone as a particular challenge for facilitators.

The number of facilitators also affects the assessment of the facilitators' competence and communication. Here, single facilitators score significantly better than two facilitators ($x = 5.59$ vs. $x = 5.29$; $d = .387$). This could be at least partly due to the fact that usually only experienced facilitators conduct simulation games alone.

Furthermore, it is interesting to look at how the prior experience with the game affects the evaluation of the simulation facilitators. Here it is noticeable that facilitators who have conducted the simulation game ten or more times in the past three years are rated significantly better than those who have done so between four and nine times ($x = 5.41$ versus $x = 5.27$). In contrast, the difference is not significant for facilitators who have conducted the simulation game less than four times ($x = 5.31$). An explanation for this is not apparent from the available data. If we look at the two subscales of competence and communication, it is noticeable that the number of times the simulation was conducted has no influence on the communication of the simulation game facilitator. However, facilitators are rated as significantly more competent if they have conducted the simulation game ten times or more ($x = 5.43$ compared to 5.26 (four to nine times) and 5.29 for up to three times).

This corresponds to the fact that the more confident facilitators subjectively feel with the simulation and the better they know the simulation, the better they tend to be rated by the students ($r = 0.06^*$).

While the length of the debriefing has no significant effect on the evaluation of the simulation game courses as a whole (cf. research question 1), it has at least a small effect on the evaluation of the facilitators ($r = 0.06^*$). The longer the debriefing, the better the evaluation of the facilitators, at least to a small extent. The minimal correlation seems understandable here. It can be assumed that students appreciate a comprehensive debriefing. However, the duration of the debriefing alone neither makes it substantial nor does it say anything about its quality.

Likewise, the length of the debriefings from the student perspective has a significant effect on the ratings of the facilitators: If the length is just right from the students' perspective, facilitators are rated significantly better ($x = 5.48$) than if the meetings were too short ($x = 4.82$) or too long ($x = 5.11$).

Students' interest at the beginning of the course has a highly significant influence on the facilitator's evaluation, but its strength is limited. The correlation between interest at the beginning of the course and the evaluation of the facilitators is $r = 0.07^{**}$. A higher level of interest is therefore accompanied by a highly significant better evaluation of the facilitators, but the correlation is very low. Even though a high level of interest on the part of the students is certainly desirable, it is of secondary importance for the evaluation of the facilitators.

The gender identity of the students had no significant influence on the evaluation of the facilitators. Likewise, the size of the small groups has no significant influence on the assessment of the facilitators from the student perspective.

Research Question 3: What is the relationship between students' assessment of facilitators and of simulation games courses?

In order to analyze the connection between the simulation game facilitators and the simulation game itself in more detail, a factor analysis was first carried out in which the five items for the simulation game and the five items for the facilitators were included. In accordance with the theoretical model, two scales emerged for the simulation game (cf. Table 3). Scale 1 refers to the comprehensibility of the simulation and has a mean value of $x = 4.85$ (α

= .83), scale 2 refers to the realism of the simulation game and has a mean value of $x = 4.29$ ($\alpha = .85$). In addition, in line with the previous observation, there is a scale for the facilitators.

Table 3. Results of the factor analysis with the items on the simulation game and the facilitators

Item	Component		
	1	2	3
The results of the simulation are very comprehensible.	,163	,875	,191
The results of the simulation are plausible.	,160	,876	,202
I understood how the simulation works.	,169	,736	,131
The simulation has a close practical orientation	,170	,238	,885
The simulation game is a good representation of reality	,174	,217	,893
The instructor is very familiar with the simulation.	,766	,160	,061
The course was well structured.	,781	,160	,147
There was sufficient opportunity to consult with the instructor.	,790	,095	,106
Consultation with the instructor took place in a constructive atmosphere.	,839	,101	,120
Support of the instructor was professionally helpful.	,818	,208	,159
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalisation. The rotation is converged in 5 iterations.			

The correlations between the evaluation of the facilitators and the evaluation of the simulation games lie in the lower middle range between $r = 0.36^{**}$ (practical relevance of the simulation game and facilitators) and $r = 0.38^{**}$ (comprehensibility of the simulation game and facilitators). A competent facilitator therefore has an influence on the perception of the relevance of simulation games to reality and can strengthen this, for example, through appropriate examples and references to reality, but this influence is limited. Likewise, the facilitator has an influence on the comprehensibility of the simulation game as perceived by the students. This seems obvious, since the facilitator can contribute a lot to the understanding of the simulation game both in the context of debriefings and in the context of discussions with individual groups. However, it is important to note that in purely mathematical terms, the correlation of the scales only expresses that there is a connection between the scales; the direction of the effect or causality cannot be empirically derived from this.

Research Question 4: To what extent are there similarities in the evaluation of simulation game courses by facilitators and students?

The basis for the evaluation of numerous lectures at universities and also for this study is the assumption that the student assessment of characteristics of courses is important and significant. In addition to pragmatic reasons⁷, there are also several good reasons for this (cf. Trautwein & Alf 2022, 66 as well as Trautwein 2004, 57ff.): On the one hand, participants perceive themselves in a more differentiated way than is possible for observers; on the other hand, a connection between self-assessment and assessment by others has been empirically confirmed many times, even though self-assessment is certainly not an objective picture of reality. In addition, even if self-assessment is objectively wrong, it is still significant, since people's self-

⁷ Objective recording of learning success, for example, but also of group variables would be extremely time-consuming, if not impossible, and therefore only feasible in a much smaller sample, if at all.

assessment is to a large extent a guiding factor for action (cf. Trautwein 2004, 58f.). With regard to simulation game courses, Schwägele (cf. 2017, 59ff.) states that the subjective evaluation of the four key factors (consistency and closeness to reality, relevance and closeness to everyday life, requirements, social situation) is decisive for their success. The subjective perception by the participants is thus of central importance for the evaluation and further development of simulation game courses.

Even if it is undisputed in research that students' perceptions play an important role for the reasons mentioned above, and studies prove the high level of judgement competence of students (cf. Cronan et al., 2012; Rindermann, 2003; Pfeiffer et al., 2015)⁸, the question arises as to what extent students are actually able to adequately grasp simulation courses as a complex learning arrangement.

Comparing the satisfaction of the students ("How satisfied are you with the course overall?") with the satisfaction of the facilitators ("How satisfied are you with the course overall?"), a highly significant correlation of 0.37**⁹ is obtained. Students and facilitators thus tend to evaluate simulation game courses uniformly. This confirms the value of student assessments and thus the approach of the study and the ZMS inventory as a whole, which focuses on student perceptions while simultaneously recording the perceptions of the facilitators.

4 Conclusion and restrictions

Overall, the evaluation of the facilitators was very positive. The experience of the facilitator plays a role here, as does the question of whether the facilitators succeed in shaping the pace of the courses according to the needs of the participants. It also plays a role how confident the facilitators subjectively feel about the simulation game and how often they have (objectively) conducted it in the past three years. In both cases, the greater experience or confidence corresponds with a better evaluation by the students.

The study also shows that students are able to evaluate facilitators and simulation games in a clearly differentiated way. Based on now more than 2,700 data sets, this confirms the results that led to the creation of the ZMS inventory. In the case of the simulation game, the students differentiate theoretically and empirically between the relevance to reality and the comprehensibility of the simulation game. At the same time, there is a medium correlation between the facilitators of the simulation game and the simulation game. The two important factors for the success of simulation game courses thus influence each other, although the present study cannot make any statements on causality.

The study also confirms the students' judgement competence. This can be seen first of all in the question about satisfaction with the course, which was asked identically to students and facilitators, as well as with regard to the overall success from the student's point of view and the satisfaction with the course from the facilitator's point of view. Furthermore, students perceive facilitators as more competent if they objectively conduct simulation games more often and assess themselves as more confident.

Even if the large number of participants in this study allows empirically well-supported conclusions for the use of simulation games in teaching, some restrictions must be taken into account. One aspect is, that only data from surveys of students at the DBHW Stuttgart are included in this study. Even if it seems likely that the results can also be transferred to simulation game courses at other universities with rather small deviations (cf. also the results of Trautwein 2011, who surveyed students from different universities), it must be taken into account that the students at the DHBW differ from those at other universities. This applies, for

⁸ Similarly, Hattie (2013, p. 42) concludes that students' judgements of facilitators' competence prove accurate.

⁹ The 115 simulation game courses for which an evaluation of satisfaction by the facilitators was available were included in this evaluation. The student responses were combined into a mean value for each simulation game course and then the correlation between the mean value of the students and the evaluation of the facilitators was formed. If, on the part of the students, the overall assessment scale is used instead of the individual item satisfaction, the correlation even increases to 0.38**.

example, to the very close integration of theory and practice. This could have an impact on the learning success in the context of simulation game courses. It is even more uncertain to what extent the results of this study can be transferred to participants in simulation game courses in a company context. In order to remedy this deficit, surveys are now also being conducted at other universities. In addition, surveys are also planned outside of universities.

With data from 31 different simulation games, the basis of the present study is exceptional in the simulation game sector. In terms of methodology, these are both haptic simulation games and computer-based simulation games, some of which were conducted online and some face-to-face. At the same time, however, it must be taken into account that these are predominantly business simulation games and the informative value of the study, for example, with regard to political simulation games, is therefore limited. Here too, further surveys have been started so that in the future it can be examined to what extent the results are also valid for simulation game courses with simulation games from other contexts.

Even though the present study once again confirms the scientifically well-documented connection between self-perception and external perception (cf. Pfeiffer et al., 2015, as an example), it should still be noted that student perception as an essential element of the present study only represents a section of reality and is fraught with difficulties (cf. Spinath & Seifried, 2018). In order to be able to look at self-perception even more closely, sub-samples are and were examined more closely in methodologically more elaborate mixed-method settings with a combination of quantitative and qualitative instruments. The preliminary results here also suggest a significant connection between self-perception and, for example, indicators of success in simulation games.

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Implementing resilience learning capacities into serious business games

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Abstract. In light of the increasing prevalence of transboundary crisis events in the Anthropocene, contemporary organizations continuously face existential threats. To withstand the ongoing assaults of exogeneous shocks they must therefore reinforce their organizational resilience. However, a comprehensive body of theoretical and empirical organizational resilience studies struggles to yield actionable knowledge that organizations may operationalize to surmount both unforeseen and foreseen shocks. This paper lays the groundwork for a potential solution to this issue, namely the development of a readily useable and demonstrably useful resilience SG design algorithm that efficiently transcribes the construct's complex multi-factor etiology into clearly defined Game Intended Resilience Learning Outcomes (GIRLOs). We thereby propose a solution to key weakness of existing resilience SGs, namely, their incapacity to furnish actionable knowledge pertaining to an organization's resilience capabilities and capacities. To demonstrate the algorithm's utility, we also show how the algorithm may be deployed based on the case of a resilience business SG scenario.

Keywords: Resilience, Game design algorithm, Resilient serious game, Business games.

1 Introduction

Serious games (SG) comprise valuable educational tools which are increasingly deployed to foster sustained learning (Arnab et al., 2015; Ratan and Ritterfeld, 2009, Mettler and Pinto, 2015) or to facilitate participatory decision-making processes for complex problems such as achieving more resilient and sustainable socio-economic systems (Abrami et al., 2012). Indeed some SGs, called Business Games (BG), have been developed to address specific business problems. Greco et al. (2015) define BGs as "... *serious games in a business environment that can lead to one or both of the following results: the training of players in business skills (hard and/or soft) or the evaluation of players' performances (quantitatively and/or qualitatively)*". As businesses face an increasingly complex and volatile socioeconomic context (Boin and Lodge, 2021), they must determine how to enhance and benchmark their resilience capabilities understood as "*skills that can be brought to bear on a challenge*" (Longstaff et al., 2013:5). However, although the term resilience is ubiquitously employed by the general media and has been the subject of multiple academic studies and theoretical papers (Duchek, 2020), its effective operationalization via tools that facilitate the acquisition and evaluation of resilience capacities still eludes most organizations.

We assert that resilience SGs that incorporate real-world resilience problematics, may offer a panacea to this problem. In effect, resilience SGs may help organizations to identify concrete resilience capabilities that may be continuously acquired and honed via their employees' participation in resilience SGs. While many resilience SGs exist, few explicitly transcribe the concept's complex multi-factor etiology into clearly defined yet adequately parsimonious Game Intended Resilience Learning Outcomes (GIRLOs). We assert that this impairs the utility of most resilience SGs since they frequently demand a prohibitive level of subject matter expertise (to deploy and administer) and generally fail to generate actionable knowledge regarding an organization's actual and potential resilience capabilities and capacities. The arbitrage common

to most SGs (Arnab, 2015) between useability, in terms of ease of access to the SG (Klabbers, 2006) and utility, in terms of learning goals being met, is thus exacerbated for resilience SGs. We suggest that a key impediment to addressing this lacuna in resilience SGs comprises a lack of a systematic procedure to integrate defined resilience dimensions and indicators within a SG. This paper delivers a potential solution to this issue in the form of a resilience SG design algorithm that may apply to any SG with resilience concerns. In this paper, we devise an algorithm focused on the transfer of learning and knowledge pertaining to the resilience concept using BGs. In line with other approaches for serious game design, the paper thus offers a practical way to think about business game configurations and design scenarios oriented toward business resilience related problems. The approach thus ascribes to the action design research program promoting artefacts based on research to transform society. The paper is set out as follows. In section two, we summarize our interpretation of the resilience concept. In section three, we delineate the resilience SG design algorithm. In section 4, we partially apply the algorithm to a theoretical business scenario to demonstrate how it may be used to overcome the challenge of designing effective resilience SGs. Section 5 comprises the conclusions.

2 Summary of the resilience concept¹

The resilience construct is a multifaceted construct relying on different dimensions. The literature refers to temporal, organizational and spatial perspectives of resilience, each of which affects and depends upon individual resilience capabilities.

Duchek (2020) for example, describes the temporal dimension of resilience within any system, as a three-phase cyclical process involving preventive, proactive and recovery capabilities. McManus et al. (2008) highlight individual capabilities. They describe a suite of indicators associated with three factors; situational awareness, management of keystone vulnerabilities and adaptive capacities which are thought to confer resilience in complex, dynamic and interconnected organizational contexts. The spatial / organizational dimension accounts for the complexity of the system and is described by Longstaff et al., (2013). The authors' systems perspective of resilience describes two dimensions: the degree of complexity of the subject system and the degree of normativity which denotes the degree of active human capabilities involved in managing the system.

Designing effective resilience SGs thus demands informed compromises to capture the essence of the resilience construct in a coherent yet simplified artifact (Klabbers, 2006) that efficiently transcribes its multi-factor etiology into clearly defined, yet adequately parsimonious GIRLOs. However, resilience SGs often lack a precise game design procedure to systematically link the organizational resilience theory to clearly defined resilience capabilities to be acquired by game participants. Gardner Le Gars & Waldeck, (2022) proposed a resilience game design algorithm which integrates distinct facets of the resilience construct in a single framework. In the next section, we present the general algorithm and describe how it may be used to design resilience BGs incorporating GIRLOs.

3 The resilience algorithm

The starting procedure of the general algorithm (Gardner Le Gars & Waldeck, 2022) is common to most games (Peters et M. Van de Westelaken, 2014) and describes the following game elements: i) the game configuration depicting the general context of a resilience SG, ii) a description of the general SG objectives and iii) the roles available in the SG.

The dynamics of a resilience SG consist of several rounds which typically occur sequentially to define a macro cycle directed toward the main objectives of the SG (for example sustainability of a resource or survival of the firm). Each round describes a micro cycle specifying players' actions, micro cycle objectives to be achieved for each participant role and specific learning activities.

¹ For a more complete discussion the reader is referred to Gardner Le Gars & Waldeck, 2022.

Resilience capabilities i.e. the GIRLOs, are specified within the micro cycles depending upon the specific action choices made by participants. The precise GIRLOs associated with a single gameplay therefore vary as a function of several parameters, the players' actions, game events and the starting conditions (resulting from past actions) at the beginning of the cycle .

In sum, a **macro cycle** is initiated by specifying the following elements:

1. Game context specification:
 - 1.1. A game configuration is a description of the game context specifying the objectives of the game, initial value of the variables, types of possible organizational settings and temporal aspects of scenarios (pre/ in/ post crisis) - at initialization.
 - 1.2. The game configuration also describes players' roles and attributes, potential action arena, resources, constraints, available information and individual objectives to attain
 - 1.3. Since resilience is a capacity of an organisation to face and withstand a crisis and the ability to adjust its functioning to expected and unexpected conditions, game scenarios must define a range of different possible crises each with specific performance indicators to manage. The initially selected game configuration context specification is thus also enriched by possible scenarios characterized by specific performance indicators to manage, for distinct types of crisis or events
2. Sequences of rounds are defined to match a scenario resulting in a suite of possible GIRLOs. Therefore, for a given game configuration, multiple potential scenarios may be played, each proposing different performance objectives and several types of potential crisis. Several potential configurations of sequences of rounds are envisaged:
 - 2.1. a sequence may differ with respect to the temporality of resilience. For instance, different rounds may be configured in pre-crisis , in-crisis or post crisis phases. Each phase will therefore address GIRLOS specific to the temporal resilience phase. GIRLOS related to preventive capacity (i.e. before a crisis) might include redundancy building, signal processing and anticipation,. During a crisis, GIRLOs might focus on communication skills, agility and decision making while post-crisis GIRLOs target the capacity to adapt and learn from the crisis to emerge stronger.
 - 2.2. A sequence of rounds may also correspond to i) a single crisis event but with distinct organizational settings/ configurations or ii) distinct role-based perspectives of the crisis scenario. Participants may thus experience organizational resilience from multiple organizational and spatial perspectives.
 - 2.3. a sequence may consist of a single temporal phase (e.g. in-crisis) but with different (crisis) events in different rounds. In this case, participants may explore their capacity to react to different resilience demanding events such as the unpredictable ripple effects of a crisis².
 - 2.4. sequences of rounds with any of the preceding combinations.
 - 2.5. In common with most SGs, the sequence of rounds terminates with a debriefing round where the focus is a discussion about perspectives to be drawn from the SG for the organization's real world context.
3. Each round comprises a micro cycle determining the actions to be taken in that round. Examples of micro-cycles played during a round are illustrated by figure 1. Each micro cycle comprises the tasks, actions or decisions to be performed by each role playing the round and the types of GIRLOs to be attained by or envisioned for participants within a round. The GIRLOs are obtained from crossing the resilience frameworks alluded to in section 2 by McManus et al.(2008) and Hollnagel (2010). Table 1 depicts the GIRLOs and illustrates how they can be generated through the combination of specific individual abilities (to rate, to detect, to decide,...) applied to different elements of the organization (resources, information,...). Each micro cycle, in common with the wider aims of the round of which it is a part, focuses on a specific game configuration which combines a temporal crisis phase,

² We refrain from describing all possible combinations, but round sequences may evidently include any possible combination of the abovementioned elements

type of organization (which roles and the level of organization that will be active in this round) and a crisis event.

The next section illustrates how the general algorithm may be applied to generate a resilience BG.

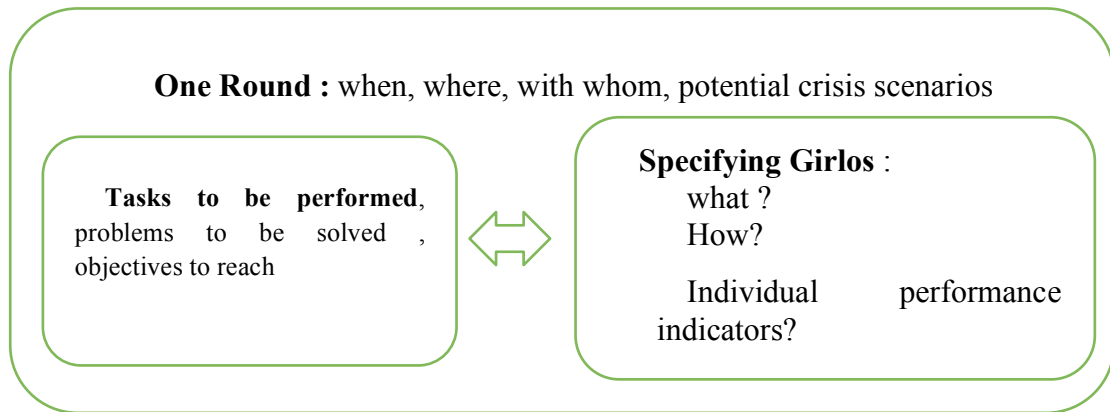


Fig.1. A micro cycle within a single round

Table 1: GIRLOs: each cross is an example of a typical GIRLO but others could be designed

(On) what ?	Type of elements				
	Protocol / process	Resources	Organizational Connectivity (Relationships)	Information (source, types)	Type of boundaries (cultural / operational)
How? (abilities)					
Detect Risks (R) / Opportunities (O)			x	x	x
Rate (R /O)	x	x	x		
Recognize (R /O)		x	x	x	
Anticipate (R /O)		x	x	x	
Decide Prioritize Improve Break Silos		x	x	x	x
Learn / adapt		x	x		x
Communicate			x		x

4 Applying the resilience algorithm for a BG specification

In this section we apply the preceding algorithm to illustrate the design of a BG with specific resilience capabilities. First, we define, as part of the macro cycle, the configuration generating mechanism (figure 2). The configuration generation mechanism specifies the general context of the BG as well as types of scenarios which may happen. We then show how sequences of rounds may be generated (figure 3). Each sequence of rounds defines a specific scenario to be tested. A scenario is defined by the indicators that participants must manage, a specific crisis or associated events. Each scenario comprises specific micro cycles (figure 1) and their associated GIRLOs.

1. Game context specification:

- 1.1. the general context of the BG is an organization /firm confronting different crises (depending on the market and institutional context of the firm). A configuration of the BG is defined in terms of a type of market structure, number of firms, type of indicators describing objectives to attain, type of roles and types of game play (coordination / cooperation / competition) between the different roles. A same BG can function with multiple configurations (e.g. public / versus private firm or cooperative versus coordination game which results in different decision mechanisms) thereby offering some flexibility in play design to the BG users/ participants. Figure 2 shows an example of a configuration (with thick blue arrows) for a business firm in a competitive market with key roles (the CEO, marketing and production managers) played as a cooperative game. An alternative configuration would be to undertake a non cooperative game where a player (within a team of players) is dependent upon the decisions of at least one other role³. A same game board may thus support multiple configurations although some configurations would necessitate another game board. For instance, should players wish to adopt a configuration where there are multiple firms represented by players (or a team of players). Nevertheless the generation mechanism depicted in figure 2 remains the same.
- 1.2. The game context specification is enriched by possible scenarios denoted by the values ascribed to the performance indicators to be managed and type of crisis and events the players can be confronted with. For example, in a public sector environment, a priority objective might be to maintain high performance with respect to social and environmental indicators whereas in a corporate environment, an organization may prioritize maintaining financial indicators above a critical level. For the latter configuration, the type of crises which may appear can be price related (such as hyper inflation), production related (such as severe manufacturing defects) and so on. Other role specific BG indicators for participants to manage might relate to: regulatory, environmental, production, marketing, governance / social climate (HR), scientific or financial concerns. Overall in the macro cycle, possible scenarios as to the type of crisis/events which may occur and the type of indicators to manage (given the specific configuration, e.g public versus corporate environment) must be described.

³ In a non cooperative game players share a common goal (success of the firm, preservation of a resource) but may have different underlying individual preferences (e.g. a commons dilemma) as well as liberty to act. In a cooperative game, the decision to achieve the common goal is negotiated and enforced by agreements between players. A coordination game is a non cooperative game, in the sense that the decision-making process between players is made independently of each other, but where it may be in the interest of players to coordinate. A competitive context may be viewed as a non cooperative game where the interests of players are antagonistic and the achievement of a superior common goal is not achievable without enforcement by players whereas in a coordination game this last is possible.

- 1.3. In the interests of simplicity, in this paper, we refrain from adding players' attributes, potential actions, resources, constraints, information or individual objectives to attain. A potential action arena is nonetheless illustrated in figure 3.
2. The sequence of rounds is shown in figure 3.
 - 2.1. It starts from a given configuration and defines scenarios. A scenario in a sequence of rounds incorporates specific performance indicators for players to manage and specific crisis / events. For a sequence of rounds (1 to n), there may be 1 to many performance indicators to manage for one to many roles.
 - 2.2. To each round in a sequence of rounds related to a scenario, micro cycles are generated. The micro cycles are related to a type of crisis scenario and delineate potential actions to be performed and associated GIRLOs to be tested and acquired.
 - 2.3. Each sequence of rounds oriented toward specific objectives in terms of resilience management, may end with a debriefing session. This session aims to analyse the results in terms of resilience performance. Such a debriefing session may also occur at the end of a game session.
3. For this illustration, we have not explicitly included the micro cycle details in terms of the tasks, actions or decisions to be performed by each role and the associated GIRLOs to be acquired/ tested. Figure 3 nonetheless illustrates how a micro cycle could be defined. For example, in the box labelled "A micro cycle" on the right side of figure 3, the crisis event "A product has manufacturing defects. Deaths and injuries following the defects" is associated with a potential action arena ("Specific communication campaign - Opening to the media - Demonstrate expertise-..."). This illustrates the resilience capabilities (e.g. prioritize information) being tested for a micro cycle within that round which concerned protecting the firm's image/ reputation.
4. Figure 3 shows how sequences of rounds could be generated: on the left side the scenario concerns events which may affect an organization's image / reputation. The objective is to maintain performance indicators (production/ image) above a critical level. The focus of rounds 1 to n then is on pre-crisis actions that participants may choose to execute. or example, they may select diverse actions such as changing the product's raw ingredients or developing a marketing campaign, actions which could be chosen in combination or alone depending on the constraints imposed by the state of play and adequacy of participants' responses to the current situation. Each action is related to a specific GIRLO which could be implemented in response to a current situation of the BG company. GIRLOs may for example correspond to the organizational resilience stage of table 2 where the participants of the game are addressing the current state of affairs (table 2, line addressing the actual) and try to develop an adequate response to the ongoing situation. The game elements in a pre-crisis phase could therefore be designed to relate to signals sent to the participants, ambiguous information which could announce a forthcoming crisis, additional information about the impact of potential actions to be taken (line Addressing the potential of table 2). Addressing the critical (table 2) could also be part of a pre-crisis phase in a preventive/defensive posture by proposing game elements related to feedback loops or network criticalities. For example figure 3 proposes the case where a marketing campaign may have a feedback effect on production with possible production shortages and negative feedback for the firm's image. Finally in a more positive stance "addressing the potential" could be related to decisions the organization could make to strengthen its future position, e.g. reinforcing relationships and communications with employees, clients and suppliers to better respond to crisis events. Similarly in-crisis and post-crisis micro cycles could be generated corresponding to organizational resilience capabilities stated in table 2.

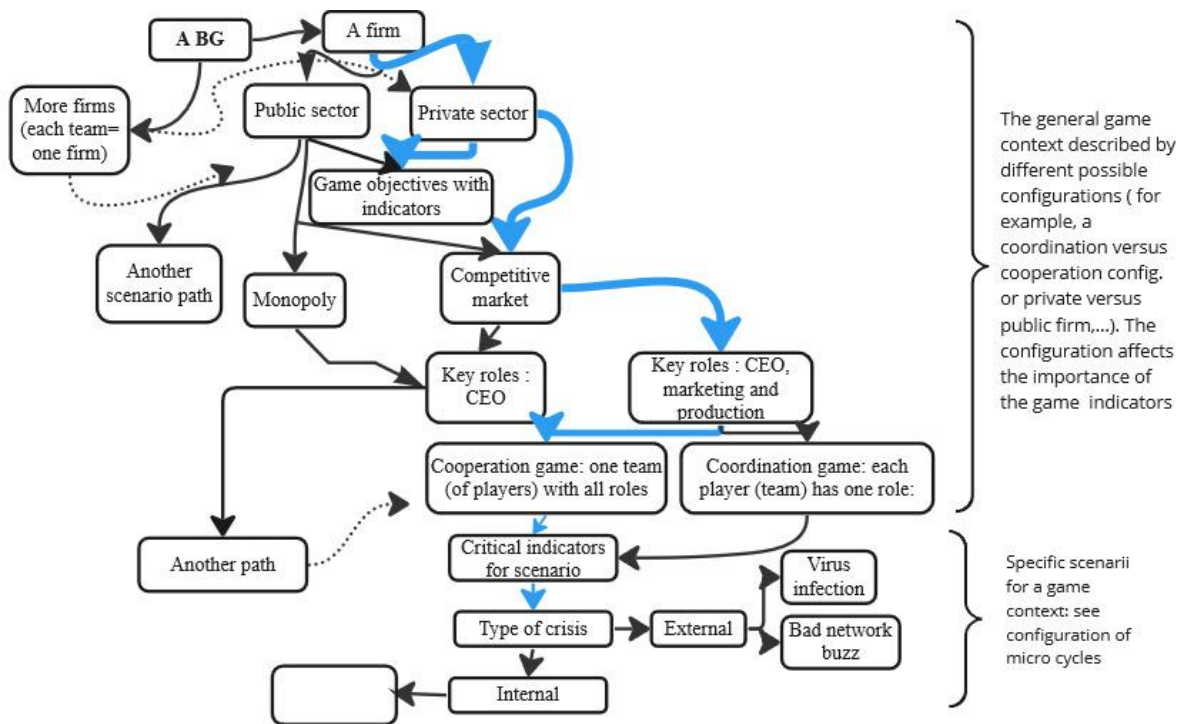


Fig. 2. A mechanism generating different configurations of a BG general context

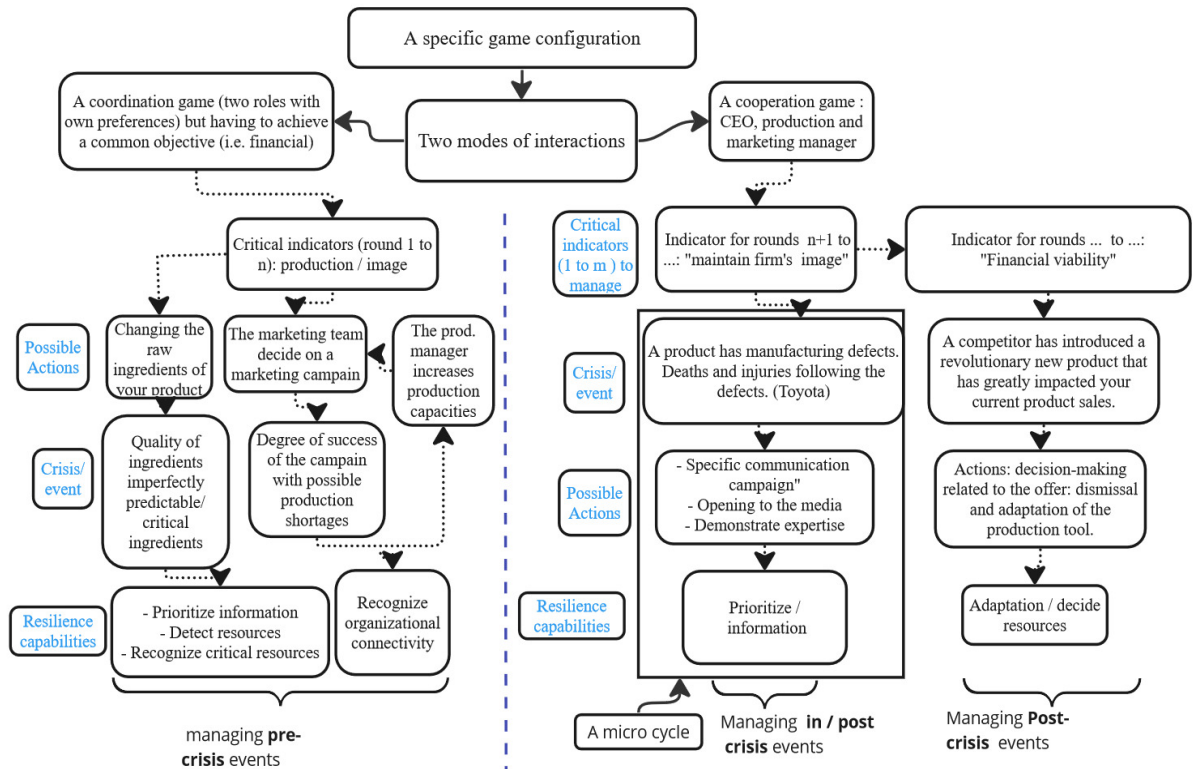


Fig. 3. Examples for the organization of sequences of rounds in micro cycles and associated GIRLOS

Table 2: Organizational resilience -and implementation in serious business games (adapted from Hollnagel, 2010 and Denyer, 2017)

Steps*	Ability*	How can it be tested in SG*
<p>Addressing the actual: the ability to respond (Insight: Interpret and respond to your present conditions.)</p>	<p>Detect, recognize, rate and act with respect to patterns and connections in your environment Condition of success: the capacity to develop multiple hypotheses about what is really going on and having the appropriate resources to implement actions</p>	<p>Events introducing disturbances, anomalies. Introduce weak signals. Introduce dispersed information among participants and ambiguous information about the ongoing situation</p>
<p>Addressing the critical: the ability to Monitor (Oversight: monitor and review what has happened and assess changes)</p>	<p>Recognize criticalities and monitor them with leading indicators. Condition of success: a comprehensive appreciation of the organization & its associated system complexity</p>	<p>Introduce game scenarios that expose participants to decisions/actions that demand the recognition of criticalities and the identification of their significance for network centralities or non linear cause-effect relations (between events, between actions of roles, between indicators to be managed, or between events, actions and performance indicators). Introduce stress scenarios to test the limits of the system. Introduce different organizational configurations.</p>
<p>Addressing the potential: The Ability to Anticipate (Foresight: anticipate, predict and prepare for the future)</p>	<p>Anticipation of future operational states which requires an effective use of situational intelligence in relation to the organization & its environment Condition of success: a strong understanding (or model) of the organization and its environment</p>	<p>Introduce events/ information and notably, weak signals pertaining to future threats and opportunities that require foresight/ responses (e.g. a resource opportunity) by participants. Potential investment actions into new products, employees, customers and resources to reinforce the organization's entire value chain</p>
<p>Addressing the factual: the ability to understand what happened and to learn the right lessons (Hindsight: learn the right lessons from your experience)</p>	<p>Learn from & understand the past, deduce "the right lessons from the right experiences". Condition of success: capacity to recognize opportunities to improve decision making / behavior based on past experiences</p>	<p>Introduce repetitive events (positive or negative events affecting the unit/organization) and/or allow time between rounds for participants to reflect on their collective approach in the game. Design a comprehensive and structured debriefing to collectively identify meaningful (as opposed to easy) learning outcomes</p>

*The central column represents the specific abilities (the “HOW” of GIRLOS) associated to the specific steps (column 1) in achieving organizational resilience. In accordance to these steps, game elements and activities are designed (column 3).

5 Conclusion

In this paper, we present a business serious game design algorithm that systematically operationalizes the resilience construct. We also set out an application of the algorithm in terms of a resilience SG model which illustrates a single macro cycle and its associated configuration, constituent rounds, micro cycles and GIRLOS.

We suggest that potential game designers may leverage the algorithm to create new resilience SGs or to ameliorate existing ones such that resilience game intended learning outcomes (GIRLOS) are clearly defined. Our main contribution is to connect the organizational resilience theory with the practice of cultivating and activating resilience in the real world. We thereby respond to a key impediment that organizations face in reinforcing their organizational resilience, namely, a paucity of effective learning tools to continuously foster and hone resilience know-how.

The design algorithm we propose is flexible, being compatible with the development of SGs for multiple contextual configurations (crisis type/ business context). In addition it is systematic, equipping organizations with the means to benefit from an efficient operationalization of the rich organizational resilience theory. Together these characteristics lend well to the design of resilience SGs featuring specific (bespoke) resilience learning permutations enriched by a truly relevant and realistic organizational setting. The use of resilience business serious games conceived in this way will we assert, help organizations to cultivate concrete resilience organizational capabilities and employee capacities, vital to coping with the increasingly prevalent and extreme crisis events impacting contemporary socioeconomic systems.

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Acknowledgments / Conflicts of interest

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Understanding the Metaverse with the Q-method

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Abstract. According to social constructivist theories on innovation, innovative concepts such as the Metaverse can serve as a 'boundary object' that allows for 'interpretative flexibility' across different communities while retaining enough 'common identity' to facilitate the interactions within and between these communities. To fully understand the innovation dynamics of the Metaverse, it is necessary to acknowledge the diverse perspectives that shape the Metaverse discourse. The authors conducted a Q-method study to examine the Metaverse's 'interpretative flexibility' in local-to-global ecosystems. The Q-set comprised 43 statements covering five categories of the Metaverse essential to the social constructivist theories: terminology, Cultural Values, Societal impact, economics, and regulation. The card sorting Q-exercise was conducted online with 25 participants who were knowledgeable about and involved in the Metaverse across sectors and regions of the world. The Q statistical analysis revealed four dominant perspectives on the Metaverse: 1) Inclusion for real innovation; 2) A non-essential technology; 3) A 3D extension of social media; and 4) The destructive power behind it. The interpretation of the frames was constructed based on the critical statements. All interviews were transcribed, coded, and analyzed to provide a narrative description of the frames. The authors argue that while the discourse on the Metaverse is still somewhat volatile, their findings confirmed that the Metaverse is a reality, but fundamental changes are necessary to ensure its positive impact on society.

Keywords: Metaverse, Gaming, Social Construction of Technology, Q-method study, Discourse analysis.

1 Introduction

The concept of a Metaverse, an all-encompassing virtual world that includes various aspects of life such as games, leisure, business, politics, and more, has existed for several decades. However, a more serious discussion about the Metaverse has flared in the last few years. In 2021, Facebook changed its name to Meta, promising to 'bring the Metaverse to life' with its immersive and embodied Internet platform 'Horizon Worlds' [1]. US Tech giants Microsoft, Nvidia, Epic Games, Roblox, and the Chinese players NetEase, Tencent, Huawei, Alibaba and Baidu [2]; Sony from Japan, Samsung from South Korea play as key competitors and strive to develop their metaverse-like platforms and market immersive 'killer applications' [3,4]. While a McKinsey report on the Metaverse concluded that consumers will be the driving force behind its evolution [5], we argue that the relationship between technology innovation and human subjectivity is much more complex than that.

The Metaverse is constructed by many interdependent actors who constantly interact in dynamic, local-to-global innovation networks. There are strongly diverging opinions in these innovation networks about what the Metaverse is (not), how it can best be named, who owns it, and how it should be valued and controlled. Many actor-network interactions are about meaning, i.e., defining the essential questions and finding workable answers. In order to better understand the Metaverse as a social-technical innovation, it is essential to reconstruct the underlying discourse, or the 'language game', around it. Which actors hold what beliefs about the Metaverse? Which actors hold similar or divergent beliefs? What are the specific issues in and between these belief systems? Moreover, how does this influence the Metaverse's future path?

2.1 Perspectives on the Metaverse

We briefly scope the Metaverse concept and sketch a few diverging opinions. This is the starting point for the Q-set of statements (see below). Reference to gaming in virtual worlds are frequently made [8,9]. Embodiment and interaction via an avatar are critical aspects of the Metaverse as a virtual world. Some argue that intelligent and embodied agents, virtual humans, will significantly transform this interaction with and via avatars [10].

Another critical aspect of the Metaverse is Virtual Reality [11]. Opinions in this regard diverge. Some authors see VR as an essential characteristic such as *Second Life* [12], whereas others do not. Some believe that Augmented Reality and Mixed Reality will genuinely define the Metaverse to become a ‘real-world metaverse’ [13,14]

Others see the Metaverse as a 3D version of the Internet, primarily used for information and transactions. This converges with a view of a more open-source and decentralized economy [15,16]. Noteworthy are the linkages between the Metaverse and cryptocurrency and blockchain [17,18]. Some see this as a step towards an online, open virtual society consisting of self-organizing transactional communities [19,20].

The Metaverse is also part of the digital intelligence revolution, emphasizing AI, Data, and Machine Learning. The Metaverse, for instance, can host simulations and Digital Twins to create a better world with better understanding and more empathy for other cultures or nature [21,22,23].

This also links the Metaverse to transformations in education and learning. Many see it as an accelerator towards remote, blended, lifelong, inclusive, democratic, interactive, and experiential learning [24,25].

A critical perspective about the Metaverse is that of online gaming and interactive entertainment (s.a., media and e-sports). According to most game designers, immersive online gaming platforms such as Epic’s Fortnite are the most prominent and promising examples of the Metaverse [9].

The Metaverse discussion is also rife with controversy and conflict. The emergence of the Metaverse might significantly impact the sustainable development of mother earth and human society in the long term [26]. On the other hand, it may aggravate some of the challenges and risks associated with the Internet, such as data security, internet fraud, and cybercrime. Some position the Metaverse as a dystopian nightmare or a techno monstrosity in the hands of big tech or totalitarian regimes [27].

An EU-recent report nicely worded the core innovation dilemma: “[The Metaverse] could constitute an entirely new space offering limitless possibilities and the potential to change our lives. Alternatively, it could turn out to be something of an empty shell: a fantasy pushed by the social media industry to distract attention from some of their current difficulties” [26].

2.2 The Social Construction of the Metaverse

The ambiguity of the concept of the Metaverse raises questions about the role of societal factors in shaping technological development. The Social Construction of Technology (SCOT) framework in Science and Technology Studies highlights the role of societal factors in shaping technological development [28,29]. Interpretative flexibility is a vital aspect of the SCOT framework, describing how technological artifacts can have multiple conflicting interpretations that evolve over time [30,31]. In this context, the Metaverse can be considered a Boundary Object - an object, artifact, or representation that facilitates communication and coordination between different communities of practice, such as organizations, groups, or individuals. Boundary objects serve as a shared reference point and help to reconcile differences in perspectives and goals between these communities while allowing for interpretive flexibility. Considering the Metaverse as a boundary object implies that it can be interpreted very differently across communities (i.e., plasticity) while maintaining sufficient ‘common identity’ (i.e., integrity) to facilitate the interactions in and between these communities. Reconstructing the

interpretative flexibility of the Metaverse may help to understand if and how the Metaverse concept can work as a boundary concept in the innovation system. If, for instance, the integrity of the concept is too low, it can quickly disintegrate and lose its communicative function.

To operationalize the social construction of the Metaverse concept in our Q-study, we, therefore, consider the critical issues identified in the SCOT theory, including the interests and cultural values of stakeholders, the societal impact, economics, and regulation..

3 Material and Methods

3.1 Research objective

The research's objective is to significantly contribute to the societal and academic understanding of the Metaverse and the social-technical innovation process that shapes it. This is relevant because the Metaverse is an ambiguous and controversial innovation concept that attracts significant investments and can potentially impact society.

3.2 Research questions:

The empirical research questions of the Q-method study are:

1. What perspectives constitute the discourse about the Metaverse?
2. What are the similarities and differences between these perspectives?
3. How and to what extent do background factors, such as the country of origin, age, gender, position, knowledge, or involvement, influence these perspectives?

Furthermore, we aim to answer the methodological question:

4. To what extent is the Q-method design a reasonable and practical approach to studying the Metaverse innovation?

3.3 Q-methodology and Subjectivity

The Social Construction of Technology research methodology attempts to reconstruct the alternative interpretations of the technology within and among different social actor groups (i.e. the organizing principles for intersubjectivity) [32,33,34]. In this paper, we try to capture the interpretative flexibility of the Metaverse by clustering its meaning in different frames, from those who are knowledgeable, and active in observing the metaverse development. To do so we use the Q methodology. Q methodology is a research method used to study human subjectivity and opinion, originally by psychologist William Stephenson in the 1930s [35]. It involves using subjective statements called "Q sorts" to understand an individual's views and attitudes on a particular topic [6,36,37,38]. Q methodology has been applied in a wide range of fields related to the topic of SCOT, such as "climate geoengineering" [39], "models, simulations and games for water management" [40], "web credibility"[41], and AR shopping [42] for just a few examples. A typical Q method study includes the following stages:

1. Collect the statements (the Q-set, usually between 30 and 50) representing diverging views on the topic.
2. Identify respondents (P-set, usually between 25 and 40) who represent diverging viewpoints.
3. Personal interviews in which each respondent ranks the collection of statements (Q-sort) on a scale (Q-scale, -3 to +3, strongly disagree–strongly agree), thus laying out a quasi-normal distribution of the cards, while giving detailed explanations and arguments to the interviewer.
4. Statistical analysis (an "inverted factor analysis") of the Q-sorts (called the Q-data) and coding of the qualitative information.

5. Reconstruct a limited set of frames based on the factor analysis but interpreted and labelled with the qualitative data.

3.4 The Q sort of the Metaverse

The research methodology employed a bibliometric analysis to examine the co-occurrence of keywords related to the Metaverse, as illustrated in Figure 1 and above. Subsequently, a systematic literature review (SLR) was conducted using the Scopus database to identify pertinent references. The selection process involved four steps: firstly, the keyword "metaverse" was used to search for article titles and abstracts in sociology, organizational, and management studies, focusing on discussions regarding the concept, role, value, and trajectory of the Metaverse towards the future. Secondly, a preliminary scan of 180 abstracts from these fields was conducted. Thirdly, a Google search utilizing the same keyword was carried out to track the latest discourse on the Metaverse in distinguished online journals such as CNN Business, Harvard Business Review, The Washington Post, and Cointelegraph, among others. Finally, statements that were deemed relevant were extracted;

The initial set of statements comprised approximately 100 items, from which a re-fined selection of 43 statements was made to ensure a balanced representation of the essential components of the Social Construction of Technology (SCOT) theory. These statements were further categorized into distinct domains, including Terminology (T=6), cultural Values (V=7), Societal impact (S=6), Economics (E=10), and Regulation (R=14), as presented in Figure 2. This process yielded a comprehensive and systematic compilation of Q statements.

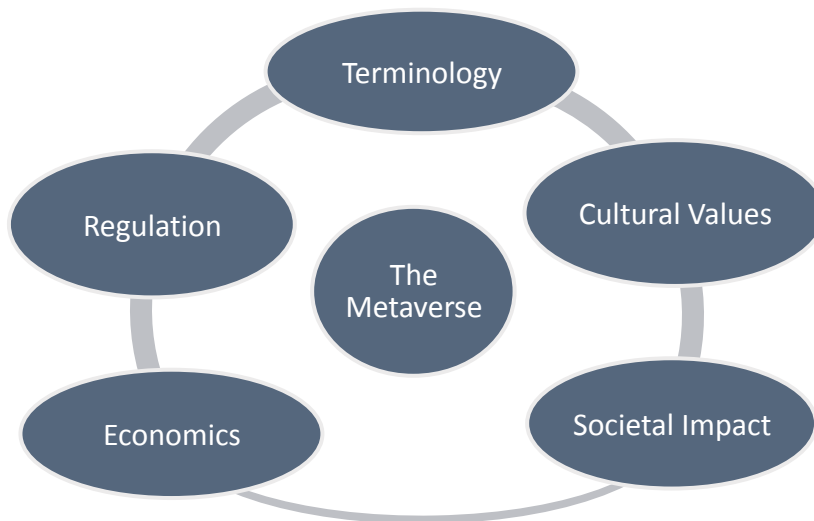


Fig 2. Conceptual constitution of the Q statements.

3.5 Participants and the procedure of the Q sorts

The participants of this study were carefully selected based on the potential to provide valuable insights on the Metaverse. To be eligible, they needed to possess a understanding of the Metaverse concept, and be actively following its development. Invitations to participate in the Q methodology study were sent to individuals who had previously taken part in metaverse-related activities organized by the researchers' lab. Ultimately, twenty-five persons participated in the study.

Each Q sort process lasted approximately 1 hour, with about 30 minutes dedicated to the card sorting process and another 30 minutes to discussing the results. The data collection and analysis were done using the web-based Q Method Software [37]. In addition, all online interviews were transcribed using speech-to-text software, and the resulting data were coded and analyzed to provide a quantitative interpretation of the participants' views on the Metaverse.

3.6 Statistical analysis and interpretation

The Pearson standard is used to calculate the correlation matrix, followed by the application of Principal Component Analysis (PCA) for factor extraction. The most common routine in factor analysis for Q-study is PCA with a varimax rotation, as noted by Brown (2004). Factors are deemed significant if their loading exceeds .39 ($p < .01: 2.58 \times (1 \div \sqrt{43}) = +/- 0.39$, 43 = the number of the statements). It is important to note that the factor analysis in Q-sort is not solely based on statistical rigor but also involves intuitive decision-making in determining the representative factors and statements. In cases of the ambiguous factor loading, where a single Q-sort statement is associated with multiple factors, it will not be associated with any factor. The interpretation of significant factors is presented in a narrative style, incorporating distinguishing and consensus statements. To ensure reliability, draft interpretations of the factors were sent to the relevant participants for review and feedback.

4 Results

Twenty-five individuals, ranging in age from 30 to 60, participated in the online Q sort and interview process. Of these participants, sixteen were male, eight were female, and one preferred not to disclose their gender. All participants resided in Europe, with 24 residing in the Netherlands and one in the United Kingdom. They were either associated with the public sector, NGOs (twenty individuals), or private industry (five individuals). Participants self-reported their level of familiarity with the Metaverse, with nine saying they knew "a few things," ten saying they knew "quite some things," and six saying they knew "many things." The nationality of each participant is documented in Table 1.

Table 1. Nationalities of the participants

Nationality	Number of participants	%
Brazilian	1	4
Chinese	4	16
Dutch	14	56
Germany	1	4
Iran	1	4
Italian	1	4
Portuguese	1	4
UK	2	8
total	25	≈100

Four factors were selected for varimax rotation to examine the frames (see Appendix 1 for an overview of the statements in the automatically generated ideal sorts). 21 participants' sorts loaded significantly only on one factor, accounting for 60 percent of the total variance. Four participants had less significant load (slightly above .39) on two factors. Specifically two sorts loaded both on factor one and three. One participant, originally from Portugal, "knows many" of the metaverse and is actively involving in VR products. The other participant, originally from Bulgaria, knows "a few" about the metaverse and is closely observing its development. Another participant, a Dutch individual who "knows a few and is actively observing" loaded on factor one

and two. The last participant loaded on factor two and three, originally from China, “knows quite some” about the metaverse and is actively observing its development. Table 2 shows the correlations between the factors.

Table 2. correlation between the factors

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1	0.29745	0.39465	0.17776
Factor 2		1	0.18116	0.24016
Factor 3			1	0.0408
Factor 4				1

4.1 Factor 1: Inclusion for real innovation.

Ten participants’ sorts significantly correlated with factor one. Table 3 presents the self-declared knowledge and experience of the Metaverse from the associated sorters.

Table 3. background of the sorts in Factor 1

Nationality of sorter	Number of sorts	Sorter’s Knowledge of the Metaverse	Number of sorts
Chinese	3	quite some	4
Dutch	5	many	3
Germany	1	know only a few	3
Italian	1	Actively producing	2
total	10	Actively using / observing	1

This frame supports the expansive version of the metaverse and its potential for innovation (T2,+2; T4, -2). It recognizes the potential for remote and distributed work (E5,+2), and the inclusion and empowerment of disabled or deprived people (E4,+2). The pace of innovation is rapid (S1, -2). However, to prevent the Metaverse from further controlling people’s lives (v6, -3) and dominating the global economy with digital technology (v7, -3), it is important to have a balanced approach to its development that involves various parties of the smaller sizes and different cultures. Effective governance should be achieved through decentralization of user empowerment, and must include the involvement of various communities (G10, +2).

(Quote 1) “When the commercial hype of it fades away, the real innovation will begin. Think about the development of the Internet you will see the same... reading the classic literature about technology innovation will help to understand it.”

(Quote 2) “Reading the theories of philosophy behind the digital transformation of society makes me believe how important it is to keep an open and involving discussion about the metaverse among different people.”

4.2 Factor 2: A non-essential technology.

Six participants’ sorts correlated significantly with factor two. Table 4 presents the self-declared knowledge and experience of the Metaverse from the associated sorters.

Table 4. background of the sorts in Factor 2

Nationality of sorter	Number of sorts	Sorter’s Knowledge of the Metaverse	Number of sorts
------------------------------	------------------------	--	------------------------

Dutch	4	quite some	3
Iran	1	only a few	3
UK	1	Active producing	1
Total	6	Actively observing	5

The metaverse in this frame refers clearly to commercial products: online virtual space where games, social media, leisure and entertainment interconnect and blend (v3, +3), through interconnecting people in different locations or parts of the world in the same virtual space (V5, +1). Behind the metaverse is a "techno-monster " in the hands of Big Tech (v1, +2) tries to influence and control people’s lives even more (v6, +2), and dominate the global economy with digital technology (v7, +2) through digital currencies and non-fungible tokens (E6, +3). However, this frame does not see the metaverse as becoming a critical part of society in the near future (S2, -3), and does not regard it as valuable for individuals or essential for humankind’s well-being and the transition to sustainability (S5, -3; S6 -3).

(Quote) “I am not willing to share much about myself on any social media, and that is the case for many young people. We interact with people we know, not strangers, in a VR chatroom”.

(Quote) “When a speaker described how he enjoyed the movie in the Metaverse with his kids on Sunday afternoon. I almost laughed and thought, why not just hold them in your arms and watch the movie on a big screen with snacks together?”

4.3 Factor 3: A 3D extension of social media.

Factor three loaded significantly with three sorts, from one Dutch. Table 5 presents the self-declared knowledge and experience of the Metaverse from the associated sorters.

Table 5. background of the sorts in Factor 3

Nationality of sorter	Number of sorts	Sorter’s Knowledge of the Metaverse	Number of sorts
Dutch	1	quite some	3
British	1	Actively using / observing	3
Brazilian	1		
Total	3		

Similar to the rise of social media, the Metaverse will bring innovation to business, create new types of professions and jobs (S4, +2), and dive into remote and distributed work (E5, +2). However, it might also exacerbate existing challenges in social media in its 3D extension of the Internet (T5, +2), such as filter bubbles and reality distortion (G6, +3), and erode territorial sovereignty due to the absence of national borders and legislation (G5, +2). While companies operating in the Metaverse should not be held responsible for what people do within it (R11, -3), they should not be given unchecked control over its development (R9, -3). The question of how the Metaverse should be regulated and governed is far from clear and requires critical reflection about the role played by the public and societal institutions and transnational institutions like the European Union (R12, -1; R14, -3).

(Quote 5) “Look at what happens with the young generation on social media, and you know what I mean.”

4.4 Factor 4: The destructive power behind.

Factor four is significantly associated with two participants’ sorts. Table 6 presents the self-declared knowledge and experience of the Metaverse from the associated sorters.

Table 6. background of the sorts in Factor 4

Nationality of sorter	Number of sorts	Sorter's Knowledge of the Metaverse	Number of sorts
Dutch	2	quite some	2
Total	2	Actively using / observing	2

The Metaverse constitutes a multifaceted and complex phenomenon that defies a singular definition, not as the virtual online platforms developed under different names by different companies for different target groups and purposes (T6, -2), nor as the multiplayer Online Games, like Fortnite to becoming virtual “hang-out places” (T3, -2), and not for augment the reality with digital data, Artificial Intelligent and interactive experience (V4, -3). However, this frame highlights the considerable influence of the Metaverse and those in control of it. The continued dominance of big tech corporations over the Metaverse will enable them to shape the global economy through digital technologies (V7, +3). The Metaverse will likely become a geo-political battleground for dominated global powers like the US, Europe, and China (V7, +3). The Metaverse could exacerbate the problem of political radicalization (R2, +3) and widen the gap between those who have access to it and those who do not (E7, +1).

(Quote) “I just want to use the metaverse for experiences. I do not like that part of the metaverse at all (about the big tech companies' control) ”.

5 Conclusion

5.1 Answering the empirical research questions

What perspectives constitute the discourse about the Metaverse? Our study has identified four distinct discourse frames associated with the Metaverse, with the primary focus being on the potential social impact and governance of this phenomenon. The precise definition and essential features of what constitutes a “true” Metaverse are subject to varying opinions and are not considered an immediate concern. Instead, the differing attitudes and perspectives towards the potential social impact and governance of the Metaverse distinguish the four frames from one another.

What are the similarities and differences between these perspectives? In our study, we have identified four discourse frames regarding the Metaverse, with a particular focus on its potential social impact and governance. Despite differences in opinions regarding the precise definition and essential features of a “true” metaverse, all four frames agree on the need to limit the monopoly power of large tech companies in the Metaverse R9, with a maximum disagreement of -3. The concern for the well-being of humankind and the Metaverse's impact on sustainability is shared across all frames, with frames 2 and 3 placing particular emphasis on these topics. Remote work, data security, and privacy are common themes in frames 1, 2, and 3, while frame 4 focuses on the Metaverse's impact on geopolitics and democracy. Frames 1 and 3 display a slightly stronger agreement, with both frames expressing a positive outlook on the diversity of metaverse products and their innovative impact on society. The level of concern over the challenges posed by the Metaverse and the need for good governance in its development exhibited the most significant differences in opinions.

How and to what extent do background factors, such as the country of origin, age, gender, position, knowledge, or involvement, influence these perspectives? Our statistical analysis revealed no significant correlation between the participant’s background and their perspectives on the Metaverse. Nevertheless, a more in-depth examination of the interview data suggests that

factors such as knowledge, experience, and interest may play a crucial role in shaping personal perspectives toward digital innovations such as the Metaverse.

Discussion

Our research indicates that while the discourse surrounding the Metaverse is still somewhat volatile, it is indeed happening in various digital forms. The Metaverse engages people for various reasons and is already transforming how we work, play, entertain, and conduct business.

It should be noted that some influential figures in the critical metaverse industries, such as opinion leaders, content creators, and strategic operators, were not (yet) able to participate in this initial study due to time constraints or not responding to the invitation. Furthermore, the study was limited to individuals residing in Europe who speak English, as the Q-sort was only available in English, and time constraints prevented translation into other languages. As a result, the study may lack representation from diverse actors and communities with differing geo-political and cultural systems, which will be addressed in future iterations of the Q-study. Nevertheless, the online Q-method study proved effective in examining the social construction of metaverse innovation. The use of web-based software enabled us to easily and flexibly reach participants from various geographical locations. The following future Q-study will provide more comprehensive and representative insights into the relationship between digital evolution and human society.

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Appendix A. Automatic generated ideal Q-sort

Statement	No.	factors			
		1	2	3	4
The term “metaverse” adds nothing since online virtual worlds, such as Second Life, have existed for some time.	T1	-2	-2	0	-1
“The metaverse” mainly refers to a vision of a digital innovation with the potential to transform society	T2	2	-2	-1	0
“The metaverse” mainly refers to Multiplayer Online Games, like Fortnite, as they are becoming like virtual “hang-out places”.	T3	-2	-1	-2	-2
“The metaverse” mainly refers to the product-services, such as Horizon Worlds, that are currently marketed under this term by the company Meta (formerly Facebook).	T4	-2	-1	1	0
“The metaverse” mainly refers to the 3D extension of the Internet.	T5	-1	-2	2	-2
“The metaverse” is a general term for a certain type of virtual online platforms developed under different names by different companies for different target groups and purposes.	T6	1	2	2	-2
The Metaverse refers to a techno-monstrosity in the hands of Big Tech.	V1	-3	2	-3	-2
The main value of the Metaverse is to use the power of the digital revolution for a better world.	V2	1	-2	1	-3
The main value of the Metaverse is to create an online virtual space where games, social media, leisure, and entertainment interconnect and blend.	V3	0	3	1	-2
The main value of the Metaverse is to augment the real (physical and social) world with digital data, artificial intelligence, and interactive experiences.	V4	0	-1	0	-3
The main value of the Metaverse is to interconnect people in different locations or parts of the world in the same virtual space.	V5	1	1	2	-1
The main value of (those behind) the Metaverse is to influence and control people’s lives even more.	V6	-3	2	-1	0
The main value of (those behind) the Metaverse is to dominate the global economy with digital technology.	V7	-3	2	-2	3
The Metaverse is unrealistic and unattainable, in the next decade.	S1	-2	-2	0	0
Within a decade, the Metaverse will likely be a critical part of our personal and social lives.	S2	0	-3	0	2
The Metaverse will likely only interest the younger generations because they grow up with it.	S3	-1	0	-2	-3
The Metaverse will likely create new types of professions and jobs, such as immersive content developer.	S4	2	1	2	2
The well-being of humankind depends on the success of digital innovations, such as the Metaverse.	S5	-1	-3	-1	-1

The transition towards a sustainable world depends on the success of digital innovations, such as the Metaverse.	S6	0	-3	-2	0
Digital innovations such as the Metaverse will likely create more wealth and employment.	E1	0	-1	1	0
The Metaverse will likely revolutionize the way we educate and learn.	E2	3	0	1	-1
The Metaverse will likely provide exciting new opportunities for business and commerce.	E3	3	2	0	-1
The Metaverse will likely provide new ways of inclusion and empowerment for people who are disabled or deprived.	E4	2	0	1	-2
The Metaverse will likely change how, when, where and with whom we work, for instance more remote and distributed.	E5	2	1	3	0
The Metaverse will likely boost the digital economy, such as digital currencies and non-fungible tokens (NFT).	E6	1	3	0	0
The Metaverse will likely divide those who do and those who do not have access to it.	E7	1	0	2	1
The Metaverse will likely create new and severe risks regarding personal data, privacy, and security.	E8	3	3	3	1
The energy use of the Metaverse will likely stand in the way of global climate goals.	E9	-1	1	-2	-1
The Metaverse will likely increase youth problems such as addiction, obesity, negative self-image, or eating disorders.	E10	0	-2	-1	2
The Metaverse is likely to exacerbate algorithmic bias and institutional discrimination.	R1	0	1	-2	0
Political radicalization in the Metaverse will likely be worse than on social media today.	R2	-2	1	0	3
The Metaverse will likely damage the functioning of democratic institutions, such as open and free elections.	R3	-1	-1	-1	3
The Metaverse will likely become a geo-political battleground for global powers such as the US, Europe, and China.	R4	0	0	0	3
The Metaverse will likely further erode territorial sovereignty due to the absence of national borders and legislation.	R5	0	-1	3	1
The Metaverse will likely cause more filter bubbles and reality distortion than on social media today.	R6	-1	1	3	1
The Metaverse will likely decrease our connection to, and empathy for nature.	R7	-1	0	1	-1
Even if we want to, we cannot control or govern the Metaverse.	R8	-2	-1	0	1
The Metaverse should be left to the tech companies to determine and manage.	R9	-3	-3	-3	-3
The Metaverse should be governed decentrally by its users, for instance in communities.	R10	2	0	2	1
Metaverse companies should be held responsible for	R11	1	0	-3	1

what people do in the Metaverse.					
The Metaverse should be well-regulated and supervised by public and societal institutions.	R12	3	3	-1	2
The Metaverse requires more and better government regulation than, for instance, social media today.	R13	2	0	-1	2
The Metaverse should be regulated by transnational institutions, such as the European Union.	R14	1	2	-3	2
Total number of the statements=43					

T=terminology / V=cultural Values / S=Societal impact / E=Economics / R=Regulation

Complexity and time in economic modeling of simulation games

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Abstract. The article aims to present different logic for creating econometric models for building a business simulation game that will be capable of working both in decision rounds and in the real-time game mode. Game designers look at aspects, such as demand modeling with multiple locations or types of markets, product and cost modeling and event modeling section with selected types of event modeling typology.

The paper will follow the examples of the games designed in recent years by the authors, which are economic engines modeled after different principles, such as multiple demand curves, modeling product and production with differences between turn-based logic and turn-based logic including real-time elements.

The conclusions of the paper contribute to the shared pool of knowledge on economic modeling of computational serious simulation games.

Keywords: economic modeling, business games, demand modeling, serious game, real-time games, complexity representation, time

1 Introduction

One of the core tasks in the field of simulation game is designing appropriate models, that represent the desired artefacts of business models, stakeholders in the game and their processes. This is an essential skill in building computer-aided simulation games. The algorithmic models or colloquially named game engines are the modeled representations of real-life systems. They are responsible for interactivity, delivery of the game mechanics and feedback to the player in a workflow consisting in decisions, actions, to producing results and financial statements.

From the perspective of the traditional simulation game design theory, they are the algorithmic embodiment of game rules [1].

This article aims to bring systematization to the modeling opportunities and show the core caveats of modeling looking through the lens of complexity and systems design. The key component of modeling in simulation gaming is understanding the dependency between complexity, game design and player experience [2] because it is impossible to talk about modeling the simulation games without deciding on the complexity level, at which the simulation game should operate. In this paper we focus on two aspects of modeling. The first one is the strategic choice of delivery of complexity to the player and the example of how it can be modeled through decisions built around the demand curves in simulated markets. The demand function is a central aspect to the modeling of business simulation games. The second topic is the role of time in modeling of business simulation games. In this contribution we look at functional role of time as a variable [3; after 4], with an example of a simulation game model and with the topic on how to build a simulation game with time as an functional resource. This approach aims at building more process oriented simulations or real-time games in video games terminology [5;6].

The article will also draw a lot of parallels with video games design and analysis, which is the authors focus in the underlining design. But, according to Klabbers, reason and philosophy of the serious gaming differs strongly with video gaming i.e. design-in-the-large [7]. However, in the practical design and implementation of simulation games i.e. design-in-the-small [7], the serious games design process is very similar to one of video games. Similarities can be seen by analyzing

video games approaches from the point of design and treatment of complexity, time and its processes. All those elements can give additional, interesting perspective and insights in the design of serious games.

2 Complexity

From a modeling perspective, there are two main facets to the design of simulation games. The first facet is the treatment of complexity in the process of systems analysis and game algorithmic modeling. The second facet is how the simulation game complexity is introduced and presented to the player.

Complexity in digital interaction with participants is both a concept and a design feature. Complexity as a concept in games is important to understand the emergence and implementation of game systems in the markets. Complexity from this perspective can be defined as a term coming from the classic systems theory and can be understood as a type of system. A complex system is self-organizing, adaptive, replicative and learning [7; p.105].

Thus, complexity is rule-based and dynamic, it has the potential to cause towards players in a counterintuitive and surprising manner. The level of complexity can have a large impact on the player's behavior and perception of the game.

In the simulation game theory and design practice complexity design is an important factor contributing to the quality of games but it also represents a non-trivial phenomenon in the simulation and gaming itself [9; 10; 11; 12]. In the article on complexity in game design the authors propose a model describing the process of dissemination of complex system into a game model [13].

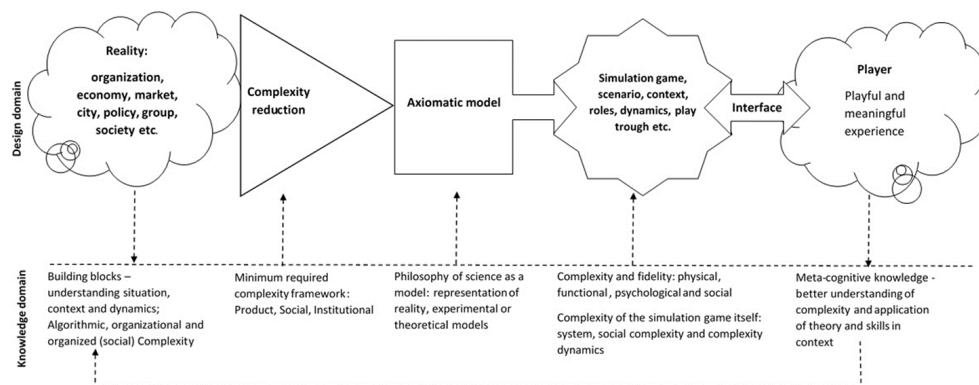


Figure 1. The model of the role of complexity in domains of design and knowledge [13].

The complexity model shows the steps, in which the observed complexity of the systems is treated through the design process, and which knowledge area contributes to the outcome. The model presented (see Figure 1) does not answer the question on how the complexity is presented and explained to the player.

Another look at the design of complexity in gaming is present in the video game design. In video game design, complexity is a feature of the game. The game designer decides on the level of game complexity through rules and game mechanics. Also, game designers decide usually on how the complexity is presented and communicated to the player during the gameplay. Rule based complexity is called innate complexity [5; p.195-196] and is often stigmatized in game design as complex games can be perceived as overall difficult and hard to understand. Players like to uncover the secrets from the programmed Black Box in order to get insights and experience how to win the game.

First of all, there are a lot of players who enjoy the challenge of increased complexity and difficulty of games. Some games with high popularity are intentionally designed to be complex. A

good example for this are simulation games like SimCity [14] or Microsoft Flight Simulator [15], which even enjoy a large public audience until today. Secondly, complex and difficult games can be an asset. The story of the game publisher FromSoftware and their most recent product Elden Ring [16], which is difficult and complex, became one of the most successful games of 2022.

The other form of complexity, which is mostly desired by players is emergent complexity. Emergent complexity is situational complexity emerging from the combination of limiting rules and dynamic decision-making under uncertainty conditions which leads to unpredictable patterns of complexity [6]. This emergent complexity is often referred to as depth in gameplay. The most prolific example of a game perfectly representing this phenomenon is the game of Go. The rules of the game of Go are quite simple but the number of potential strategies and gameplay variations is extremely large. Emergent complexity is quite harder to achieve and balance than innate complexity.

Game designers use different approaches to build complex game systems and subsystems and defining dependencies between them. The designer sees the game in macro perspective with all its internal systems and structures, in which complexity is just a feature of game design. However, the player experiences the game's complexity through tasks and challenges that he faces in the game. So, from the systems design perspective, they face the opposite ends of the same system. In such case, a game designer does not just model the game around the innate and emergent complexity levels but also needs to decide on the strategy on how the complexity is presented to the player. Looking at both examples, serious and video games, we can establish two basic strategies of introducing the complexity to the player.

The first strategy is the incremental exposure to the game's complexity.

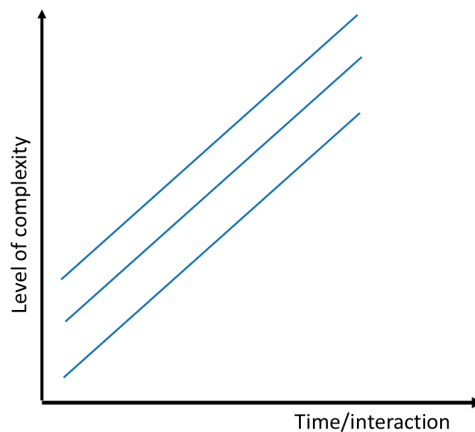


Figure 2. Incremental complexity introduction.

In this strategy, the game progressively exposes complexity. The pace and manner of the exposure depends on the game design purpose or can be automated based on the player's progress in a dynamic way [17]. The player is presented with a dynamically growing number of rules and game mechanics but also has time to adapt to the new complexity level of the game system. In this way, the game lowers the entry threshold for new players but the initial state of the game can give a false image of the simulated system to be trivial. In the video game industry, StarCraft II [18] reveals vastly complex real-time strategy gameplay, through the tutorials and the campaign introduces players gradually to the different types of units, buildings, and resources for each playable race independently. In simulation gaming many business simulations are built around the startup scenario, in which players starts with a very small number of decisions and as the company grows the number of decisions and rules are growing as well e.g. Marketplace Simulations [19] or Hotel Stars [20].

The second strategy is exploratory introduction of complexity.

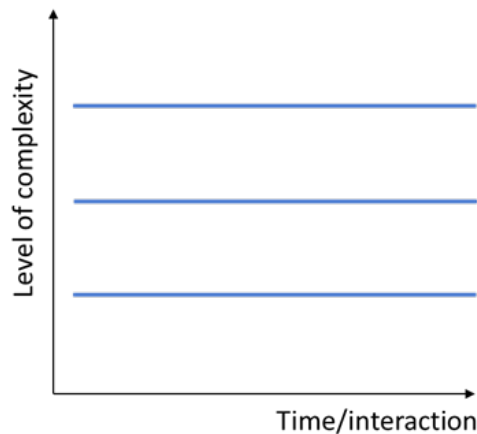


Figure 3. The exploratory model of game complexity.

The exploratory strategy presents the full complexity of the game to the players from the beginning, asks the player to interact with the game and discover the game system and learn from interaction and feedback. The introduction of the game complexity at a high level can be discouraging or off-putting for the players. Especially, if the innate complexity of the game is behind the complexity barrier for the player, which is the feeling of the player, that the game's system responses is completely random.

In video game industry, above-mentioned game *Elden Ring* almost immediately introduces the player to the game world with its full complexity. The effect of this game design decision polarized the player community. One side prized it for its brilliant game and terrific design and the other side complained about the game being too hard and therefore uninviting. In simulation gaming many business games built around corporate scenarios are presenting a high level of complexity accompanied by very long and elaborate player manuals explaining hundreds of rules and mechanisms e.g. *CapSim* [21], *TOPSIM General Management* [22].

One additional important aspect of the complexity introduction strategy is how the game communicates the complexity to the player. In traditional simulation game design, publishers offer help to game facilitators through extensive instructor manuals for them and the participants manuals for the players as pre-readers, but in more digital game-based learning-oriented games and video game design, where the facilitator is not present in the onboarding process, game feedback and narrative are the player's guide through the complexity of the game. The relation between the game complexity and narrative is ambiguous. On one side, the narrative can have the role of introducing the player to the complexity of the game system and explaining rules through feedback. It can be called narrative context framing through storytelling and nudging. On the other side, the narrative as a game subsystem can contribute to the overall game complexity significantly by introducing many narrative elements, plots, and timelines [6]. Pursuing this purpose and in contradiction to above named software learning products, few serious games offer both, a reduced complexity in manuals and decisions as *PRIMESIM Strategic Management* [23] with a quick entry into a fluid decision making process also for a huge number of participating persons that can be up to 100 persons in 2 markets for one facilitator.

3 Time in games

Simulation games are a popular instructional method due to their ability to engage trainees' affective in cognitive processes [24]. The treatment of time in simulation games is an important aspect of the game design, as it can be used to create a sense of urgency or progression and affect the overall experience of the game. In computerized business simulation games, time is a key element in decision-making and can be considered to increase the application domain of

simulation games in the organizational context [4]. Additionally, simulation games are designed to model real systems and processes, which can be used for various purposes, including education and training, policy and decision making, testing of strategies, organizational transformation, and research [25]. The key classifications of time in simulation games are processing methods and its implications for time representation in games [4] and functional roles of time [3]. Processing methods divide the simulation game in two subcategories:

- Batch-processing method – in this method decisions are represented by the amount on decision to fill the masks. Then the simulation is run, and finally results are presented to the game’s participants and reports can be distributed to the audience digitally and – nowadays more seldom - physically.
- Continuous-processing method – in this method, data and decision will be updated and processed in real-time. The results are presented to the players when the in-game time of the processed action is finished.

Time and time-flow can have many dimensions in simulation games [3]. One of them is the functional role of time. Depending on its usage it can have two separate roles:

- Time as an independent variable: This variable represents duration of various processes in organizations and markets simulating individual, group and organizational behavior.
- Time as a dependent variable: This variable represents the impact of time on conceptualization, experience and usage of time by individuals, which may impact temporal patterning of behavior.

In video game design, time is either a feature, game mechanic or subsystem [5; 6] and it refers to either time for the player to make a decision, finish the task, in-game time flow or time for the system to react and interact with the player. In video game design, classification of games through processing time can be divided into three categories:

- Real-time games – games in which time is represented in real values of time;
- Turn-based games – games in which the time is paused for the player to make decisions;
- Turn-based games with real-time elements – games, in which the game has a different, mostly accelerated time flow as in real life and decisions can be paused or slowed down from the normal pace of time.

The crucial difference between those three types of games are stop-go rules, which are the rules governing the game behavior when the player is making a decision or action. In real-time games, the stop-go rule is defined as “always go!”, because the game does not stop when the player or players are making decisions or performing actions. Examples of such games are most multiplayer online games. In turn-based games the stop-go rule is always to stop the flow of in-game time, when the player is making a decision or performing an action. The duration of pauses can be limited, but the base rule stays the same. Examples of such games are most computer-aided simulation games and games like tic-tac-toe, chess, backgammon, and go. In turn-based games with real-time elements the stop-go rule is fluid and in many cases player dependent. The player can play in-game in real-time mode, can also slow down, speed up, or stop the time. Examples of such games are strategy games and simulation games like Total War, Civilization, or SimCity 2000.

The majority of simulation games, especially business simulation games, utilize turn-based systems or batch-processing. The in-game time is connected to the rounds (turns) and can vary between a week and a year. The main advantage of such a system is an easiness to control and to model, as the simulation needs to calculate the results only one outcome per turn. It also allows easy control and course management. The disadvantage of such systems is a relatively low level of fidelity of the game and a higher level of inconsistency [4].

4 Modeling econometric data between time and complexity

The critical element of designing simulation games is both model granulation and in-game time flow [26]. The most challenging element of the model is how the model gathers the decision data for calculation with regard to the chosen stop-go rule. In turn-based or batch processing games, the game pauses for the duration of decision inputs and then calculates the results and “moves” forward by the aforementioned amount of in-game time i.e. game period. From the algorithmic point of view in most cases it also either simulates the process or calculates the beginning and the end of the period and based on those simulations it produces the results and applies feedback mechanics.

However, the game designer needs to decide, when decisions will influence outcomes. An example of decisions can be investments. The effect of the decisions can be applied immediately on the beginning of the batch calculation or on the end of the calculated period, which functions as a delay in outcome to affect the model. The theoretical perspective on this process is similar to the six dimensions of temporality of business processes [27], in which the sequence and cycle are the equivalents of the business process dimension in the simulated organizational model. Also, if the game follows a scenario or features in-game events, then the game designer disputes, when to modify the variables and constants of the algorithms. The most common solution is to apply the changes at the beginning of the calculation, but the disadvantage of this solution is assuming that everything happens at the beginning of the period. In such case, any choice made by the game designer will require sacrifices of fidelity and realism and is traded for simplicity and a synchronous calculation scheme [4]. Cycle of decision making is also simpler and complexity modeling comes down to algorithmic complexity [7], which in business games is connected mainly to the demand modeling, number of decisions (i.e. variables) and additional events happening in game.

A different approach to the simulating processes is using turn-based games with real-time elements, in which the simulation process will have the flow and duration dependent on the in-game time flow. However, for a game engine to work it needs to have an additional variable of time attached to every other function and constant in the game. The time variable needs to be connected to the function or duration of effect, decision, or value. In other words, time has a functional role of virtual currency of limited amount. The goal of adding the time as variable to the model will allow for building continued processing game models.

Continued processing allows building the models more polychronic, and require players to do several tasks in parallel [4]. Thus, it adds an additional layer of complexity for the player. Modeling of complexity does not only consist of algorithmic complexity of demand and events. In the player’s perspective there are also a pre-defined (and often increasing) number of tasks the player has to do in a certain amount of time to meet the decisions-period deadline given by the system or the instructor. Traditional business games decision cycles that batch processing systems have, are not present. It is replaced with many smaller cycles ruled by the temporality of dimensions [27].

In the next part of the paper we analyze two examples. The first example is a batch processing game model, in which complexity is modeled through multiplicative demand equation. The second example is a model build with continues processing logic. Time is modeled as a variable and is attached to every element of the model.

5 Demand modeling

The central element of economic models is demand. Since 1982 the landmark publication of Gold and Pray [28] was the typical standard for demand modeling in business simulation games. It introduced the multiplicative equation for calculating market demand, company demand, and market share. Following 1983, several modifications or alternative demand algorithms were presented in papers at conferences [29; 30; 31;32, 33; 34, 35, 36, 37; 38, 39, 40; 41; 42].

The main advantage of multiplicative equations is the stability of the responses, except for marginal and fringe cases, and a good representation of the market mechanisms in large-scale simulations. However, from the point of view of complexity and time, it offers scalability in case

of complexity but completely ignores time as an element of the model. Thus, it is a good match for turn-based or batch processing simulation games.

Authors in further work and game design proposed different approaches to the simulation model design. For purpose of the analysis, we look at two models with completely different design logic but incorporating both complexity design and time constraints.

6 Example 1. Hotel Stars game

Hotel Stars is a computer-aided simulation game [20] created as part of an innovative program of teaching called "Economics in practice", implemented by the Foundation of Development of Education Initiatives. It is a program supported by a business simulation game addressed to secondary school students to teach them fundamental knowledge in economics, entrepreneurship, and business administration. The game has been designed to be played in small groups of 2-3 students. The game aims to create, run, and manage hotels in the virtual city of Pekunia. Teams can choose three different locations for their establishments, and the decision will have long-term consequences. Information about the features of each location is provided and tied to planning and budgeting activities. There is a total of 16 quarterly decision rounds during which the players will have to manage their business, which will gradually grow and, consequently, involves more and more complex decisions [42].

The game features a multiplicative demand function:

$$f_o^R(x^R) = D^R \cdot A^R \cdot (a(\max((x^R + c - C^R); 1))^t - b + B^R)$$

Parameters a, b, c, and d of the demand function.

$$A^R = 1 + \frac{1,5 \cdot \sum_{i=1}^J A_i \cdot w_i^R}{\sum_{i=1}^J A_i}$$

$$B^R = \sum_{i=1}^J B_i \cdot w_i^R$$

$$C^R = \sum_{i=1}^J C_i \cdot w_i^R$$

$$D^R = \prod D_i^R$$

Different stages of the game involve numerous decisions which affect the function of demand. They are modeled in the form of w_i factors, i.e. assuming certain values mainly from the range of 0 to 1, but sometimes including values which are negative (lower than zero) or bigger than 1 as well, which makes it possible to carry out a proper simulation of the effect of a given factor. In this model, each w_i factor features 4 assigned values, i.e. A_i , B_i , C_i , D_i , which define the effect on the demand function:

A_i – affecting A factor of scaling (multiplying) the demand function

B_i – affecting B factor of a vertical shift of the demand function

C_i – affecting C factor of a horizontal shift of the demand function

D_i – D factor of direct multiplication of the demand function; appears sporadically

The values of A_i , B_i , C_i , D_i are set for a given location and a given type of room and do not change throughout the game, whereas w_i factors are subject to change.

Let us assume that J is the amount of all identified factors, R is the round number, and w_i^R , $i = 1, \dots, J$ is the value of all factors in round R . It should be noted that many of these values may equal zero, e.g. when a given factor is inactive or has not appeared in the game yet.

Next, a limit for the function should be set since demand cannot have a negative value, and the size of the demand and revenues cannot exceed the number of rooms in the hotel.

$$f_1^R(x^R) = \max(f_o^R(x^R), 0)$$

Demand function limitation to the maximum number of available rooms and nights per quarter.

$$f^R(x^R) = \min(k \cdot 90, f_1^R(x^R))$$

where k is the number of rooms in the type and 90 is the number of nights available in the quarter.

The example follows the Gold & Pray [28] principles but it also introduces new elements. The demand parameters are built to scale with the complexity of the game and can respond properly to different model elements. Also, as it is modeling demand from the service industry introduces the concept of time into the equation limitation as the simulated quarter, as a decision period, has 90 days and it is incorporated as the equation maximum limitation. The complexity scaling in the game comes to introducing new decisions and events influencing demand and costs, otherwise the in game variables are equal to 1 thus they do not influence the function outcome. In such case, the complexity is relatively easy to manage and scale event through relatively long and complicated gameplay scenarios.

7 Example 2. Pop-up Shop Helper

Pop-up Shop helper simulation game was created as a part of the Erasmus+ project [43]. The project aimed to develop a unique innovative entrepreneurial training product to help those in the creative/artistic sector to make the transition from creativity to commercialization. One of the outcomes of the project was to create a game in which people coming from the creative sectors can train their business skills through the virtual Pop-Up Shops.

The game was designed and modeled with turn-based games with real-time elements or continues processing logic. As time is one crucial key factors for success for entrepreneurs, it was also important to design a appropriate scenario. The game scenario was built based on the experiences of around 100 entrepreneurs from Europe interviewed for that purpose. Most of the stressed importance of time management and doing many tasks at the same time. Based on their stories, we have chosen a week as a basic in-game cycle and an hour as a simulation iteration. Also, the game has been designed to play in single-player mode.

The game features 4 different locations to choose from for the players ($L1, L2, L3, L4$), on-line sales, and event sales e.g. fairs or festivals. Thus, the game featured 6 demand curves out of which player can experience between 1 to 3 at the same time i.e. chosen location, on-line sales and event sales.

Demand per hour for price P_x

$$L1 Dh_{L1} = \langle P_x, D_{L1_x} \rangle * (pqc_x * ppc_x * ptc_x) * spb_x * oma_x$$

$$L2 Dh_{L2} = \langle P_x, D_{L2_x} \rangle * (pqc_x * psc_x * ptc_x) * spb_x * oma_x$$

$$L3 Dh_{L3} = \langle P_x, D_{L3_x} \rangle * (psc_x * pvc_x * ptc_x) * spb_x * oma_x$$

$$L4 Dh_{L4} = \langle P_x, D_{L4_x} \rangle * (pvc_x * ppc_x * ptc_x) * spb_x * oma_x$$

$$\text{On-line} Dh_{ON} = \langle P_x, D_{ON_x} \rangle * (pvc_x * ppc_x * ptc_x) * spb_x * oma_x$$

$$\text{Events} Dh_{EV} = \langle P_x, D_{ON_x} \rangle * (pqc_x * psc_x * pvc_x * ppc_x * ptc_x) * EV_x$$

Where:

Location:	L_x	Product quality:	pqc_x
Product size and texture:	psc_x	Product variety:	pvc_x
Packaging:	ppc_x	Product testing:	ptc_x
Event type and duration:	EV_x		

Also: Sales promotion: spb_x

Activities for online presence website updates – a sum of time for online advertising, social media presence, and influencer marketing: oma_x

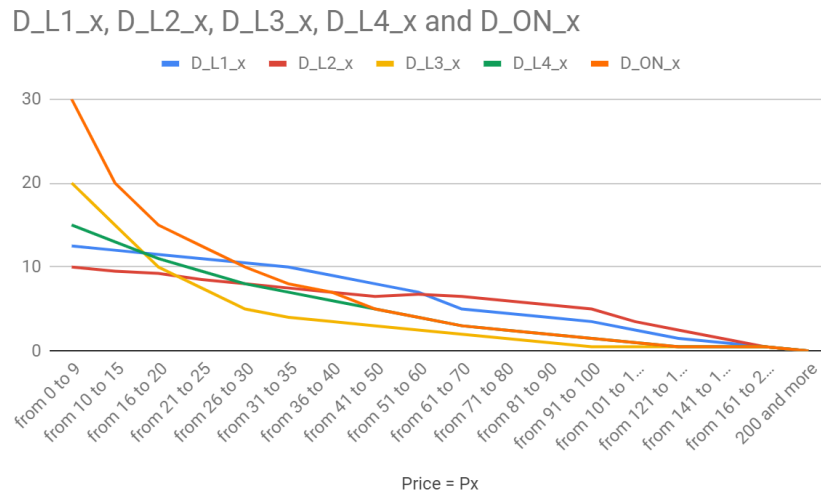


Figure 4. Demand curves for the locations and the online sales

The demand function, where modeled through tables in easy to optimize and calculate manner.

Table 1. Example demand modeling table with time drilldown

Demand per h	Location - base demand per h				On-line base demand per h
	D_L1_x	D_L2_x	D_L3_x	D_L4_x	
Price = Px					
from 0 to 9	12.5	10	20	15	30
from 10 to 15	12	9.5	15	13	20
from 16 to 20	11.5	9.25	10	11	15
from 21 to 25	11	8.5	7.5	9.5	12.5
from 26 to 30	10.5	8	5	8	10
from 31 to 35	10	7.5	4	7	8
from 36 to 40	9	7	3.5	6	7
from 41 to 50	8	6.5	3	5	5
from 51 to 60	7	6.75	2.5	4	4
from 61 to 70	5	6.5	2	3	3
from 71 to 80	4.5	6	1.5	2.5	2.5
from 81 to 90	4	5.5	1	2	2
from 91 to 100	3.5	5	0.5	1.5	1.5
from 101 to 120	2.5	3.5	0.5	1	1
from 121 to 140	1.5	2.5	0.5	0.5	0.5
from 141 to 160	1	1.5	0.5	0.5	0.5
from 161 to 200	0.5	0.5	0.5	0.5	0.5
200 and more	0	0	0	0	0

The demand, product design and production, marketing, and other activities of the player have both costs in money and in time. Also, every effect has duration as the indicator of the decision cycle. Thus, a player is not just spending money in the game but also time. This form of modeling has two advantages. Even in a very simple model, the complexity of the decision is relatively high as the player has to manage two decision constraints – time and money. It gives a new layer of complexity to the decisions but also brings us closer to the reality of the creative entrepreneur and the inherent trade-off of a scarcity of time as a resource. The second advantage is that the model based on the time-modeled approach is real-time simulation ready as it is very easy for the system to simulate the game hour-by-hour. In this case, it can give the player feedback through the whole simulation process and not just as a final outcome.

The main disadvantage of such a model is the difficulty in modeling and optimization of time and money trade-offs. If we have a limited amount of time per week it is necessary to limit the in-game elements and mechanics to the level of giving the player choice but not overbearing them with must-have decision cycles and deadlines.

8 Conclusions and summary

The paper presents a few important aspects of simulation game modeling. The authors would like to emphasize the dependency between the choice of complexity representation and logic behind the different game types. The logic behind can have a very profound impact on the design outcome and the player's experience with the game.

Complexity in both examples has similarities and differences. The Hotel Stars example features the incremental complexity introduction strategy (see Figure 1) with relatively complex demand modeling model heavily relying on algorithmic complexity. The complexity level can easily be scaled with number of decisions presented to the player at every stage of the game and the multiplicative demand equation easily incorporates both small and large number of variables. The player faces only one decision cycle and without in-game deadlines.

In the Pop-up Shop Helper game the complexity modeling is more difficult even as the demand equations are simpler and less demanding. The game design follows the strategy of exploratory model of game complexity (see Figure 2). However, given the restriction of time and multiple decisions cycles, the player experiences several decision cycles and in-game deadlines.

Both analyzed examples have their advantages and disadvantages and the purpose of the game and its playability should be the deciding factor when choosing one. Video games industry has solved a lot of issues of using continued processing or real-time gaming. Looking for similarities and parallels between the design of serious games and the design of video games can be very beneficial for further development towards more robust continued processing simulation games.

The majority of simulation games and especially business simulation games are built with turn-based or batch processing logic in mind. Turn-based simulation games with decision rounds and periods have many advantages but also shortcomings. They are easier to design, balance in difficulty and scale, but can present the simulated reality in distorted and even in manipulative way [44]. One of the key disadvantages of turn-based simulation games is that it largely ignores the time and time effects, which are becoming increasingly important [44; 45]. Especially, if we would like to show a long term impact of player decisions, which is crucial for creating simulation games on sustainability. Thus, the examples show how to incorporate time into different models and highlighted the advantages and disadvantages of modeling logic.

The landmark research on time and temporality presented by Lainema [4] shows the opportunity of using continued processing game models or real-time game models. Interestingly since the research was conducted not many continued processing simulation games came onto the market. While this paper is an attempt to bring this topic forward, there needs to be further scientific and modeling works done, since the research and the design opportunity still exists for today and the future.

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Designing Immersive Multiplayer Location-Based Augmented Reality Games with Remotely Shared Spaces

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Abstract. Location-based augmented reality games (LBARGs) hold the potential to foster physical activity, enhance social engagement, and boost self-esteem. While LBARGs have shown success, they currently have limitations in terms of accommodating multiple players from remote locations in real time and how they interact with their physical surroundings. There is uncertainty on how to expand LBARGs to overcome these limitations. This exploratory study focuses on designing and evaluating immersive multiplayer LBARGs that enable remote player interactions within remote shared spaces through the game "ARrive." To better understand the experience and preferences of players, multiple prototypes are proposed to evaluate them through a user study. This helps to identify the impact of different game design elements and triangulate qualitative data with quantitative data. The proposed game design includes three different game modes, and data are expected to collect through questionnaires and semi-structured interviews to assess the level of spatial presence, AR immersion, and user experience of players. Moreover, these prototypes will help us understand the limitations of current LBARGs by pushing their boundaries and improving the way real-world environments are incorporated into gameplay. The outcomes of this study could contribute to a comprehensive understanding of real-time multiplayer LBARGs and inform the design of more engaging and healthier games for game developers.

Keywords: Augmented Reality, Location-Based Game, Multiplayer Games, Spatial Presence.

1 Introduction

The gaming industry has seen a significant surge in growth in recent years, with the global market estimated to be worth over \$268 billion by 2025 [1]. This growth is influenced by various factors, including the development of cutting-edge technologies such as virtual and augmented reality [2]. Nevertheless, extensive engagement in conventional sedentary video games has been demonstrated to exert negative impacts on physical and psychological well-being, such as diminished physical fitness, poor self-esteem, and reduced social interactions due to prolonged gameplays being stationary [3]. However, on the other hand, active video games, particularly location-based games (LBGs) that incorporate augmented reality (AR), have been found to have the potential to promote physical activity, social engagement, and self-esteem [4,5,6].

This study explores the utilisation of synchronous multiplayer LBGs with AR to enhance player interactions within a remotely shared environment. Through research through design [7] approach, various prototypes were created to assess the impact of the overall gameplay experience. This paper describes these game designs in detail and the proposed evaluation methods but does not present the empirical data which are yet to be gathered. The objective of this research is to identify potential areas for improvement in future game designs by examining these factors through various game prototypes. Game designers could use these findings to create healthy, engaging game activities. Furthermore, these prototypes aim to examine the limitations of current LBGs [8] by broadening the scope of existing LBGs and enhancing the meaningful integration of physical environments in gameplay.

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The following sections present the research gap identified through the literature review, the design of the game prototypes, and the experimental design to evaluate the gameplay experience.

2 Background on Location-Based Multiplayer Games

2.1 Location-Based Games

LBGs use the player's indoor or outdoor environment in the game through networked interfaces [9]. Therefore, LBGs promote novel ways of interacting with the physical world in play. Furthermore, LBGs create an interface between players and locations, leading to a hybrid intuitive gameplay space [10].

LBGs can have many forms, such as GPS coordinates-based, AR marker-based, or markerless approaches. In this study, the term "LBG" refers to any AR game that takes players' real-world location and physical-world interactions, such as movements, into the game using network interfaces.

LBGs are categorised into three main groups [11]: spatially discrete, spatially continuous, and mixed-formed LBGs, as shown in Figure 1.

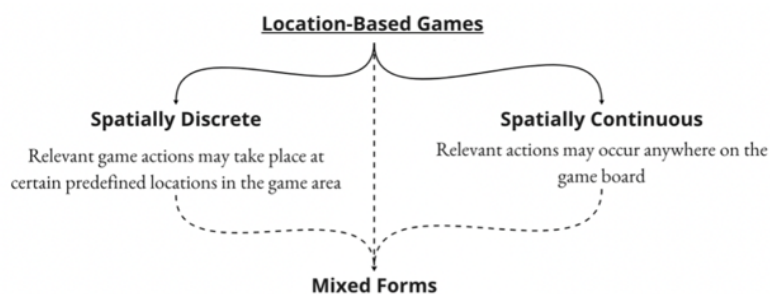


Fig. 1. Types of LBGs

Spatially discrete LBGs refer to a gaming experience where gameplay is tightly coupled to a specific, physically defined location. Players are required to be at a specific place to play this type of game. These games may employ GPS, mapping software, or AR features to create game experiences for players. Spatially discrete LBGs are popular due to their ability to consume virtual and real-world elements, creating a unique and engaging form of entertainment.

Unlike the spatially discrete, the spatially continuous LBGs allow players to navigate the real world while engaging in the game. However, due to the nature of this type of game, players may require some assistance to navigate through mini-maps or visual cues to navigate. Additionally, the game may change game elements and mechanics according to the present place of the player using GPS or AR features.

It is worth noting that it is possible to exist LBGs with features from both spatially discrete and continuous types, which can be identified as a mixed form. A game which requires its players to physically be present at a specific location only to initiate the game, and then, they are free to navigate around the physical space engaging with the game activities is an example of a mixed-form LBG.

According to the above classification, whatever the LBG type is, they are supposed to be based on a place of real-world location or virtual location in a meaningful way. Hence, the extent to which the features of a location within an LBG can impact the gameplay experience. For example, what if an LBG can use water from a nearby pond as a game artefact to extinguish a fire within the game? What if the LBG requires players to walk around the place and find wood and pass it to another player in AR as a game object to build a hut?

However, most LBGs are currently limited regarding the meaningful usage of their environment [12]. For example, they use the place as a medium to instantiate the game and to

place AR content. But there is no effective use of the characteristics of the place within the game. This limitation is an opportunity to expand the boundaries of existing LBGs without limiting them to tabletop games or little spaces. Therefore, further studies are required to understand how to embed real-world location-based properties into LBGs in meaningful ways so players can enjoy an additional degree of freedom.

2.2 Location-Based Multiplayer Games

Multiplayer LBGs are certainly not new, and there has been massive growth in this field with popular games like Pokémon Go [13], Ingress [14], Geocaching [15], and board games like Tilt Five [16], and the upcoming version of the Catan game [17], in AR.

AR technology has taken the multiplayer LBG experience to a new dimension. It allows players to interact with virtual elements in real-life settings, creating an immersive and engaging experience. Studies have shown that AR game designs have the potential to promote collaborative social interactions [18]. Also, if the game has some level of uncertainty due to distributed gameplay, it has been discovered that this heterogeneity helps players to experience higher engagement with the game [19].

Another study [20] which used location-based AR in a Participatory Design (PD) approach to facilitate meaningful place-making for children, has presented some design recommendations for serious games to improve social interactions. According to those research findings, meaningful social interactions were observed when children worked together. Furthermore, that study encourages further research on location-based AR applications to accommodate more in-game interactions and collaborations.

However, it is imperative to acknowledge that LBARGs should not be restricted solely to co-located outdoor settings but may incorporate a combination of indoor and outdoor spaces. Despite the numerous benefits of LBARGs, this limitation persists in the game design-based research with regard to comprehending the impact on remote multiplayer games that bridge multiple gaming spaces. This limitation has also been identified in a recent study [21].

Moreover, it is crucial to understand how remotely located participants from distributed locations can contribute to LBGs, even though the researchers have already identified that LBGs help foster social interactions [20]. Therefore, when multiple people engage with an LBG, their social presence within the game needs to be studied further to understand whether it affects the gameplay experience and ultimately leads to more immersive real-time multiplayer LBGs.

Previous key findings are motivating to design highly engaging LBGs that make use of the real world. The traditional LBGs have sparked social interactions with each other, representing enjoyable, interactive gameplay experiences. Nevertheless, what if the LBGs could expand their scope further by utilising the characteristics of gameplay locations within the game and allowing distributed synchronous gameplay? This direction motivates us to explore LBGs, and further understand spatial presence, immersion, and how to use the attributes of a place in an LBG meaningfully.

2.3 Spatial Presence in Location-Based Augmented Reality Games

According to multiple studies, spatial presence refers to the subjective sensation of being physically present in a mediated environment [22, 23]. Following the concepts of spatial presence, it has been discovered that the LBARGs have the potential to enhance player immersion and spatial presence [18]. Furthermore, multiplayer games in AR can increase spatial presence by allowing players to see and interact with virtual objects in the real world [18].

However, further study is required to fully comprehend the creation of immersive real-time multiplayer LBARGs that promote a higher degree of spatial presence. The following section outlines our suggested game design approach for the study of spatial presence in LBGs.

2.4 Immersion in Augmented Reality Location-Based Games

A widely accepted definition of immersion within the field of digital media is the state in which an individual experiences a raised sense of presence and engagement within a mediated environment, leading to a suspension of their disbelief and a perceived blurring of the boundaries between the virtual and physical realms [24]. This definition declares immersion as a multifaceted concept entangling cognitive, affective, and perceptual elements.

Another notable study defines immersion as a psychological state in which individuals are encircled and interact with an environment, allowing for continuous experiences [25]. The authors suggest that immersive virtual environments (VEs) have been achieved through wearable devices such as head-mounted displays (HMDs), which confine the user's view to the simulated environment. However, AR with handheld mobile phones may produce a different type of immersion, more closely associated with the context or content rather than display technology.

The combined subjective and behavioural methods used in another study [26] present that users' cognition dynamically influences and is influenced by immersion. These researchers argue that immersion and users are interactive and co-evolving; immersion influences users, and simultaneously, users build immersion. They consider these interactions as a constantly evolving element and bidirectional rather than being one-time or temporary. Previous researchers have also identified the need to explore different types of multiplayer LBG designs to understand how other participants from different locations can engage with a game [11]. However, as per our best knowledge, no study has identified how multiple players of a location-based augmented reality game (LBARG) experience spatial presence and immersion within the gameplay.

There are multiple definitions of immersion due to the continuous application of the concept in a wide range of research fields. Sometimes, it is visible that researchers use the term immersion interchangeably with other terms like engagement and presence [27]. According to Adam and Rollings [28], mental absorption in the narrative or the created world constitutes the phenomenon of immersion on a diegetic level, which they call "narrative immersion." This concept refers to the experience of being fully engrossed within a story, whereby the individual perceives the world and events of the narrative as real. When considering a truly immersive LBG experience, we believe that this way of looking at immersion is more relevant because the meaningful usage and interpretation of the characteristics of a place in an LBG play a significant role, as described in the following section.

Moreover, based on these previous studies [24, 25, 26, 28], we expect to evaluate the immersion of our proposed game designs and compare them with each other to determine which type of location-based interactions induce a higher degree of immersion and to identify possible recommendations for designing future LBARGs.

2.5 Place in a Location-Based Game

The location where an LBG takes place is essential to study further because it serves several important functions. Firstly, the location provides the context and sets the platform for the game, supporting the creation of a sense of place virtually and enhancing player immersion. Secondly, location can impact gameplay mechanics, such as providing opportunities for exploration, navigation, and problem-solving. Furthermore, location can also influence the social dynamics of the game, as players may interact with each other based on their physical proximity and the resources available in their respective locations.

Going one step further, the location-based aspect of these games has the potential to offer novel gameplay experiences through the use of real-world data. Some examples are using the weather conditions within the game to make the virtual gameplay more linked with the real-world. This location-based aspect not only adds to the authenticity of the game world but also may offer opportunities for increased player immersion and presence, as the game can be tailored to the player's physical location.

Researchers call the specific location relevant to an LBG a Point of Interest (PoI). Common examples of PoIs in an LBG can be a road, a pond, a statue or a building. By using PoIs, mobile applications have the capability to enhance physical locations with virtual content and interactive experiences, especially by linking game scenarios coupled with PoIs specific to real-world locations [29]. The quality of a PoI is influenced by the connection to the real-world, uniqueness and metadata available about the PoI and the placement of the PoI [29].

The attachment to a place in the physical world has been identified deeply in the field of psychology, and the concept of "place attachment" has been introduced. Place attachment is identified as the emotional connections individuals form with their places of dwelling [31]. Furthermore, previous studies have discovered that a consistent predictor of place attachment is the existence of strong social ties among people sharing a place [33, 34].

Remotely located gameplays in LBGs require novel techniques for connecting places together, facilitating situational awareness, co-presence, and affordances for collaborative task performance. Therefore, this study aims to design multiple game designs connecting multiple players from remote locations in real time and understand which technique promotes a higher degree of spatial presence and immersion.

Doing so will strengthen social bonds connecting friends and families closer. Moreover, it has been discovered that LBGs help to make strong place attachments [34]. Strong people-place attachment may lead to positive attitudes and behaviours toward specific places and influences people to explore nature reducing the sedentary time.

However, a challenge in the development of multiplayer LBARG is the representation of the play environment and the effective sharing of this representation among players. This study endeavours to address this challenge by exploring and evaluating three different perspectives of place representation in the context of AR. The selection of these perspectives is guided by a review of relevant prior research in the field, drawing on established principles and empirical findings to inform the design of our study. Perspectives to be studied include the bird's eye view perspective, a room-scale perspective, and the use of portals to allow users entering or at least viewing a location.

Studies on remote multiplayer games have shown how a virtual environment is represented can significantly impact players' sense of spatial presence. For instance, a study found that AR tabletop views, which present virtual objects on a real-world surface, support collaborations between multiple users indoors and outdoors [35]. Presenting a bird's eye view perspective in location-based gaming can greatly facilitate the spatial understanding of crowd movements, and researchers argue that the perspective allows for a comprehensive and intuitive representation of the environment and enables users to effectively assist individuals on the ground level in navigating and comprehending their surroundings [35]. Therefore, this perspective influences us to investigate further how a bird's eye view or a top-down perspective affects an AR LBG.

Similarly, another study found that AR overlay views, which present virtual objects of the same size as the real environment, can enhance players' feeling of experiencing a more natural environment in AR [36]. Several studies [19, 37] denote that the ability to move through virtual environments and overall spatial awareness can be improved by incorporating virtual environments on a room-scale or real-world a like scale. Interestingly, another study [37] has looked into the effectiveness of using either table-scale or room-scale AR applications for learning. It was anticipated that the implementation of AR, allowing individuals to roam freely within large-scale virtual environments, would enhance the spatial aspects of the experience. However, the results failed to show a significant improvement in these metrics. Based on these findings, it can be assumed that the size of the AR content and environment can influence educational AR content and LBGs and alter the degree of spatial presence.

Portals are a relatively new, effective element to make game transitions seamless, and they have been helpful in achieving a higher presence within virtual reality game scene transitions [30]. This perspective, which allows players to see a remote environment from a real-world location through an AR window, was inspired by studies on mixed-reality games and

teleportation mechanics. Research has shown that portals can create a sense of connection between real and virtual spaces and foster a higher presence during in-game transitions [30]. However, even though portals are studied in the virtual reality domain, we believe that introducing portals in AR, too, a like feature to provide a smooth interaction flow between distributed gameplay locations in AR, may depict some exciting influences on the gameplay experience.

2.6 Research Aim

Multiplayer LBGs that connect players through shared gameplay spaces need to study further to understand their impact on fostering spatial presence and immersion. Although studies have been carried out to understand engagement and meaningful social interactions in traditional LBGs, accommodating remote players in real-time and their interaction with spaces and each other is still unclear.

This study aims to investigate the fundamental research question of designing an LBARG that fosters the spatial presence of both remote and local players while simultaneously representing the spaces of remote players. Specifically, this study expects to delve further into the aforementioned research direction, with the goal of comprehending the mechanisms by which a player's space can be effectively represented to another player who is also remotely connected, all while inducing higher levels of immersion and spatial presence. Ultimately, this study intends to generate practical recommendations for game designers aimed at crafting multiplayer LBGs that encourage physical activity and social interaction, all based on the results of the study.

This study was inspired by previous studies [19, 30, 35, 37] that have explored the relationship between the representation of virtual environments and players' sense of spatial presence. Based on the findings from the literature review, this study includes three conditions for our game design to test our hypotheses. These distinct conditions vary based on their use of the place visualisation technique. The three visualisation techniques are AR miniature view, AR overlay view, and AR window view and based on these, we derived the below hypotheses.

- H1. Game mode 1 (AR miniature view): Participants will elicit the lowest level of immersion and spatial presence in a top-down miniaturised view compared to other modes.
- H2. Game mode 2 (AR overlay view): Participants exhibit enhanced collaboration and coordination abilities while playing in this mode due to the local player being situated in a virtual space of real-world dimensions relative to the remote player due to the highest level of immersion compared to other game modes.
- H3. Game mode 3 (AR window view): The AR window view will elicit the highest spatial presence among participants compared to the other two modes, allowing players to pass objects between their physical and virtual environments.

Each modality of the game design is chosen carefully with the aim of getting a deeper understanding of how these visualisations affect the overall gameplay. Each of the game modes, gameplay scenario and also how we are planning to conduct the user study to assess the above hypothesis explained in detail in the next chapter.

3 Methodology

3.1 Study Design

This study follows the research through design (RtD) [7] approach as it will provide multiple game designs. Feedback from players will be gathered to understand how players immerse themselves in novel remote multiplayer LBG designs, as described in the following sections.

The user study is planned to conduct with test participants assigned within-subject form where each participant experiences all three game conditions, which would heavily reduce individual

differences so that each participant may notice subtle differences in the spatial presence, immersion and user experience in each mode and provide more valid feedback. A within-subjects design may reduce the impact of extraneous variables such as gender, previous exposure to AR-related applications or age.

Adopting a "within-subjects" design presents the challenge of longer completion time for each participant, as they must experience the game and complete questionnaires for each condition. However, this challenge is being addressed by limiting the number of questionnaires and keeping them short. For instance, we will utilise the short version of the User Experience Questionnaire (UEQ-S) [43] consisting of only eight items instead of the longer 26-item UEQ. The following sections describe the game design, data collection and evaluation.

3.2 Experimental Game Design: ARrive

In order to elicit a thorough understanding of the influence of user experience and spatial presence, "ARrive" is designed including into three different game modes. These three game modes will be used to check the validity of the hypotheses through the analysis of the data collected from a user study, allowing for a comparative examination of each game design strategy.

The proposed game is designed as a mobile-first game and incorporates real-time networking capabilities for remote player connectivity. The game's development was executed using the Unity 3D game engine [38] due to its compatibility with the preferred AR development kit, Niantic Lightship ARDK [39]. This development kit was selected for its provision of essential features for LBARGs, such as real-time meshing, semantic segmentation, and a visual positioning system (VPS), which are crucial components in the design of the game. Furthermore, real-time sharing of updated AR content and environment is another vital game design requirement, and to fulfil that, we use the Normcore library [40].

The experimental game design facilitates two player roles as the "local player" (host), an individual participating in a game physically situated in the environment while being connected to another player remotely. Conversely, a "remote player" (peer) refers to a participant who is not situated in proximity to the other player but instead engages in the game from a remote location.

The game design requires the host and peer to exchange 3D scans of their respective physical locations to initiate a game session. Lidar scanning is our preferred method for capturing these 3D scans of their physical surroundings. In the context of this experimental game design, the host is placed in an outdoor environment while the peer is situated within an indoor space. This is illustrated in Figure 2, which depicts the distributed locations of both players and provides examples of 3D scans of their respective environments.

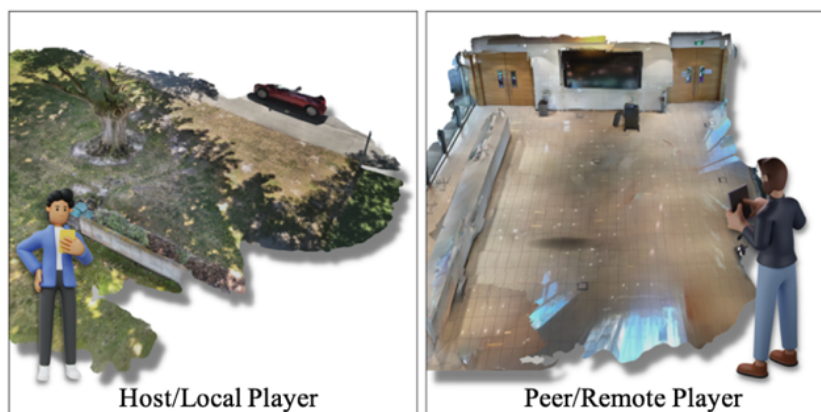


Fig. 2. Example scenario of host's and peer's location-sharing. From left to right: The host shares his outdoor surroundings as a 3D scanned model, and the peer shares his indoor surroundings as a 3D scanned model.

In a game session, players are encountered flying enemies that pose a threat to their survival. Players are equipped with the capability to throw water balls to counteract these enemies. However, first, each player has to craft water balls before throwing those toward enemies to destroy. For crafting water balls, players must collaborate with each other. The player designated as the host is responsible for exploring the physical environment to gather necessary resources such as wood, grass, and clouds, which are incorporated into the game mechanics. The collected resources are then transferred to the other player via AR, which can be achieved through an AR window, overlay space, or miniature mode. An illustration of this game scenario is presented in detail in Figure 3.

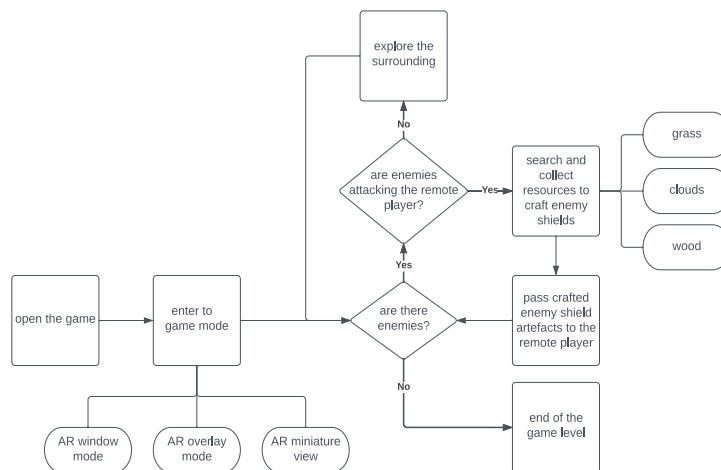


Fig. 3. Flow diagram of the game scenario

This game design allows for the integration of real-world elements into the gameplay by exploring the local environment to find resources. This further gives meaning to the game-based interaction across multiple locations by allowing each location to contribute to the game's progress. In multiplayer scenarios, if one player lacks certain resources, they can obtain them from their peers, who have collected them from their own physical environments. This feature induces collaboration and encourages players to work together to achieve their objectives. Figure 4 presents screenshots of occasions where the host is requested to collect some resources by scanning real-world physical properties to help the peer under attack.

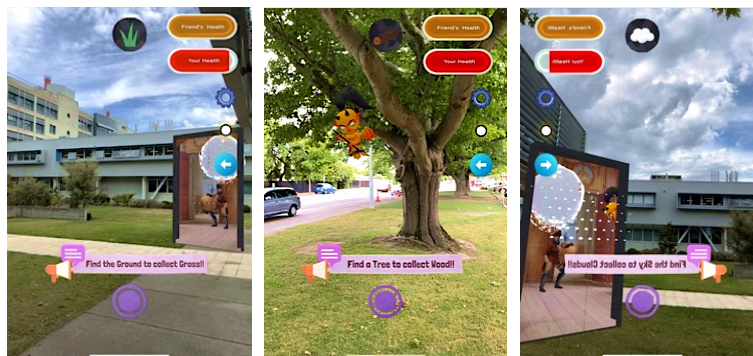


Fig. 4. Screenshots of the resource collection phase. From left to right: The host is requested to find grass, wood, and clouds.

For this game design, three game modes are introduced, as shown in Figure 5.

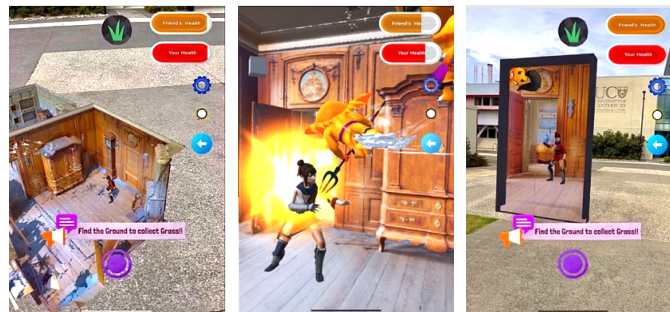


Fig. 5. From left to right: AR miniature mode, AR overlay mode, and AR window mode.

1. The AR miniature mode presents the game environment on a surface from a tabletop perspective, providing players with a more holistic experience. In this mode, players' movements and AR objects are updated in real-time and maintain the high-level spatial representation of the peer's entire space.
2. The AR overlay mode superimposes the AR environment over the physical environment, allowing players to perceive both virtual and real elements simultaneously. In this mode, the host can experience the peer's space in its true-to-life size and aspect, including the peer's avatar representation. In addition, both players can interact with virtual game objects within the AR space as well as observe real-time updates on each player's movements.
3. The AR window mode shares the 3D scan of the peer's environment through an AR window, enabling the host to interact with the peer in real-time. For instance, the host can share virtual objects from his space with the peer, which will be reflected in real-time through the AR window to the peer.

Additionally, during the game's development, we recognised two categories of game components: screen space elements are fixed on the display screen and don't interact with the physical world. These elements, such as the health bars of each player, game menu icons, and informational pop-up messages, are deemed screen space components due to the requirement for immediate accessibility and ease of use. On the other hand, world space elements interact with the real world and are part of the game scenario. In this regard, all AR game objects, and shared spaces were designated as world space elements to create a seamless blend of virtual and physical components, resulting in a heightened sense of spatial presence for the user.

3.3 Participants and Data Collection Methods

The user study envisions user testing with approximately 30 participants. This sample will include individuals who have and have not previously played LBARGs. We expect to keep each user study session approximately 45 minutes, including time to fill out questionnaires. The questionnaires are based on the Spatial Presence Experience Scale (SPES) [41], the Augmented Reality Immersion (ARI) Questionnaire [42], and the short version of the User Experience Questionnaire (UEQ-S) [43].

The UEQ-S instrument will be employed in this study to assess the user experience and test the first hypothesis (H1), which posits that the AR miniature view would result in lower immersion and spatial presence levels compared to other modes. The UEQ-S questionnaire comprises only eight items, including dimensions such as "obstructive or supportive" and "boring or exciting." This instrument is chosen over UEQ due to its simplicity, making participants complete the evaluation without feeling overwhelmed.

The ARI questionnaire consists of 21 questions categorised under six factors: interest, focus of attention, flow and more. Participants rate their agreement with each statement on a seven-point Likert scale. An example item from the ARI questionnaire is: "I was more focused on the

activity rather than on any external distraction." This questionnaire will be used to evaluate the level of AR immersion experienced by the participants, particularly in testing the second hypothesis (H2), which stated that the AR overlay view would elicit the highest level of AR immersion due to the local player being situated in a virtual space of real-world dimensions relative to the remote player.

The SPES will be selected to evaluate the level of spatial presence elicited by the AR game modes, particularly in testing the third hypothesis (H3), which stated that the AR window view would elicit the highest spatial presence among participants compared to the other two modes. This questionnaire consists of eight items that assess the degree of spatial awareness. Participants rate their agreement with each statement on a 5-point Likert scale. An example item from the SPES is: "I felt like I was really there in the environment of the presentation."

During the reflection phase, the players can report on their game experience, explain why they liked or disliked game elements, and express ideas for further improvements. The collected data will be further analysed to evaluate each game mode's degree of spatial presence and immersion and use elicitation techniques to propose design guidelines for designing future remote multiplayer LBARGs.

4 Conclusions and Further Work

The game design presented in this study highlights the potential of multiplayer LBARGs to deliver elevated levels of spatial presence and immersive user experience to all remotely connected players promoting physical activity and social engagement. The implementation of the three game modes provides the opportunity to assess the most impactful approach for the gameplay scenario. Furthermore, resource sharing may yield higher collaboration between players as an innovative game element enhancing the gameplay experience. The design recommendations derived from this study may guide future game developers in creating healthier and more engaging LBARGs. Future research can build upon the insights gained in this study to further research design meaningful game interactions for multiplayer LBARGs. Overall, this study sheds light on the promising future of LBARGs and their potential to promote healthy and socially engaging gameplay.

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CAUSERIE: a GIS-supported serious game to collective grounded solutions for crop and water protection in head catchments

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Abstract. Serious games have so far hardly explored the issue of water quality protection in agricultural catchments, while it is key to succeed agroecological transition in this type of landscape, in order to keep agricultural land uses while drastically decreasing chemicals to reach the rivers. Complexity of factors to be represented explain this lack of experience with games to explore this situation in a strategic and collective way. We developed CAUSERIE a metagame to be specified in various agricultural catchment to explore transition pathways that include collective action aside individual practices improvement. It worked out the complexity of this issue through time representation at the scale of crop rotation and the use of a GIS-based model to compute consequences of players' choices. Interface with this computer is mediated by one dedicated facilitator, decreasing the capture of players attention by the screen interface, as reported in other examples of computer assisted game simulation. Initial sessions of these games are promising as they could point out the difficulty to explore solutions on a collective basis even though these might be more efficient, but unfitting professional biases.

Keywords: Water Quality, Agriculture, Landscape, Serious Game

1 Introduction

Water quality is a strong issue in agricultural catchments, threatening river ecology, human health and drinkable water availability. Agricultural practices to secure crops facing undesirable pests, illness or weeds are regularly pointed out as the main cause for this situation. Public policies trying to handle that issue target farmers' individual practices in order to generate less pollution. Each farmer is required to improve his or her own practices with decreasing their overall use of chemical inputs. Hardly any public policies with this aim implement a collective or global landscape based approach. A few ones propose the development of hedge networks. None of them copes with a collective thinking to strategically localize main efforts nor to investigate the overall consistency of individual efforts at the catchment level. The interactions between farmers and public policy representatives (ie. Agriculture department representatives or river basin organization) are mainly one to one, contributing to a sterile opposition between farmers and non-farmers in these landscapes.

The Spirit and Dialectic action research projects have tried to enlarge the ways in providing tools to support dialogue with and within groups of farmers to enable the emergence of innovative and collective grounded solutions to better reconcile agriculture and water quality. Taking stand on recent experiences showing the benefits of serious games to understand and facilitate the transformations of social ecological systems [1], we implemented a serious game approach to meet the collaborative objective. We included an anonymised GIS-based model in

our approach to make the game more relevant to farmers' constraints related to the spatial organization of the landscape and its impact on pesticide use, fate and transfer to watercourses.

In this paper, we present the design of this exploratory approach, the meta-game that has been designed and two of its specifications together, as well as outcomes of initial experimental sessions on two different agro-pedo-climatic sites.

2 Serious games and water quality in agricultural landscapes

Serious games are now well known tools to work on environmental issues such as natural resources management, biodiversity or climate change [1-8]. They allow exploring possible evolutions, testing new policies, explaining social ecological system dynamics, understanding behavioural patterns. They are particularly good at dealing with the complexity that is characteristic of most environmental issues. For the last three to four decades, the literature is full of examples of games, each attached to a specific issue and most often to a specific place.

While agriculture is regularly pointed at for river pollution due to chemicals meant to fertilize the soil or to control weeds, insects and other pests, there are very few examples of games dealing with this issue. Several European policies address this issue. For example, the Water Framework Directive defines water quality objectives, and the CAP 2023-27, in line with the Farm to Fork Strategy, sets out a 50% reduction by 2030 in the use and risk of chemical pesticides as well as a reduction by 50% in the use of more hazardous pesticides. However, the difficulty in implementing the resulting agricultural transition programs (e.g. Ecophyto plan) at the national level, as well as the reactions to the recent ban from the French Agency for Food, Environmental and Occupational Health & Safety on the commonly used herbicide S-métolachlore, which threatens access to drinkable water, show that the relationship between water quality and agriculture is challenging and generates multiple tensions. While environmentalists suggest alternatives to chemical pesticide use such as organic farming or advanced agroecology, most farmers argue that they can not make a living with these practices and that it would prevent from reaching food security. The debate is framed by this confrontation. Nevertheless, other techniques to limit the use and transfer of pollutants inside the field or from the fields to the river exist at landscape levels (e.g. crop rotation, inter-row grassing or hedges on field borders that dissipate the pollutants). Furthermore, incentive tools such as payments for environmental or ecological services or the agri-environment and climate measures of the CAP, as well as institutional tools such as basin management plans may offer the means and framework to collectively think about the best crop protection strategy at catchment scale taking in account heterogeneity of fields in terms of soil, slope, landscape features and distance to river. These tools and techniques enable opening the debate on farm viability and water quality protection as multi-dimensional, and are suitable for a collaborative exploration of solutions with a serious game.

A few examples of serious games dealing with water quality and agriculture have recently emerged. They are all committed to facilitate a transition towards agroecological practices. SEGAE [9] is an online game meant to facilitate training to agroecological practices at farm level with a flight simulator-type interface. It does not explore interdependencies between farms through the game. Time speaking, it works on a yearly time step, allowing to demonstrate the pathway for a transition to agroecological practices at the farm level but not the benefits at larger time and spatial scales. The CAPIPP game [10] explores the cumulative effects of winegrowers' practices in a specific catchment in Southern France to enable agroecological transition and a decrease in use of pesticides. It featured three different scales, block of plots, farm and catchment. This choice enables to take into account the natural diversity at block level (eg. slopes), the human diversity (farm choices) and the regulatory feedback at catchment level. It is very realistic, calibrated on a specific catchment, using many parameters to fit actual farmers' decision processes regarding crop growing and treatment. It takes then too much time to play more than two steps, meaning two years as it is used with a yearly time step. Therefore, the

collective dynamics that the game could facilitate can not emerge through the game session, while more farm level levers can emerge such as training on technical practices. The game DYNAMIX [11] is used within a participatory process regarding agroecological transition towards crop-livestock integration among farms. It includes both farm and landscape levels and could add logistic aspects that make the link between both. Although it is used with a full contextualisation, it is not a site specific game and can be reused in other places with issues of crop-livestock integration. As a type of game, it rather mimics negotiations of possible actions of each player and simulate the consequences of these choices over a season, without including a longer time horizon with cumulative effects. The WATPPASS-game [12] is also included in a larger participatory approach, which is meant to facilitate the emergence and test of innovation at landscape level to improve water quality in an agricultural catchment in French West Indies. The game itself is based on the use of a model simulating crop growth and pesticide transfer. Players make choices regarding their crop at plot level on a weekly time step. The outcome is more for players to experiment alternative operational practices rather than to understand cumulative long term effects. Strategic perspective on water quality with serious games is even less frequent. SELECT ECOTECH [13] focuses on policies to decrease the quantity of nutrients reaching the Baltic sea. It is a two players strategic game, each player acting on land uses without taking in account neither the efficiency of land use policies nor farmers or other stakeholders interplay. The consequences of a specific land use policy are pre-coded in the game according to investments in development interventions or eco-technology investments and according to the occurrence of external events. RES'EAULUTION DIFFUSE [14] is an interesting intermediate game. It simulates the evolution of farms in an intensive cereal production landscape with an increased demand for water protection. It simulates crop rotation in order to take into account operational constraints, enabling the simulation over a longer time horizon. However it is dedicated to the specific situation it has been developed to deal with, an intensive cereal production area in the limestone plains area East of Paris, and does not include spatial transfers of pollutants at landscape scale.

With the exception of SELECT ECOTECH and RES'EAULUTION DIFFUSE, these few examples are on a short time horizon, while investments at the level of landscapes take time and have long-term impacts, be it to shift from one rotation type to another or to implement agroecological features as hedgerows. Consequences on crop yields are important to consider, as they matter not only on the short term (e.g. the budgetary balance of the farm) but also on the longer term on further investment capacity. All these games but SELECT ECOTECH feature the needs for computations of the consequences of the players' choices, inducing either long time steps during the play or the use of computer simulation within the game setting. RES'EAULUTION DIFFUSE could find some compromise in implementing rounds representing several years. We chose then to build on this experience, trying to make it more generalizable.

Current challenge regarding serious games with such operational purposes as innovative dialogue support is to handle distance and contingency. Distance enables participants to think beyond immediate interest and contingency, and to make the link between their current situation and the tools they may activate. We explore it developing a meta-game to be specified in context of use and through a connection to a GIS-based model developed for this purpose. Use of a realistic, yet anonymized, GIS based model provides the contingency aspect. We have implemented the GIS-based model on "archetypal" catchments, which cropping systems (crops rotation, plot delimitation, landscape elements) and hydrological behavior are similar to the real catchment the players are involved in without being exactly the same. It allows participants to reflect on situations that are fully realistic for them, without being tied to the constraints of their farm and the judgment of other participants, which gives them more freedom.

With this technical choice, we contribute to a secondary methodological challenge in simulation and gaming: connecting game and computer-based simulation models. These solutions of Computer Assisted Simulations [15] raise the risk of capturing the attention of players and missing opportunities to learn through handling physical objects [16]. If hybrid

games are a way forward, they need to be cautiously designed to overcome these potential biases. To deal with these risks, the GIS-tool is being implemented by an “external operator”, so that players can focus on their role, without being disturbed by the model. They provide their action choices to this operator: players remain in a human-human interaction mode but benefit from the outputs of the GIS-based model.

3 CAUSERIE: an approach based on a meta-game including a GIS support tool

A major challenge linked with contingency is the cost. Development of a highly contextual game takes time, to design and to play (cf. CAPIPP), and it is hardly re-usable in other contexts as for RES’EAULUTION DIFFUSE. We chose to develop a meta-game, with a common given structure that might be adapted in various contexts. This meta-game provides the game structure, including the documents to be prepared, the interface with a GIS-based model, the game dynamics and the operational elements. In this section we describe this meta-game which resulted from co-design workshops in two contrasted places, a winegrowing landscape of Beaujolais and a mixed crop and livestock area in Monts du Lyonnais, using the ARDI method [17].

3.1 Meta-Game structure

Principle is to gather about five to seven roles of farmers and two to three role of structuring stakeholders that are instrumental in framing water conservation and agricultural practices. These roles have to improve collectively water quality in a shared watershed. Each of them also has an individual objective to cope with. Meta-game is hence made of a list of roles and their inter-relations and connections to shared watershed.

Farmers. Farmer roles have to be fine tuned according to the local typology of agricultural practices and the farming population. This typology should specify a diversity of objectives in conducting farms. It should include farm economic viability according to local specificities, as well as the development of more environmentally friendly practices, the development of alternative complementary activities, the capacity to pass on a viable farm to successors, etc. Each farmer role is associated with a list of fields and initial cropping systems located on a map of the catchment. Each farmer role includes also a list of possible actions with options for each of these. A first set of possible actions is related to farm level cropping activities. It includes systematically cropping pattern choices on a strategic time scale, ie. about three years, considered as the minimal time step for structural changes taking in account possibility of perennial crop development or restructuring, and annual crop rotations within cropping systems. Finally, options focus on the levels of chemical inclusion for crop protection. According to specific stakes and local adaptation possibilities for main crops, other actions to mitigate weed development might be proposed such as the use of mechanical devices or the choice of various crop rotations. The second set of possible actions is related to landscape level actions. These actions, such as hedge development or ditch revegetation, are characterized through their cost and impact on pollutant transfer from the field to the river. The third set of possible actions concerns other social and economic ways for farmers to modify their farm outputs, often involving collective action: eg. labelling, agritourism, diversification. All these actions are characterized according to their costs, conditions of implementation and direct impacts on an expert knowledge basis. Some farmers can have an additional role, such as being mayor of their community.

Stakeholders with institutional role. For these roles, only one instance of each is planned. They include systematically a river management organization representative and a technical farm extension service representative as they are the most framing local institutions regarding farming development, water policy related rules and incentives implementation. CAUSERIE opens the

way for the addition of one or two additional types of stakeholder, rather acting at the agricultural sector level, such as a cooperative for output distribution or joint buying of inputs. These roles have a small budget they may use to improve their knowledge or as an incentive to lead some farmers towards specific practices. They may interact with farmers either on a one-to-one basis (ie. advice) or on a one-to-many stance (ie. dialogue support). Both ways are explicitly reminded to them on their role sheet.

Additional structuring random events. In addition, specific event cards can be chosen by the game facilitator at the end of each round with consequences either on the efficiency of the corrective solutions and the river quality, or on farmers' economic balance. These events represent existing uncertainty of the river basin environment. There are three types: natural events (e.g. meteorology, pest pressure), local socio-economical events (e.g. conflicts with neighbouring situations, taxes to preserve the drinking water resource) or more global regulatory or economic events (e.g. pesticide ban, market issues).

Connections. Connections between players come first through the shared catchment, each farmer player having the possibility to act on the state of specific cropping cells and their borders, modifying hence the inputs to the catchment in terms of land use and chemicals as well as in terms of their transfer towards the river network. According to water pathways, pollutants may run through fields of one player, coming from another one, down to the river, or pollutants from various farmer plots can be captured and dissipated thanks to the investments of one single player.

Beyond these direct connections, CAUSERIE opens for direct interactions between players. While game session is unfolding, periods of time are open during each time step for discussion that might be one to one or more collective in order to prioritize investments subsidized by institutional stakeholders or to elaborate coalitions within the group to benefit from better valuing of their products or lesser production costs.

3.2 Connection to GIS support tool

A key aspect of CAUSERIE is to explicitly represent the shared catchment through an interactive GIS-based model of a realistic catchment, representative of agricultural systems facing issues of water pollution due to agricultural practices. It is based on the use of GeoMelba [18], a geomatic tool that assesses the potential surface runoff generation of water and pesticides on each agricultural plot, depending on its slope, surface area, soil occupation, cultivation system. GeoMelba also assesses the potential of transfer mitigation of each landscape element: agricultural plot, non cultivated area, as well as vegetative strips, hedges, banks, artificial wetlands, roads, ditches or paths. Depending on their characteristics (vegetated or not), these two last types of elements can be either buffer zones or short-cuts conducting contamination to the river. For each overall spatial configuration of land use, cultivation system and landscape element management, which is defined during the game, Geomelba calculates an indicator of the related water quality all along the river network, taking into account topological connections between each landscape elements. It embeds a spatial analysis component allowing to show, for example, the spatial origin of pollutants in a specific reach of the river or the contribution of a specific field to the overall pollution. GeoMelba enables a local or global diagnosis of the transfer pathways in the catchment to represent in a dynamic way the consequences of players' choices, as in figure 1.

GeoMelba is used all along the game session as a tool to provide expert knowledge to stakeholders (or farmers) that may order for more targeted spatial analysis as part of their portfolio of actions. Players' choices are gathered and entered in GeoMelba and global consequences are then computed to deliver the water quality situation in the catchment as well as specific indicators on demand.

GeoMelba is spatially explicit in order to meet the demand for context-rich support. It is based on a real map that is simplified and anonymised to facilitate playability with a limited number of players. Each farmer player has hence a set of fields that is restricted in number (to reduce the number of decisions to be considered) but representative of the typology of farms in the area.

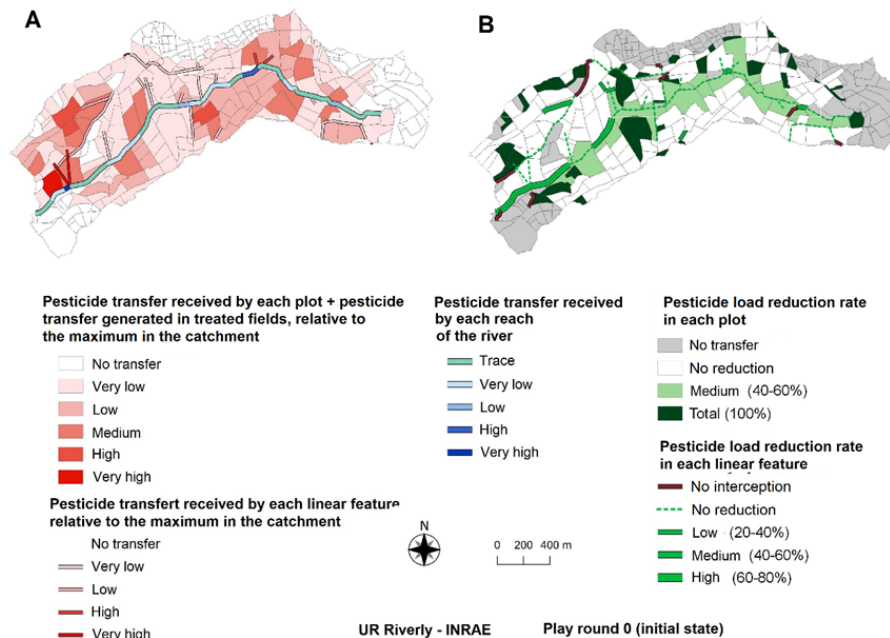


Fig. 1. A. Cumulative transfer of pesticides in runoff or tile drainage received by each plot or linear landscape feature (hedgerow, ditch, road or river) and generated by each treated field, B. Pesticide load reduction rate in each plot or linear landscape feature.

3.3 Game dynamics and setting

The game session is organized in a classical way with a briefing, a simulation and debriefing. The simulation is organized as a sequence of play rounds, each being structured in five phases:

1. Selection of actions by each player. Possible open discussions. Players write down their choices on their account book sheet. This phase is limited in time. Structural decisions regarding cropping system are restricted to one by round for the sake of realism,
2. Registration of all selected actions for running GeoMelba,
3. Drawing of two random events cards, one regarding meteorological trend during the time step, and one regarding economic or social issues,
4. Economic balance computed by each farmer player thanks to a dedicated action sheet guiding the computation,
5. Collective appraisal based on GeoMelba outcomes (optional to the decision of players with institutional roles).

The spatial setting of the players is organized in order to enable collective discussions and to share the evolution of the catchment as shown on figure 2. Each role (endorsed by pairs on the picture) is assigned a table, with all tables organized according to a horseshoe shape. The circle is closed by a table dedicated to the registration of the selected actions in GeoMelba, and the simulation of their consequences. In the center of the circle, a large table

is set with enough chairs for each role to sit. This table is dedicated to collective meetings that can be initiated by any player.



Fig. 2. Spatial setting of a game session.

The running of a game session requires a pair of facilitators: one to impulse the overall game dynamics and manage time, and one to handle the GIS-based model especially for phases 2 and 5: entering action choices and delivering consequences and including specific expertise request.

4 Specialization and initial tests

The present design of CAUSERIE results from workshops with stakeholders in two contrasted places, both facing issues of water quality in relation with agricultural practices. These are the Ardières catchment in Beaujolais area where vines are the main land use (North of Lyon, France) and the Gimond catchment in the Monts du Lyonnais whose main activity is the breeding of dairy cattle and the production of associated fodder (South West of Lyon France).

The same structure is used but most of the material has to be specified: role sheets, balance sheet, catchment modelling in GeoMelba, calibration of economic parameters, action sheets. Figure 3 below presents one of these support documents. They result from a list of activities in interaction with local stakeholders, conducted or facilitated by the game design team. The list of roles and activities comes from ARDI workshops, but the specification of the role sheets comes from preliminary qualitative one-to-one semi-open interviews in each catchment that provided a typology of practices, farm characteristics and constraints. The calibration of economic parameters comes from expert knowledge of the local farming sector. Modelling of catchment in GeoMelba is performed by a GIS specialist and hydrologists in the research team based on local knowledge or data. It takes into account the dominant processes regarding pesticides transfer, and factors determining these processes: for example surface runoff triggered by soil, slope, inter-row grassing, presence of small ditches inside the plot in order to limit erosion, agricultural practices, the type of buffer zone, etc.

Farmer 1 Age: 55, Dairy Farmer with 56, 2 ha of inherited land. You are a member of an agricultural machinery cooperative.		Starting Conditions (2021)	Round 1 (2022-2024)	Round 2 (2025-2027)	Round 3 (2028-2030)	Round 4 (2031-2033)
Herd Size +8 <input type="checkbox"/> -4 <input type="checkbox"/>		50				
Tillage Practices (Annual / Minimal) <input type="checkbox"/>		Annual				
Crop Management Practices	Short rotation <input type="checkbox"/>	Predictable -5 <input type="checkbox"/> +5 <input type="checkbox"/>	2.1 ha			
		Optimised -4 <input type="checkbox"/> +5 <input type="checkbox"/>	/			
	Long rotation <input type="checkbox"/>	Optimised -3 <input type="checkbox"/> +4 <input type="checkbox"/>	/			
		Without synthetic inputs -2 <input type="checkbox"/> +3 <input type="checkbox"/>	/			
Permanente pasture 0 <input type="checkbox"/> +2 <input type="checkbox"/>		35.2 ha				
Feed and Nutrition Plan	Nutritional needs	-2.00 <input type="checkbox"/> (20x4)				
	Fodder production	+175 <input type="checkbox"/> (21x5 + 35.2x2)				
	Complementary fodder needs	-2.5 <input type="checkbox"/> (200-175)				
Procurements (from agro supplier)	Complementary fodder purchases (-2 <input type="checkbox"/> / orga: -3 <input type="checkbox"/>	-50 <input type="checkbox"/> (25x2)				
	Seeds and synthetic inputs	-105 <input type="checkbox"/> (21x5)				
Investments (for water catchment operator)	Landscape features	/				
	Complementary activity (berries/Dairy)	/				
Income	Sales	+400 <input type="checkbox"/> (50x8)				
	Label (Nature Friendly / Organic)	/				
	Complementary activity (following round)	/				
Subtotal (income - procurement - investments)		+2.45 <input type="checkbox"/> (400-50-105)				
Event card		/				
Others costs (including agricultural machinery cooperative)		-2.20 <input type="checkbox"/>	-2.20 <input type="checkbox"/>	-2.20 <input type="checkbox"/>	-2.20 <input type="checkbox"/>	-2.20 <input type="checkbox"/>
Treasury (last year's balance + subtotal - other costs)		+2.5 <input type="checkbox"/> (245-250)				

Fig. 3. Example of balance sheet for a farmer player, specified for Gimond catchment case.

This leads to two implementations. The first one, characterized by wine growing and a few orchards, pays attention to the conditions to change the vineyard and associated crop protection practices. It includes river basin organisation and extension service representatives, as institutional stakeholders. Simulation choices in initial game sessions explored vineyard restructuring (lesser density) and grass cover between rows. Cereal growing and cattle raising with possible collective actions to diversify towards cheese production characterize the second one. The latter includes an additional structuring institutional stakeholder: the agro-equipment provider who highly constrains and influences farmers' choices. Simulation choices explored first longer crop rotation but also investment in cheese production.

5 Discussion and perspectives

We held sessions once in each basin with local stakeholders, and once with students in wine growing with the Beaujolais application. These initial uses of CAUSERIE have allowed an increased shared understanding but are still short of pushing professional participants towards collective action. Technically the common structure is helpful to quickly adapt from one place to another, and the introduction of a GIS-based model is well appreciated. However even though simulations are effective over several rounds, it is still covering a rather short time horizon (about 10 to 12 years).

5.1 Increased shared understanding

The game sessions constituted an opportunity to deepen a shared understanding of the shared basin. This is the case thanks to the map of the watershed in front of which the participants exchange, take notes on the directions of the flows, identify their farms, take pictures before returning to their tables. This understanding was facilitated by the presence of a hydrologist who answered participants' questions and explained the phenomena depicted on the map.

This increased understanding also comes thanks to the distance introduced by the game medium, including through the cartographic representation of the watershed in miniature. As pointed out by Levi-Strauss [19], it offers "a kind of reversal of the process of knowledge": in this type of live scale model "the knowledge of the whole precedes that of the parts". Regarding these rural

catchments, the attention, usually focused on the field, widens to the catchment. The game format fosters intelligible dimensions and promotes successfully the perception and understanding of the intra-territorial interdependencies of the choices and actions of stakeholders in a shared basin.

The 5th phase of play round provides the opportunity for players to explain their initiatives, and prioritization of actions. The use of GeoMelba in this phase has been instrumental as it enabled to visualize the paths of water and pollutants beyond the crop they are supposed to protect, which is normally invisible. It acted as intermediary debriefings in the game session and proved to be useful to push the exploration aspect of the game simulation.

5.2 Collective action exploration

Regarding the objective to stimulate the experience of collective action, the initial sessions are rather still featuring inter-individual interactions. In both sessions with stakeholders, players focused on their individual practices and did not take advantage of the opportunities for collective meetings.

In the evaluation interviews conducted with the participants after the end of the process, it appears that all the participants recognize that they have made "a few efforts" on the scale of their farms, rather than having tried to act collectively on areas beyond the scale of their farms. One of the first explanations given is the density of information to be integrated: understanding one's role, the structure of one's farm, one's current farming practices, one's plots of land, etc. This required time and made it difficult to look beyond one's farm. The game aims to create conditions favourable to collective action, but without forcing it. It provided for configurations, means, and time that could have been more dedicated to collective action, but which were only slightly seized by the participants.

The debriefing after the simulation discussed this predominance of inter-individual interactions as actually reflecting the reality of the interactions between these different actors in the two case studies. In the course of the game, a certain number of actions were carried out in a bilateral relationship involving a structuring actor (the animator of the river union, the technical advisor, the mayor) and several farmers. The choice to manage individual relationships with each farmer seems to correspond to the reality of the professional practices of the actors interviewed. On the contrary, when having students play, they were more keen on exploring collective solutions as their play was more attached to game instructions and less influenced by professional practice.

Another element in understanding the preponderance of individual actions lies in their adaptive nature, i.e., their integration into current farming systems without upsetting them, producing short-term beneficial effects without taking much risk. This is the case, for example, with the installation of landscaping such as hedges or grassed strips, which are part of a logic of adaptation to the environmental constraints weighing on the farms. These are low-risk actions that fit in with current production methods without upsetting them. These are known as "adaptive" or "incremental" actions [20]. Conversely, collective actions propose deeper transformations, requiring more risk-taking because they modify agricultural production methods and/or ways of organizing between actors.

While individual values may motivate some players to adopt more environmentally friendly practices, economic and political support emerged as major levels for initiating change, particularly through compensation for crop losses in bad weather years.

5.3 Technical choices

We chose to introduce a computer model within game simulation knowing the risk that it might capture players' attention. From our observation of game sessions it did not happen even though the tool was fully used and operational. The human interface to access the GIS-based model, the localisation of the computer interface in the margin of the room and the additional medium of paper action and balance sheet probably helped to prevent the attention capture bias. The game is also framed to favour negotiation, be it inter-individual or collective. This contributes to keeping

non-computer mediated interactions dominant in the game. On the opposite, the outputs of GeoMelba were the support of strategic thinking for players, mainly the river basin manager, as well as for interactions between players.

Even though we could reach round 4 and players are fully at ease with the game, it is still quite slow. Initial round takes close to 45 minutes. On this aspect, we could do slightly better than several existing games, but it is not yet fully satisfying, as it does not enable exploring strategies over a long period (ie 20 years or more that represent the pace of structural change at a territorial level).

Finally, last key technical choice is related to development of a meta-game and specializations for various contexts. With only two cases, it is too early to suitably assess this approach. However it enabled having patterns for documents supporting players and prepare a technical development document to explain the specialisation process.

6 Conclusion

With this experience we could develop a metagame, CAUSERIE, with two specializations in contrasted contexts in French agricultural catchments. We could represent with these games strategic decisions on farm and catchment levels regarding water quality and crop protection. CAUSERIE met our first objective to understand the possibilities for collective management of water quality in an agricultural catchment, showing that professional biases push stakeholders towards one to one interactions instead of seeking more efficiency at a collective level.

It has been an exploratory tool to test the capacity of building on a meta-game and using an anonymized GIS-based model to bring in contingent aspects without closing the exploration to existing situation only. This initial exploration has proven successful. The meta-game aspect should still be assessed in other context, to assess the time gain it generated in game design. It might now be also repeated in other contexts to consolidate this approach of metagame development, meant to suit a specific type of issue and assess how it depends on its context of development. However this still provides material to start with in the development of games on relations between agriculture and water quality taking in account mutual feedbacks between landscape and farm scales. It also provides an experience of connecting computer-based elements in a game based on human interactions limiting the attention capture bias.

On an operational stance, this tool is now open for use to support change in catchment and facilitate an agro-ecological transition that would suit farmers' constraints. We are starting this in two ways: the training of stakeholders such as catchment organisations officers so that they are more open to system thinking when they interact with farmers in a catchment, transfer towards consultancy groups that facilitate strategic collective thinking in catchments. The meta-game aspect of CAUSERIE makes it more attractive to these thanks to its potential to reduce the time of design.

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Modeling social parameters in renewable energy sharing: activity analysis in simulation game

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Abstract. The European energy landscape is currently undergoing a technological and societal transition that is questioning the energy market with Renewable Energy Communities (RECs). With the democratization of photovoltaic panels, the redistribution of roles between energy production and consumption is redefining the consumption model. This model must now achieve the goal of self-consumption, i.e. either consume the energy when it is captured or propose it, according to rules to be established, on the very local market of an energy community.

What behaviors will future consumers/producers adopt within these energy communities? How will the rules of remuneration between these actors influence the governance of these communities? To provide elements of answers to these questions, this article first presents the methodology used to build a board game simulating the management of a REC and write the game rules to synthesize real complexity. Using a platform for analyzing human activities, it then qualitatively analyzes a game and discusses quantitatively many key points identified among observed human behaviors. Finally, it proposes several perspectives useful for simulating environmental and social transitions.

Keywords: Gaming for policy making, Shared renewable energy, Social factors of transformative changes, Behavior modeling, Activity analysis

1 Context and problem statement

1.1 The Energy Transition

The Green Deal for Europe, presented in December 2019, calls for a reduction in our carbon footprint and aims for climate neutrality through the implementation of a circular energy economy [European Commission, 2019]. In this context, the European energy landscape is undergoing a technological and societal transition that challenges the energy market by diversifying its offerings : equipped with photovoltaic panels, millions of consumers are becoming micro-producers alongside traditional electricity suppliers, who are losing their exclusivity. The question now arises : how can we transition from a centralized and constant electricity production-distribution system to a distributed and intermittent energy production system ?

This energy transition is currently generating two emerging movements :

1. a digital transformation of interactions : data sharing, artificial intelligence, IoT and blockchain are tools that support the thinking and are seen as the keys to mastering the complexity of the new energy landscape ;
2. the emergence of Renewable Energy Communities (REC) as a new "consumer-producer" actor, bringing together a group of geographically close stakeholders with diverse needs and means (including households, communities, businesses, industries, and administrations).

The integration of RECs into the distributive energy equation is currently underway, but in a very techno-centric way, based on mainly economic strategies, where mechanisms of fairness and acceptability need to be specified at both individual and collective levels.

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1.2 The SERENITY Project (uSER ENergy communitY)

To promote this socio-technical transition of redistributing roles of production/consumption in the dynamics of energy "Uberization", our research project uSER ENergy communitY, for SERENITY, aims to address the following questions :

- what consumption models are emerging to achieve the goal of self-consumption among these emerging distributed production actors ? In other words, what behaviors will future consumer/producers adopt within these energy communities ?
- how will the rules of compensation between these actors influence the governance of these communities ?

Breaking away from current predictive approaches based on historical consumption profiles, the SERENITY project aims to identify the human parameters of this complex issue and to understand the mechanisms of self-consumption of electricity.

The governance of a Renewable Energy Community requires mastery of numerous multidisciplinary variables. We classify them into three categories : (1) technical concepts, related to the energy needs of buildings and their electrical equipment, (2) legislative and economic concepts, related to the frameworks and resources of actors to ensure their consumption, and (3) social criteria, related to human behavior during community negotiations and decision-making. These observable variables are themselves conditioned by uncontrollable variables, such as weather conditions, changes in the energy market, or the occurrence of impactful events (heat waves or international politics, etc.).

One of the peculiarities of our project lies in its bottom-up approach : the process is driven by the needs of end-users, members of a REC. Therefore, an ascendant approach is taken to conduct this research. In addition to traditional focus groups, which collect discourse (which may be biased to remain socially acceptable), the serious game approach allows actors to be placed in a situation and better identify spontaneous behaviors, reflecting their level of acceptability and engagement in the collective dynamic.

2 Research objective

To capture and articulate the interaction of these variables, we have developed a serious game that we have implemented as a tool for understanding and raising awareness of the shared energy issue.

Based on a brief preliminary literature review (section 3), this article first presents the methodology used to construct and analyze this board game, then synthesizes the real complexity (section 4). Using an activity analysis platform, it then studies a game session (section 5) and discusses several key points identified among the observed human behaviors (section 6), validates the approach and contributions, and finally proposes a perspective useful for simulating environmental and social transitions (section 7).

3 Literature review

Our literature review on serious games is based on the two fundamental concepts of the object of our research, which are energy transition and complex systems. We explored different categories of games to select the one that seems best suited to our research objective and carried out a review of serious game design methods to implement the construction of our game.

Serious games are already used in the field of energy transition to educate actors on the different issues and mechanisms of transition to more sustainable and renewable energies [Abdusselam, 2020 ; Ouariachi, 2020]. The historical energy supply system, managed so far by negotiated political arrangements, is now moving towards an "uberization", involving numerous new actors, making it more complex [Müller et al., 2017].

Serious games prove to be an effective tool for better understanding and modeling this socio-technical system [Bekebrede, 2010 ; Sajjadi, 2022 ; Varma & Liu, 2022]. Different types of serious games can be used in scientific research contexts to study their effectiveness and effects on users, whether in terms of learning, skills development, behavior change, or improvement of user well-being [Djaouti et al., 2011 ; Hammady & Arnab, 2022]. Simulation-type games [Mayor et al., 2014 ; Lanezki, 2020] provide participants with a simplified representation of complex reality and the opportunity to freely experiment with their strategies and experiences and question the consequences of their actions [Lukosch et al., 2018]. According to [Cohard, 2019], learners can observe the simulated impact of their own decisions, reflect on the concordance (or not) between anticipation and actual outcome. Here, serious game actors give us access to the complexity of the energy system [Müller et al., 2017] as they allow us to study their behaviors such as decision-making, social interactions, and problem-solving in situations that are difficult to observe in real life [Luo et al., 2017].

4 Methodology

4.1 Game Design

Based on Peters & Westelaken's method [2014], our game is based on three principles to synthesize reality and promote good gameplay dynamics : reduction, which consists of representing only the key elements of reality, abstraction of the complex system representing the game elements less detailed than in real life, and finally symbolization, which consists of giving a new appearance to real-life elements.

The design of our serious game is constructed in 4 steps : (1) definition of the system components, (2) establishment of the table of system components and game elements, (3) choice of the game format, and (4) game development.

Definition of system components

The scenario involves actors with varied resource profiles who will interact within a renewable energy community (REC) based on (1) their consumption needs, linked to the measurement of their activity, and (2) their production capacities, modulated by their photovoltaic panel surface areas.

The objective is to achieve self-consumption within the community, meaning to cover the needs through their own means of electricity production. Therefore, the actors are invited to distribute their energy units to satisfy a majority of them, as each unit of energy taken from the network market penalizes them all financially. Each person will make decisions personally, but they will involve the entire community : as the seasons change and faced with various individual situations, weather fluctuations, and energy market fluctuations, when to invest and in which equipment ? According to what rules should the productions be distributed and at what price ? How much trust should be given to other actors in negotiation ?

Time plays a preponderant role in the evolution of uncertainties and thus the intentions of each actor. It comes into play in the short term, considering a day during which a negotiation regarding energy distribution induces a sequence of decisions, and in the long term, over the seasons that modulate sunlight conditions and activity levels.

Ontological Model, System Components, and Game Elements

To synthesize the complexity of the future reality we are trying to model, we first compose an ontological model that identifies which elements will constitute the game, in relation to the components of the system (the approached reality), establishing the link between the serious game and the future reality of a REC. By respecting the three recommended principles of reality synthesis, namely reduction, abstraction, and symbolization [Peters & Westlaken, 2014], the concepts that synthesize the REC model are thus concretized in Table 1 below.

Choice of the game format

The second step consists of defining the format and type of the game ; which mode to adopt between a competitive game or a cooperative game ? In order to meet the main goal of the research, which is to observe social behaviors towards collective self-consumption, we choose to work on a cooperative board game : its type conveys the community aspect and its "board" format allows us to first observe in real-time the interactions between the players and then facilitate its deployment to multiply awareness-raising games among the general public.

Table 1. Ontological model synthesizing the energy sharing issue, linking the components of the system (approximated reality) and game elements.

Approximate reality	Ontological model : mobilized concepts	Game Elements
<i>Social parameters</i>	<i>Activity type and occupancy</i>	<i>Profile cards</i>
	<i>Usages : consumption needs</i>	<i>Profile cards; Action cards; Investment cards; Event cards</i>
	<i>Individual and collective decision-making behavior</i>	Actions = observed variables
<i>Technical parameters</i>	<i>Building characteristics and Production capacity</i>	<i>Profile cards</i>
	<i>Equipment levels</i>	<i>Profile/Action/Investment cards</i>
<i>Economic parameters</i>	<i>Market conditions</i>	<i>Event cards</i>
	<i>Value production</i>	<i>Points</i>
<i>Legislative context</i>	<i>Distribution rule</i>	<i>Game rules</i>
<i>Physical context</i>	<i>Meteorology</i>	<i>Event cards</i>
<i>Temporality</i>	<i>Quarter-hourly consumption</i>	<i>Time cards</i>
<i>REC manager</i>	Governance = main research question	<i>Game master</i>

Production of the game

In the final step, we proceed with the production of the game, which involves establishing the rules, constructing the scoring formula, and designing the cards and game board. We briefly describe them below in accordance with the game elements identified in the previous table 1.

Rules and Scoring

The goal of optimizing collective self-consumption is measured in "energy points", which count for each player the consumption units related to their usage and production, either from photovoltaic potential (positive) or from the electricity grid (negative). Each action chosen by a player earns or costs "virtuous points", depending on whether their behavior favors or penalizes the use of renewable resources.

Through repeated implementation, it has been specified that a turn must be played in four phases : (1) first, the declaration of each player's needs and production, according to their profile and the seasonal situation ; (2) followed by a three-minute debate phase during which players announce their possibilities and intentions, then negotiate with each other to find a compromise ; (3) the third phase is the action phase during which players play their cards. Their actions may or may not be consistent with what they announced during the debate phase. Each player thus has the freedom to play a card different from what they announced. (4) Finally, the last phase is the points tally, calculated at the end of the turn to assess the impact of the decisions of the different members.

Profile cards

The profile cards identify the individual status of the player : as a household, business, company, school, etc., they indicate their daily activity levels, the resulting consumption, and their potential

seasonal photovoltaic production. The majority of players belong to the REC, but some players may not participate in it.

Action cards and investment cards

With a hand of three action cards per player, they actively participate in the management of their own energy and that of the REC by modulating their consumption or investing in equipment, which earns them points. Some actions carried by the investment cards have a permanent status : once played, these investment cards correspond to investments in equipments and therefore offer a permanent effect on all subsequent rounds (for example, investing in energy-efficient appliances reduces consumption permanently).

Event cards

The event cards generate random external factors that interfere with the intentions and goals of the players : for example, the occurrence of a power outage, extreme cold conditions, an energy market situation, etc.

Time cards

Time cards manage the pace of turns and establish a specific seasonal situation for each player, evolving throughout the seasons - predictably modulating production levels - and combining a random day of the week - modulating activities and therefore consumption needs.

Game board

The game board is designed to represent the collective energy potential of the REC, in which members can offer their produced energy for sharing.

Managing the game

The manager of the REC plays the role of game master : as in real life, they explain the principle and objective of the game and ensure that the rules are respected. They also act as a facilitator to promote collective dynamics.

4.2 The game protocol and experimental posture

Several rounds were initially organized, which made it possible to refine the components of the game and its rules in order to achieve a playable and relatively balanced level in terms of starting profiles, pace of drawing action cards, point reward, etc., including the management and deployment of the game over a reasonable period of time. The experiment consists of observing a game in real time. As researchers, we adopt the position of observer-participant : we play the game like ordinary players, i.e. not as game masters in order to not influence the game too directly. For our analyses, we use video files captured by a camera that is positioned from above, recording audio as well from the scene (figure 1).

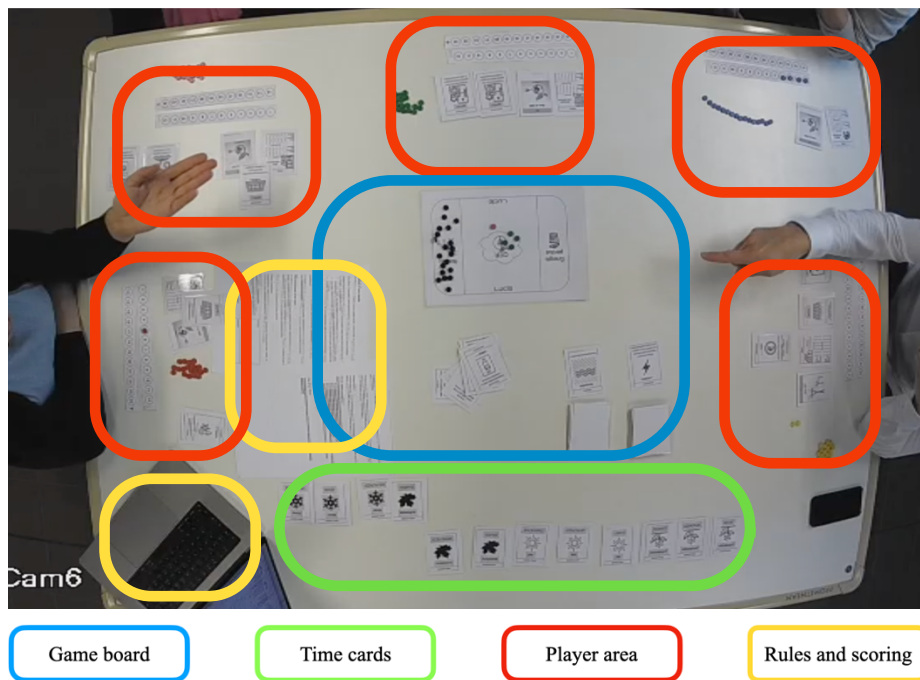


Fig.1. Video recording and zoning of the game space.

4.3 Analysis modalities

Behavioral analysis is performed using a coding method, using a platform for analyzing and visualizing human activity called COMMON Tools. Designed to study sequences of multi-actor interactions, this web application has been developed by our team since 2013 to manage large corpora of collaborative activity data [Ben Rajeb & Leclercq, 2015]. It allows the representation and analysis, through graphic comparisons, of the temporal or statistical evolution of multiple variables derived from verbatim or detailed descriptions of complex interactions.

4.4 Transcription method

The transcription method consists of sequentially transcribing the recorded verbatim, phrase by phrase, using one line per player and per focus addressed in each player's comment. Each line is completed with a timestamp and the player ID (table 2).

Table 2. Transcription grid with example.

Time stamp	Player	Verbatim
10 :23	B	<i>I play the "take 2 EU from the REC » card. I earn 2 points because I run the school dishwasher.</i>

The observation data is then specified on each line of these verbatim, using a pre-established coding grid that details the aforementioned variables (see section 4.1 Ontological model and table 3).

Table 3. Verbatim coding grid with their main categories.

Card played	Focus	Expressed motivation	Action performed	Temporality
<ul style="list-style-type: none"> • Profile card • Action card • Investment card • Event card • No card 	<ul style="list-style-type: none"> • Production • Consumption • Economic considerations • Points • None • Else 	<ul style="list-style-type: none"> • Show solidarity • Judge as inequitable • Win for oneself • Invest in equipment • Change behavior • Judge as too expensive • No choice • Without motivation • Else 	<ul style="list-style-type: none"> • Inform • Get informed • Influence another player • Announce his intention • Decide collaboratively • Decide neutrally • Decide in contradiction • Conduct the game • No action • Else 	<ul style="list-style-type: none"> • Immediate • Future projection • Not applicable

The grid is composed of five main categories, each with different subcategories (observable) to analyze users' social profiles. As an example, we take the "Focus" category, which allows us to identify players' interests in energy, production, consumption, or economic gain (e.g. points). Verbatims related to game behavior or rule reminders are qualified as "No Focus."

5 Game analysis

5.1 Corpus and Macro Analysis

A game is played with 4 to 10 players. It usually consists of 12 rounds, covering a year of four seasons, and lasts about 1.5 hours. The experiment we choose to describe here concerns a game played by five players who have already played several previous games (four on average) ; they are therefore familiar with the principles of the game and are aware of the cooperative goal of self-consumption. The observation covers three seasons (spring, summer, and autumn) because the last winter season is not very productive in solar energy, making it less useful to study : since the participants do not have energy to share, observing their actions is less useful.

Our corpus consists of 451 verbatim, stated over 78 minutes, transcribed and coded according to the procedures outlined in section 4.3. This initial measurement shows that the game was lively in terms of exchanges, with an average of 5.8 verbatim per minute for five players, or one verbatim per minute per person.

Our method starts from a qualitative observation that we translate into verbatims. The coding method then allows us to generate quantitative data.

145 verbatim are related to the conduct of the game. Issued by the game master as well as the four other players, they therefore account for one third of the exchanges. This number is an indicator of the complexity of the problem addressed : its high level reveals the need to recall or confirm the rules, which are nevertheless a simplifying synthesis of reality, to players who are already aware and trained in the notions of energy sharing.

The distribution of verbatim among the five players divides them into two categories in this game (figure 2) : three players state their actions equally (12 to 17% each) while two players (E and C) generate nearly 60% of the exchanges, already reflecting a "discussant" posture.

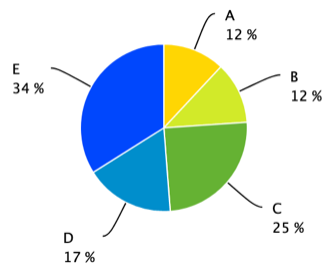


Fig. 2. Distribution of verbatim among the 5 players during the game.

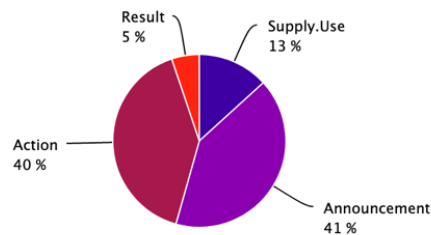


Fig. 3. Distribution of verbatim across the 4 phases of the game.

The distribution of verbatim across the four phases of each round (statement of energy supply and use / annoucement of intentions / actions / round assessment) shows that discussions were equally lively during the annoucement and action phases (figure 3). In the former case, discussions focus on conceptualizing possible scenarios, leading to negotiations between players; in the latter case, verbatim often reflect justifications for actions and reactions from other players who judge or adapt to them.

The majority of motivations expressed by the players during the observed game concern solidarity and behavior change (figure 4). They are complemented by references to investment and inequity. Self-centered positions only account for 3% of the exchanges.

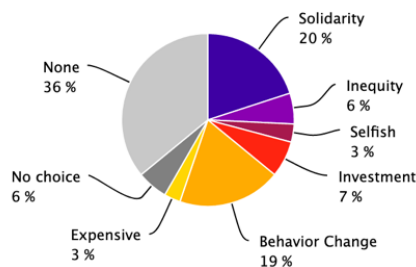


Fig. 4. Distribution of player motivations during the game.

5.2 Temporal progression of the game

The timeline, composed of the succession of verbatim (independently of their individual durations), traces, for each player, the evolution of a chosen variable. figure 5 provides a visualization of the evolution of motivations expressed in each verbatim : the abscissa of this graph represents the succession of the three observed seasons, with three rounds per season, while its ordinate superimposes the motivation lines of each player (A to E).

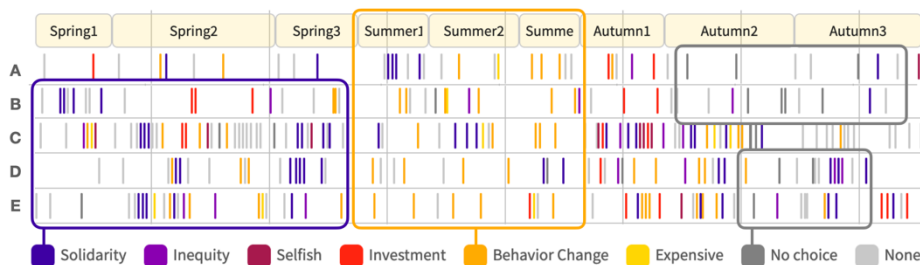


Fig. 5. Evolution of motivations expressed in each verbatim.

One interesting group phenomenon can be observed : during the summer season, when energy production levels are at their highest in the profile cards, players show a stronger tendency to change their behavior (i.e. to modify their habits to adopt more energy-saving postures in order to achieve a balance between production and consumption), both within the REC and for player B, who is outside the community and manages his balance at an individual level.

Before that, i.e. during the spring but also during the initial deployment of the game, the players express rather solidarity-oriented verbatim.

As autumn arrives, production resources decrease ; players who can invest in production equipment (photovoltaic panels) or household equipment that offers reduced electrical consumption. By analyzing the content of the verbatim, we can see that they adopt this investor posture in anticipation of the approaching cold season.

Finally, in the heart of autumn, we realize that a majority of players are playing cards that are imposed on them ("no choice") because their investments, shown in the form of investment cards, remain permanent and do not offer them the possibility of harvesting and playing various action cards. The end of autumn also shows a majority of verbatim without motivation, preceding the winter period that will freeze positions.

5.3 General distribution of verbatim

Let's see what the general distribution of verbatim reveals according to the main variables related to the energy transition issues in the REC for the entire group of actors : main concerns, short- and medium-term projections, and collaborative dynamics of energy sharing.

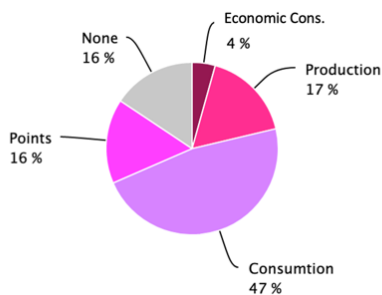


Fig. 6. Distribution of verbatim across the 4 phases during the game.

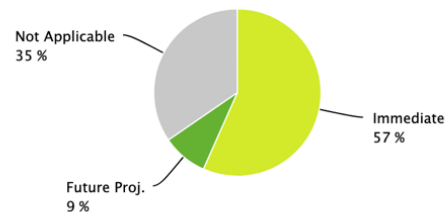


Fig. 7. Temporality expressed in the verbatim.

Main concerns

The observation of the themes addressed by each verbatim (focus) indicates a largely explicit formulation : 84% of the comments made are categorizable, since only 16% are "without subject" (figure 6). Almost half of these comments (47%) are related to consumption concerns, which corresponds to the most accessible action lever for actors, unlike energy production (17%) which requires technical capture devices or resources to invest in it. Remuneration, translated into points in the game, is only the subject of 16% of the conversations. With the mention of the budget at 4% of the exchanges, it shows that in the playful approach, the economic aspect does not seem to be the top priority, unlike the observations made by Bonnardot [2020].

Projection in the short and medium term

The analysis of temporal evocations in the verbatim reveals short-term strategies (figure 7) : more than half of the comments concern the current round being played. The future is mentioned only once in ten comments. Therefore, the short-term remains privileged over the long-term in the group's reflection as a whole. We will see later what characterizes individual action on this subject (see "Actor Profiling" below).

Collaborative dynamics of energy sharing

Referring to the overall distribution of motivations (see figure 4), we can characterize the collaborative dynamics of the group of players : 39% of the verbatim identifying a motivation (or 60% of the motivations expressed when not considering verbatim without motivation) involve cooperative attitudes for the benefit of the energy community, by taking supportive actions or adopting behavior that saves energy consumption. Less than 5% of the motivations expressed reflect selfish behavior.

5.4 Profiling of the players

Examining the same key variables related to the issues of the energy transition in REC, visualized by player, allows us to perceive certain characteristics of the players.

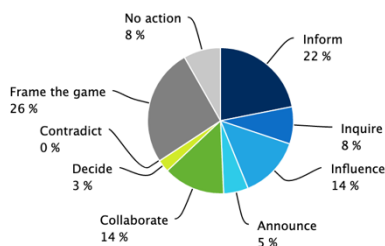


Fig. 8. Actions of player D during the game.

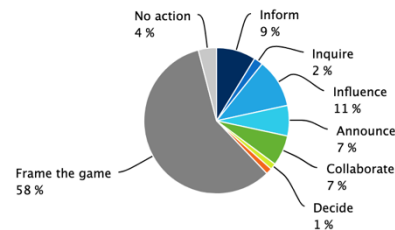


Fig. 9. Actions of player E during the game.

Actors D and E in particular account for 39% and 69% respectively of the labeled actions "frame the game" and "influences" (figures 8 and 9). This testifies to a certain control over the course of the game. It turns out that these players both have a greater mastery of its mechanisms since both of them are co-designers of the game and that E acts as the game master. As such, he is tasked with leading the other players and conducting the assessment at the end of each round. In this regard, he occupies the position of community manager, responsible for explaining the remuneration rules, advising actors to collectively achieve self-consumption equilibrium. The cards distribution allocated the players as follows: (A) is a business, (B) is a non-CER house, (C) is a corporation, (D) is a house, and (E) is a school.

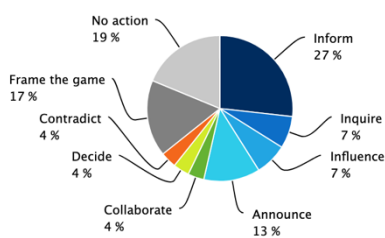


Fig. 10. Actions of player C during the game.

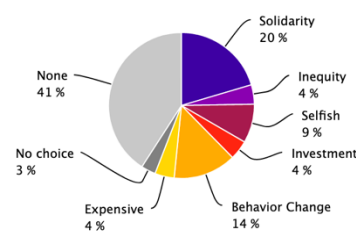


Fig. 11. Motivations of player C during the game.

Actor C has a "discussant" profile. This means that he participates a lot in the discussion even when it does not concern his own decisions or actions. He plays the role of social/emotional leader in the game. As identified above (figure 10) : a quarter of their interactions reflect game management (17% "leads" and 7% "influences"). They gather a lot of information (27%), but they also make decisions by both collaborating and contradicting their stated intentions. They could be considered a less reliable actor, which also corresponds to their highest rate of "selfish"

motivations among all players (figure 11). More realistically, this actor acts according to their own interest in each situation that arises. While initially supportive, they do not hesitate to change their mind in response to the attempts of other actors to influence them.

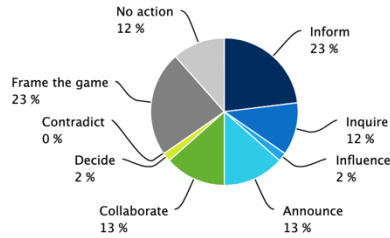


Fig. 12. Actions of player A during the game.

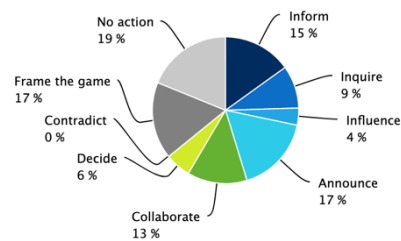


Fig. 13. Actions of player B during the game.

Actor A has the most balanced distribution of action verbatim among the actors in the REC (figure 12). He exerts very little influence, informs and seeks information, and makes decisions in a collaborative manner, consistent with his stated intentions. This is a cautious and thoughtful profile that analyzes the game as much as he plays it.

Finally, actor B, who does not belong to the REC, also presents a balanced distribution of actions (figure 13). He has the highest rate of neutral or collaborative decision-making (6+13%), which reflects his isolation : he remains consistent with himself, not accountable to other players.

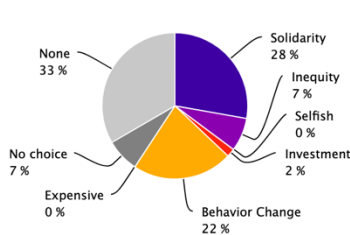


Fig. 14. Motivations of player D during the game.

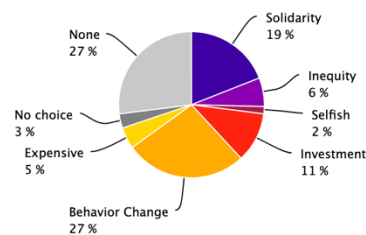


Fig. 15. Motivations of player E during the game.

We also observe that players D and E each have a more pronounced rate of verbatim evoking inequity (figures 14 and 15). They also have the two profiles that do not have a photovoltaic equipment at the start of the game. Actor E has the opportunity to install one in the middle of the game, while actor D is never equipped with a solar production means throughout the game. Their "inequity" verbatim are probably prompted by this unfavorable personal situation. In correlation, we also note the "temporality" graph of this disadvantaged actor D, who never has the opportunity to invest, and whose comments almost exclusively concern immediate action (figure 16). He is systematically in a problem-solving posture, having to find the energy needed to meet his short-term needs.

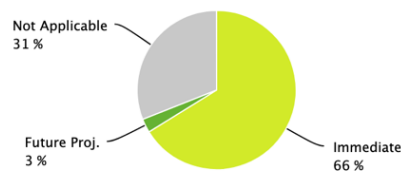


Fig. 16. Time expressed by player D during the game.

We remind here that this is one game analyzed to validate our method. We do not have the ambition to qualify the profiles obtained at this stage.

6 Discussion

6.1 Model validation

The ontological model on which the game was built, and which served as the basis for the construction of our analysis framework (section 4.1), seems to be stable and relatively complete. Indeed, all items in our grid are used, and none are missing. The "Else" item does not reveal any missing category or criteria. The games are played within the allotted time (less than two hours to cover the four seasons of a year). As for usability, the draw presents a balanced distribution of cards, as shown in figure 17 : (1) profile cards are used in 15% of verbatim, which corresponds well in volume to the 13% stated during the needs announcement phases ; (2) event cards and investment cards occur four times less frequently than action cards.

If the number of verbatim related to the game management (33% of actions, figure 18) recalls the complexity of the real world that the game tries to synthesize, the examination of the content of the verbatim themselves shows however that all players are sensitized to the issues of energy sharing and gradually master the impacting factors. They inform, learn and mutually influence in a third of their verbal exchanges.

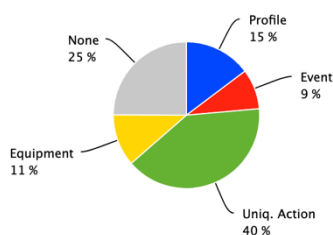


Fig. 17. Distribution of card types drawn during the game.

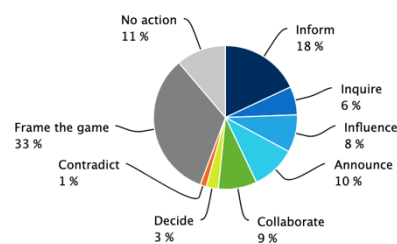


Fig. 18. Distribution of actions throughout the game.

The parameters of the proposed analysis grid thus allow for a good understanding of the role of human factors in relation to the multiple situations in which consumer/actors may find themselves. Their analysis makes it possible to characterize the trends adopted by all members of a REC (in the game analyzed here, a clear desire to aim for the common benefit) and also to identify specific characteristics adopted by each player (collaborative, cautious, investor, more egocentric, etc.).

6.2 Validation of the game through simulations

The rules of the game, which represent the legislative parameters framing the sharing of energy in a community, provide some keys to try to induce virtuous behaviors or to circumscribe possible drifts. In order to visualize the effect of the rules of the serious game, we have sought, on an exploratory basis, to calculate the balance sheet of a REC based on the simulation of three different community scenarios :

1. Scenario 1 : Players are not part of a REC and there is therefore no common objective of collective self-consumption ;
2. Scenario 2 : Players are members of a REC and follow a rule of full sharing ; they share all available photovoltaic energy equally among themselves ;
3. Scenario 3 : REC members only share their surplus energy produced between themselves equally, after satisfying their individual needs.

We simulated, based on PHP code, 57 rounds, specified with the following parameters :

- 5 profiles, labeled from P1 to P5, are selected to diversify consumption profiles and means of production ;
- 10 players, with a combination of 2 to 5 profiles, without any repeated profile, except for combinations of 6 to 9 profiles where the same profile may be repeated twice ;
- 3 seasons : winter, mid-season, and summer (as spring and fall have consumption and production data that are roughly similar) ;
- 6 combinations per seasonal situation for one round : for each season, one round is played with one weekday and one weekend day.

The results of this simulation are visualized by the number of energy units required, indicated in each box of a graph (figure 18) that shows, on the ordinate axis, the 57 different games with 2 to 10 player profiles, and on the abscissa axis, the six rounds/seasons for both situations (energy balance of the REC on the right and energy balance of the grid on the left).



Fig. 19. Serious game simulations based on three scenarios : no REC (on the left), complete sharing of production (in the middle), and sharing of surplus production (on the right).

Green boxes represent a positive balance for the scenario, while red boxes represent a rather negative balance, occurring when the surplus is not fully consumed or when a lot of energy is consumed from the grid.

These results first show that, for the 3 scenarios, the energy produced is not fully consumed during the summer and the consumption from the grid is higher during the winter. This logical observation is explained by the fact that photovoltaic panels are of course more productive in summer than in winter.

For scenarios 1 (non-REC) and 2 (full sharing), the negative balance is spread across all 57 rounds of the game as the energy produced is not allocated according to the specific and varied needs of each profile.

In the 3rd scenario (surplus sharing), the negative balance is rather marked during extreme seasons, but the unconsumed green energy remains always lower than in scenario 2.

As shown by the balance of scenario 1, the simulation of the Saturday/Winter combination is invalidated, revealing the inconsistency of a profile-card, which could then be eliminated thereafter. Indeed, prosumer profiles produce as much as they consume. Therefore, there will never be a surplus of production for this combination of day/season, no matter what the energy sharing rules are. This doesn't allow to observe changes in players' behaviors.

7 Conclusions

This study highlights the contribution of the serious game approach in understanding environmental issues, particularly in raising awareness and understanding of the complex challenges of energy transition.

The gaming instrument is first built based on an ontology that identifies the main parameters for synthesizing the future reality of energy sharing in a renewable energy community. It then allows players to be put in situations through games, one of which is studied in detail here. This analysis is carried out using a dedicated protocol and methods of analysis and validation.

The method provides good indicators on the evolution of individual behaviors, influenced by the situation of each actor. Without claiming to generalize the conclusions drawn from this single game presented here, it validates the serious game approach to build governance rules for renewable energy communities by integrating social parameters, and identifies the drivers of cooperative dynamics such as equity, and solidarity, through the identification of specific profiles of its actors and the detection of deviant behaviors.

7.1 Limitations

In order to ensure the good usability of the game, several concepts had to be neutralized or simplified in the ontological model : for example, the notion of profit comes in the form of points attached to actions, which constitute a dematerialization of the economic factor ; the notions of prior investment do not appear ; the point values are not correlated to actual monetary values, etc.

Similarly, the unit of time is one day (with two states : working day or day off) played three times per season, whereas the balance of electricity consumption/production is measured in 15-minute increments, or 48 times per day, requiring a much finer reactivity than what is simulated in a game.

On the contrary, a game played over one year does cover all four seasons, but it only allows to measure the initial effects of investments in photovoltaic panels, which actually bring a certain benefit to their owner over the course of about twenty years.

In our analysis method, many parameters could not be questioned in this article, such as the impact of a player's verbatim influence on the decisions of others, or the effect of anticipation on successive seasons, or even variations in decision-making depending on individual energy unit situations, etc.

Of course, this study comments on a unique and non-reproducible game, to identify human parameters, whereas it would be necessary to analyze thousands of games before claiming to understand in detail the motivations of decision-making behaviors.

7.2 Perspectives

To overcome this methodological pitfall and go beyond the combinatorial approach presented in our simulation (Section 6.2), the SERENITY project aims to model a variety of situational postures, animated by the specification of human parameters described in this experiment, which will be interacted through simulations of thousands of games rounds in fictitious communities. Based on an agent system parameterized on the observed behaviors here, this large-scale

simulation will more broadly indicate which governance rules can govern, as fairly as possible, the ongoing energy transition.

Acknowledgments

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Frameworks for understanding the Novice-to-Expert growth of simulation facilitators

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Abstract. Skills take time to develop, and experts accept that developing and maintaining their skills is a lifelong process. In our current research we are exploring the knowledge needed by novices intending to develop expertise as facilitators of simulations for learning. This article is aligned to a book on facilitation skills for educators in academic contexts (Leigh & Levesque, in press), which introduces the use of two existing frameworks to better understand the importance of focusing on ongoing facilitator skill building and awareness. In the educational contexts where we are working, simulations are structured activities creating temporary contexts that are miniaturised replications of specific aspects of human relationships and interactions. Educators who facilitate simulations and games for learning are expected to prepare for, launch, monitor/facilitate and debrief each activity appropriately for the environment and stated learning outcomes. To do so requires developing an awareness of, and the skills to manage, how simulations differ from other modes of learning. For example, many simulations employ a shift in power relationships – relocating issues of authority and control from the educator to the learner in specific ways that alter how all those involved understand and engage with their rights and responsibilities.

In this article we utilize three conceptual frameworks and briefly describe their uses to make sense of the development of facilitator expertise. These insights from adjunct fields of research provide insights into the experiences of facilitators of simulations and serious games in the journey, specifically understanding the development from novice to expert, and the ability to shift from oversight of games that range from hierarchical to collaborative to autonomous. Through use of narrative cases and reflective analysis we illustrate some ways in which readers can combine theory with practice to expand their facilitation capabilities.

Keywords: Facilitation, Education

1 Introduction

Applying a systems perspective to ‘classroom’ practice we maintain awareness of as many factors as possible, while acknowledging that it is impossible to account for them all, every time. Here we focus on the skills and knowledges important to educators who are – or are considering – using simulations and/or games for learning purposes. In this article we employ two particular frameworks to suggest how skills and knowledges can be developed and briefly examine a model for guiding which facilitative behaviors to choose before, during and after use of the kinds of active learning that simulations and games encourage. These frameworks are a) the concept of skill and knowledge development progressing from Novice to Expert as developed by Dreyfus and Dreyfus (1980) and expanded by Benner (1992); and b) a growth-oriented path from unconscious incompetence to unconscious competence (Burch, 2022). In addition to those, a framework for informing behavioural choices was developed by John Heron (1999) and guides educators to respond more flexibly to the needs and nuances of educational situations.

2 What is expected of the Simulation Facilitator’s role?

The role of the facilitator can be quite different from that of a teacher in a more traditional educational setting and therefore requires a bigger repertoire of skills, knowledge capabilities and

emotional responses to assure effective outcomes of these more complex contexts. Since we are limiting this work to the use of simulations and games, we provide a brief overview of the kinds of contexts to which we are referring before introducing the frameworks and model. Simulations may be large scale exercises occupying an entire floor of a huge warehouse (Parkin, 2019) or hundreds of square miles of land and thousands of participants (Talisman Sabre, 2021). Alternatively, they may be small and intimate events engaging only a few participants such as a class of students. They may employ high-tech supports or a simple pack of cards. They can create environments that are overtly familiar or entirely unfamiliar. Some simulations focus on skill development, others introduce and explore conceptual problems, while still others address forward planning and analysis of wicked problems.

Games are activities that can share many characteristics of simulations or are structured as competitive activities with (perhaps) fewer direct references to real life. In our context we employ the terms interchangeably and keep the focus on the learning purposes for which all/any such activities have been devised and are being employed. Whatever their structure, focus, or degree of recognizability simulations and games for learning require participants to ‘suspend their disbelief’ (Coleridge, 1817) and engage with a set of actions that may challenge all or some of their current perceptions, beliefs and practices. This is the domain of the facilitator – creating the unexpected, managing the resulting uncertainty, and helping learners acquire new insights into their own and others’ habits and convictions.

In its most practical form, the facilitator’s role simply requires being able to complete four interconnected tasks. The first involves preparing the materials, the setting, and participants for the experience ahead. The second task, commonly called the briefing, introduces the activity and launches learners into the action by providing specific information about the materials, roles and rules, interactions, and any boundaries regarding interacting with facilitators. *For these two tasks the facilitator has full control of the process.* The third task can be the most difficult– it involves standing away from the action, remaining uninvolved while closely observing what is happening (ref: Leigh & Spindler, 1998). *In some simulations and serious games, it is essential that while learners are completing this task, the facilitator exerts (almost) no control in order to create an autonomous environment for the participants.* Even in simulations or games where the facilitator influences the action, they must understand how and how much to interfere. In the final task of debriefing, the facilitator engages participants in intense conversations to unpack, analyse and assess how the experience has provided new insights, amended current perceptions, or provoked deeper questions about the topic of the action. *For this task the facilitator is both ‘leader/guide’ and follower, sharing issues of power and control with participants.* While facilitators are primed with questions and observations based on the action, they also watch for and explore emergent signals about participants’ emotional and experiential responses to the preceding happenings.

We consider these shifts in power and control during a simulation to be the cause of some of the difficulties encountered in developing relevant expertise. Such issues are seldom addressed when discussing standard skills and knowledges for academic educators and thus the changing power dynamic can surprise a novice facilitator of simulations.

There is a good deal of information available about conventional teacher education (see for example Zeichner, 2023; Darling-Hammond, 2006) as well as facilitator capabilities – such as those put forth by the International Association of Facilitators (2023), which introduces 6 core competencies for facilitators described as forming “the basic set of skills, knowledge, and behaviours that facilitators must have in order to be successful facilitating in a wide variety of environments.”

While the general thrust in such work is valuable, there is an assumption underlying it that the facilitator always remains the person with final say about matters of power and control. In contrast facilitating learning through simulations and games requires a particular kind of courage to stand aside from control and power at crucial moments in the learning process to avoid becoming prematurely engaged in the action. Not interfering will nurture and encourage

emergent learning – and can do so even to the point where intended learning outcomes are abandoned in favour of exploring issues emerging from participants’ interactions.

3 Frameworks for acquiring skills and insights

3.1 Novice to Expert – a developmental continuum

The concept of learners as progressing from Novice to Expert – as proposed by Dreyfus and Dreyfus (1980) and explored in depth by Benner et al. (1992, 1996) – considers learning as a developmental process that is, to some extent, situationally bound and integrates degrees of conceptual understanding with relevant application of actions appropriate to the context (see Figure 1). In effect novices may know the facts and understand what is required of them in specific settings without being fully able to take swift action, while an expert is able to take action without hesitation, in a manner illustrating deep knowledge of a complex set of theories and practices. Intriguingly, the Expert may later be unable to fully describe their rationale for action, because their expertise has become second nature, embedded or even buried beneath layers of learning acquired through repetition, observation and reflection.

Skill/knowledge level	Novice	Advanced beginner	Competent	Proficient	Expert
	<i>Just getting started on developing a skill but not yet familiar with it</i>	<i>Can work on problems alone, using ‘recipes’, with context relevant awareness of when to use which components of the body of knowledge</i>	<i>Possesses a sense of what is relevant and what is not in varied contexts. Can use ‘ingredients’ from a range of ‘recipes’ to build responses for specific situational needs</i>	<i>No longer reliant on creating or finding rules for action. An intuitive sense of the goal helps rules seem ‘obvious’ but not entirely without thinking</i>	<i>Operating by intuition; knowing the goals, what to do, and what should happen. However, it may be harder to explain why actions were taken.</i>

Fig. 1 Summary of Novice to Expert Characteristics (Benner, 1996)

Facilitators are advised not to interfere during the action phase of a simulation. But this can be a hard lesson to learn – as the novice facilitator in Narrative Case 1 found out.

Narrative Case 1 - Learning ‘on the run’ – a novice learns the hard way.

During a simulation chosen to illustrate how social interactions are shaped by access to physical resources, a participant who had been given what they considered to be too few resources chose to steal from the resources in the so-called distribution centre. The person in the designated role of police officer was called, resulting in the ‘thief’ dashing from the room with the ‘policeman’ in pursuit. The (novice) facilitator halted them, stated that the policeman was immediately demoted and then allowed the thief to get resources from the game’s social support office - without any punishment for theft.

The debriefing highlighted the error of the facilitator’s decisions. Neither thief nor policeman saw them as realistic or viable (although they complied) and thus they undermined the veracity of the entire experience. The facilitator learned the hard way about the importance of non-interference during the action, and the debriefing was an intense learning experience for all involved. Educational programs with predetermined learning outcomes may require educators to adhere to these with some diligence. So, what happens when a participant derails the session by demanding attention to a personal learning need apparently unrelated to stated outcomes? The likelihood of this happening is greater with simulation-based learning than conventional teacher-driven sessions due to the potential for activity-based learning processes to trigger for individuals an unexpected reaction during the action or novel connections during the debriefing. In the

following example, participants were employees who had been identified for promotion in a finance sector business and were preparing to manage groups of employees after achieving success in an unrelated role. The chosen simulation was intended to promote discussion about how to generate and manage good office communication practices.

Narrative case 2 – an expert encounters a challenge

As the debriefing began one participant exclaimed: “Now I know why the United Nations doesn’t work!” Since this appeared to have nothing to do with the activity nor the topic of office communication his words halted everything. The facilitator, experienced at handling the unexpected, took a moment to settle his surprised peers before asking “That sounds intriguing, what did you see here, to help you make that connection?” The intention was to link the passionate opinion to session goals, which the speaker quickly did, describing his interpretation of others’ actions and how this helped him address his personal disquiet concerning a major international incident involving the UN.

In that case, the expert facilitator’s question drew out the speaker’s emerging appreciation of the importance of effectively managing communication processes on both large and small scales, helping his peers reflect on their actions gaining insights into personal motives and their impact on communications. It was a spontaneous response and afterwards the facilitator found it difficult to explain why that response was chosen. A less experienced facilitator might have ignored the comment altogether or even chided the speaker to stick to the topic. The intuitive response to seek for understanding of the links the speaker had made allowed everyone to consider a much larger framework for good communication than the facilitator could have imagined when planning the session.

In between the two stories provided in Narrative Cases 1 and 2 lies a wealth of learning gathered from both formal and informal sources. The novice is at the beginning of a journey that will involve accumulating expertise through both good practice and trial and error. Benner (1996) notes that:

Articulating the knowledge, skill and ethos embedded in practice is the explicit goal of [the work of *From Novice to Expert*] ... in order to [raise] new issues and questions. [And highlight that] *skill is [more than] just a mechanistic following of formal propositions.* (italics added)

For both facilitators in these examples, an understanding of their current position on the Novice to Expert continuum provided guidance and help in achieving and maintaining capability relevant to immediate contextual needs. While there is a beginning to the Novice state that is usually associated with an emerging awareness of the absence of knowledge or skills, there is no end point relative to Expertise. New contexts and new expectations will reveal yet-to-be explored issues by the expert who is by now familiar with the thrill of chasing down new knowledge.

3.2 A Consciousness/Competence matrix

Like the journey from Novice to Expert, the path outlined within the Consciousness/Competence matrix (see Figure 2) begins the exploration of knowledge and skills acquisition at a point prior to possession of either. In the state of being Unconscious and Incompetent an individual is oblivious to their own lack of knowledge or capabilities and unaware of a need to acquire them. Only when/if some change in surrounding conditions alerts them to the existence of such knowledges and skills, might that individual become interested in exploring what it will mean to become capable. In effect they have become aware of a gap in their abilities and are in a position to consider if there is value and benefit in becoming ‘competent’.

There are decisions to be made from this point on. Individuals who are already capable educators must decide whether to invest the time and energy needed to become competent

facilitators of learning via simulations and games. Understanding this as a decision point is a most helpful aspect of the matrix for Novices and those newly aware of their status as ‘consciously incompetent’. It is only when a decision is made to progress towards competence that the learning really begins. Being a competent – even Expert – educator does not, of itself, imply any definitive capabilities as a designer, user, or facilitator of the processes involved in using games and simulations for learning. While giving advice to industry trainers and adult educators on the design and use of simulations, Gary Shirts – a renowned designer of powerful simulations – cautioned that they are widely misunderstood by the instructors who adopt them (Shirts, 1999).

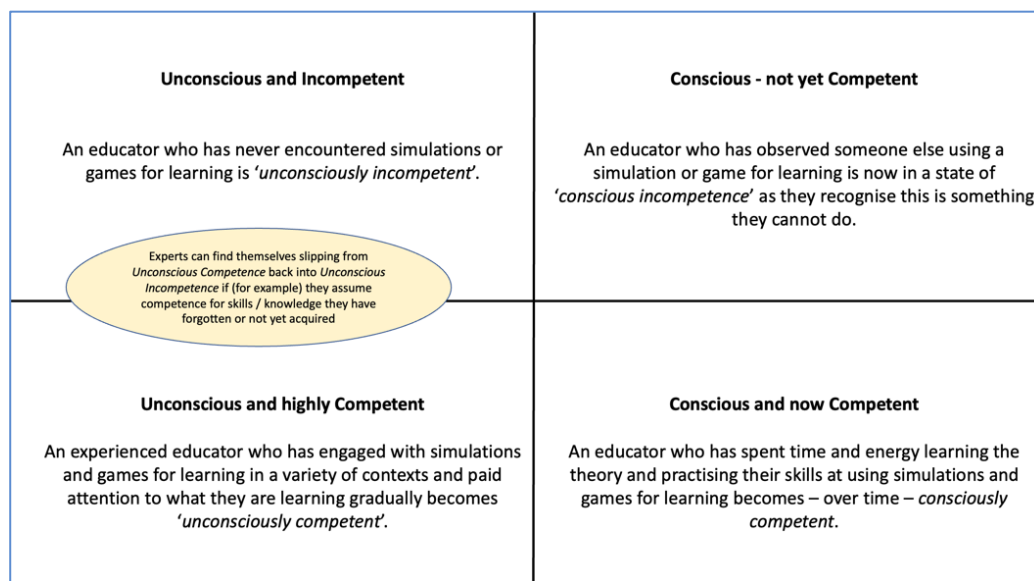


Fig. 2 The consciousness/competence matrix based on Burch (2022)

As useful as it is in highlighting that decisions must be made consciously to actively engage with learning, Burch’s framework does not indicate anything about the nature, length or quality of the learning that will be involved for anyone deciding to move ahead with gaining conscious competence in a chosen field.

For facilitators of learning via simulations and games, that learning can be acquired through attendance at conferences (like the annual ISAGA or MOBTS conferences where this is a regular topic), reading articles in relevant journals (see for example *Simulation & Gaming*, SAGE, or *The Journal of Management Education*), discussing with colleagues, or through their own trial-and-error. Regrettably there are, at present, few formal sources for such learning, thus recognition of competence is more often received through peer acknowledgement than formal certification.

The fourth quadrant of the Matrix – Unconscious Competence – is not dependent on external recognition. Rather, it references an expert level of skills and knowledge achievable only through action. Since facilitation is a practice, the expert must be observed ‘in practice’ and even then, real skill may be disguised in the form of quiet observation, minimal guidance during debriefing sessions or unobtrusive shifts in planned activities. Unconscious Competence means what the title suggests – that the possessor is unconscious (unaware) of how their now intuitive movements and words reflect the deep knowledge and skills of an expert.

Narrative case 3 – adapting to what is present in the moment.

The colleagues involved in the following exchange had been working together on a change management program for some time. On this occasion the first speaker is a designated observer while the second speaker is the program lead.

Scene 1 – on the way to the workshops

Speaker 1 (S1) - so what's the plan for this workshop? How will you open the first session?

Speaker 2 (S2) - I plan to use the same format as the previous openings. A short introduction, followed by the activity that invites them to list the reasons for the program as well as their presence here. I will introduce the Action Learning projects that follow this workshop and explain how they are designed to help [the organisation] reorient its activities to suit the changing context.

S1 – that sounds like a good start. There is a lot to share so this should give them a good overview.

Scene 2 – at morning tea, 2 hours into the first day.

S1 – so what happened?

S2 – what do you mean, 'what happened'?

S1 – well as I recall your words on the way here you were going to *use the same format as before*, introduce *the team projects* and *set the 'change' scene*. You did none of that! Instead, you opened with a question about why they thought they were here, put them straight into an activity and challenged them about their perceptions of the organisation and got into a tense exchange about how it is 'punitive'. Why?

S2 – [slowly] I wasn't consciously aware that I did that. When I walked into the room, I just knew something was very 'wrong' but couldn't say exactly what it was, except that I sensed a lot of resistance. So, I chose that activity in the hope that it would create an environment where whatever was 'wrong' would emerge. And as soon as we started, I knew I was right. The debriefing was bristling with negative comments – I'm sure you noticed that! – and when the issue of 'punitive' emerged I knew I had got to the heart of what was troubling the 'ring leaders' of the resistance.

S1 – I didn't see any of that except the reactions during the debriefing. So, what exactly did you see to make the change?

S2 – I'm really not sure. it was a kind of gut reaction to what I felt when I walked in. I knew that earlier plan would be useless, so I had to try something else. It's worked. And now that we know they believe they will be punished if they attempt change, we can do something about it. Because *we* know if there was to be any 'punishment' it would be for not engaging and giving it their best shot. All the prior workshops have demonstrated that.

For this facilitator the choice of a simulation to address unspoken but strongly felt emotions in the room was a natural and comfortable choice. Only when questioned about motives for the change did the difference between spoken plans and actual events become consciously evident¹.

A final note about the Matrix concerns the warning in the oval shape that competence can deteriorate without its possessor being aware of its demise. It is a reminder that Experts who are Consciously Competent and/or Unconsciously Competent must not lose sight of the fallible nature of their abilities and always afford themselves time to review, rehearse and revise, taking all necessary actions to assure themselves, and others, of continuing competence.

¹A footnote: the facts as described during the debriefing were correct. But had occurred 20 years ago. A member of the current executive team was one of those 'punished' – and he was drawing on the experience to drive the program. He wanted his managers designing what happened next – in ways not available 20 years ago. The story of the organisation's 'punitive culture' was known but 'undiscussable' and was impeding senior staff engagement. This day's events killed its influence!

4 A framework to guide facilitator decision-making

Competence as a facilitator of learning via simulations and games involves flexibility in regard to decision-making. It especially requires unending awareness that factors of power and control, authority and management, and relevance of content and process are fluid and changeable. Simulations and games energise learners' emotions and senses in ways that conventional teaching (including facilitator-led) processes seldom do. Being alert to the ever-changing currents of group dynamics involves an ability to recognise when to alter the locus of control in response to participants' emergent awareness. It requires both situational awareness and an ability to defer to others even when it seems that one's expertise could quickly solve the problem/s encountered in the course of the action. As that Novice facilitator in *Narrative case 3* found to their cost, interfering in the action can damage or even destroy the intended learning outcomes.

John Heron understood this well. As a facilitator of Action Learning programs, which have many characteristics in common with simulations and games, he developed a framework for guiding facilitators' decision making and actions. It introduces six 'Dimensions of facilitation' across three Modes of operation, as outlined in Figure 3. There is no intention to value any one combination of dimension + mode over any other combination. The purpose of the framework is to illustrate the array of possible decisions and resulting actions available to facilitators and – further – to aid them in the making of such choices by demonstrating outcomes of each combination. Heron had in mind as he worked any “person who has the role of empowering participants to learn in an experiential group” [where] “an experiential group [is] one in which learning takes place through an active and aware involvement of the whole person.” (p1).

Figure 3 incorporates brief indicators about how participants and facilitator will interact given the facilitator's choices in regard to mode of operation and behavioural dimension. In effect the table as a whole incorporates all the ways that such interactions normally occur. For example, where the facilitator identifies the operational mode as “Hierarchical” and chooses to retain total control of how the session will be structured the result is that “*Decisions about how learning will be structured are made (wholly) by the educator*”. In contrast a choice to operate in an Autonomous mode means that “*Decisions about how to structure the learning are deferred to the group. The educator may be a resource.*” While such decisions within the learning context may result in major shifts in power and authority, it is clear that the facilitator always retains the power of making the first choice about which combination to employ. Further, it is evident that only once a choice of combinations is made does the group attain the position of being in control, or being controlled by, the facilitator.

All such choices are not made once for the duration but are enacted again and again as the learning continues. Facilitators of simulations and games for learning operate in Hierarchical mode when planning to use an activity to further learning objectives and then shifts to Cooperative mode while introducing the activity before shifting to the Autonomous mode as the action gets underway and then reintroducing the Cooperative mode for discussion and reflection at the end of the action (as illustrated in *Narrative case 3*). And within this set of shifting power relationships facilitators may find themselves facing further decisions if (for example) it becomes evident that there is a need to Confront emergent issues during the debriefing.

In this article we can only provide a brief introduction to Heron's comprehensive exploration of the dimensions of facilitation for the purpose of highlighting the complexity of some of the knowledge and skills yet to be acquired by Novice facilitators and already possessed by expert facilitators. We strongly recommend that educators intending to become expert facilitators of learning via simulation and games explore for themselves the dimensions of Heron's work and set themselves the task of becoming competent in employing his advice.

5 Summary and concluding comments

We began with the observation that skills and knowledge take time to acquire and that maintaining them engages Experts in a lifelong learning process, and two ways of identifying and tracking one's current capabilities were introduced for consideration. We describe this pathway as the gradual acquisition of capabilities as an individual moves through identifiable stages from *Novice* to *Expert* and the concurrent awakening of consciousness as competence is enhanced. Both frameworks for development summarise what might have been years of work, suggesting that there is no simple end point beyond which further development is unnecessary. Heron noted that decisions are made within contexts that affect, in identifiable ways, the actions and interactions observed within those contexts (as summarised in Figure 3). That insight is offered as a powerful tool for all facilitators to employ in developing their own capabilities. As we continue to research and explore what is expected of facilitators of learning via simulations and games, we anticipate providing further examples of tools and models for use by both Novices and Experts.

At the ISAGA conference in 2023 we plan to demonstrate some the ways in which facilitators can collaborate on sharing understanding of the journey to expertise through use of such tools as these.

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<p>Power modes <i>Within which facilitators operate.</i></p> <p>Facilitation Dimensions <i>Learning purposes and what is to be achieved</i></p>	<p>Hierarchical</p> <p>Educator directs the process, exercises all power; leads from in front; thinks and acts on behalf of the group.</p> <p>Educator makes all decisions about methods and content. Learners receive input.</p> <p>Educator tells learners the meaning of the lesson and directs their responses to content.</p> <p>Educator identifies presence of resistance/avoidance and acts to name/address it. Learners follow and respond.</p> <p>Educator has charge of emotional quotient throughout, so feelings are addressed in relation to their capabilities.</p> <p>Decisions about how learning will be structured are made by the educator.</p> <p>Educator's values drive the climate focus often on importance of learners acquiring relevant content</p>	<p>Cooperative</p> <p>Educator shares power; manages dimensions with a group; enables and guides group to become self-directing by conferring with members.</p> <p>Educator engages learners in decision making. Learners contribute to decisions about methods and content.</p> <p>Learners are encouraged to develop their own meanings. Educator guides consideration of options.</p> <p>Educator and/or learner may identify resistance/avoidance. Decisions about how act should be collaborative</p> <p>Feelings that arise can be named by anyone and the means of handling them are decided by mutual agreement</p> <p>Decisions about how to structure the learning are managed as a collaborative task, and carried out together</p> <p>Values are named as a whole group and an individual issue when identifying needs and interests. Decisions are made after due consideration of how all issues identified</p>	<p>Autonomous</p> <p>Educator respects autonomy of group; enables it to find its way without intervention; does not do things for or with them.</p> <p>Educator operates as resource. Learners decide on methods and content.</p> <p>Learners derive personal meaning from experiences. Educator observes</p> <p>Anyone can name existence of resistance/avoidance behaviors and the group as a whole finds ways to respond</p> <p>Feelings are acknowledged as part of normal interactions and individuals are able to name and address their own emotions.</p> <p>Decisions about how to structure the learning are deferred to the group. The educator may be a resource.</p> <p>Values are raised as an issue for resolution as part of addressing overall learning processes. No single person has priority in shaping issues of integrity.</p>
<p>Planning - Relates to group's aims, and how to fulfil them. Ask: who creates the objectives and programme?</p>			
<p>Meaning - About participants' making sense of an experience, knowing what to do and how to react. Ask: how is meaning given to and found in experiences and actions of group members?</p>			
<p>Confronting - raising awareness of a group's resistance to/avoidance of things it must deal with. Ask: how to raise the group's consciousness of these matters?</p>			
<p>Feeling - about managing feeling in a group. Ask: how to handle feelings within the group?</p>			
<p>Structuring - the form of experiences in a group and how will they be structured Ask: how to structure the learning experiences?</p>			
<p>Valuing - about integrity; creating a supportive climate honoring and celebrating group members; staying in touch with their true needs and interests. Ask: how can such a climate of personal value, integrity and respect be created?</p>			

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Fig. 3 Adapted version of Heron's Table of Facilitator Dimensions

Emotional high resolution of crisis management simulations

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Abstract. The emotional high resolution of a simulation, that is the capacity of a simulation to create in participants the whole gamut of emotions that the real situation simulated (here) would, characterize the highest possible degree of fidelity and participants' engagement for the simulation. However, observing and analyzing emotions remain difficult exercises, complicated by the ambivalent nature of emotions. The authors present here a concrete evaluation of emotions displayed in crisis management simulations and discuss expanding the debriefing to better take into account the emotional high resolution.

Keywords: Simulations, Crisis, Emotions

Simulation maintains a relationship of fidelity with reality, through congruence with a set of scientific data (Mauriras Bousquet 1984), by eliciting an effort of completeness through the players' imagination (Goutx & Langumier 2015, Naccache 2020, Gaillard et al. 2020), through a relationship of familiarity (Créton-Cazanave 2010, Goutx and Langumier 2015) or again, in the confrontation with the idea that one has of it (Dubey 2001), the lived experience constituting the hinge between the representation by the simulation and the referent that the simulation claims to reproduce faithfully (Zaccarà-Reyners 2003).

A simulation can be considered faithful to reality by creating original emotions (ie specific to the simulation) which seem genuinely similar to ones the real situation, simulated in the exercise, would have. This is what Nordgren (2008) saw in three nordic Live Action Role Plays (LARPs) which created a particularly deep and powerful playful experience in the participants, that could not be transcribed with the vocabulary available at the time. Nordgren defines the concept of High Resolution, since used in the analysis and theory of LARP by distinguishing on the one hand the part of the player's communication (particularly non-verbal) which must be considered as significant in the game and, on the other hand, the extent of the emotional palette which the player is free to interpret in the game.

The work presented here applied this to crisis simulations. These are teaching tools enabling all the participants to immerse themselves in a crisis situation by becoming a simulated crisis unit (Dautun et al. 2011, Sauvagnargues et al. 2019, Verdel et al. 2010). Through these simulations, various objectives, educational, organisational or structural can be aimed at (Lapierre et al. 2019). In order to make sure of the educational value of the crisis management exercises, researchers have been looking for several years at how to create these simulations (Lapierre et al. 2020, Limousin et al. 2016, Richard et al. 2022). It seems that one of the factors making participant commit to the simulation is how they assessed its credibility (Fréalle 2018). An emotional high resolution plays an essential part in establishing the credibility of the simulation. The aim here is to study the emotions of participants through the prism of the ludicity in play in crisis management exercises.

1 The Emotional resolution of crisis simulations

Observing and analyzing emotions in a crisis simulation first requires observing the ambivalent nature of emotions and considering ways to characterize them.

1.1 Categories of emotions

Observing emotions in a way that complies with certain expectations of objectivity and methodological rigour is difficult (Micheli 2013). The word emotion covers phenomenons which are both behavioural and experiential (Tcherkassof & Frijda 2014), which can be put into five major categories (Bernard 2015) :

1. Physiological phenomenons : These emotions are visibles, so they are quantifiable (Damasio 1999) through technical medical means (Damasio 1999) like electroencephalograms, electrocardiograms, change in cardiac rhythm, analysing the electrodermal activity (AED) (Sequeira & d'Hondt 2013) as well as facial electromyography (Korb & Delplanque 2013), but these physiological approaches have a tendency to reduce the range of emotions picked up to stress or fear (Lonsdorf et al. 2017).
2. Social phenomenon, the effects of social pressure and control as a result of observing emotions in social life experiences, such as 'emotional labour' (Hochschild 1983, 1993).
3. The discrepancies between the subject and the situation in which he finds himself, highlighted by the sociologist Irving Goffman (1961) who is more interested in the emotional dynamics of interrelations than in the nature of the emotions mobilised, and in particular the emotional outpouring that translates the release of an accumulated tension between the subject and the situation
4. The performative signs by which the subject manifests and establishes his or her affective space, relying on a connectedness of expressive behaviour and the subject's affective state (Drouin-Hans 1995), making his or her facial mimics 'emotional facial expressions' (EFEs) even though these EFEs are inherently ambiguous (Hassin et al. 2013), with their interpretation closely dependent on the context in which they are judged (DiGirolamo & Russell 2017, Tcherkassof 2018).
5. The objects of categorisation and definition of reality.

It seems difficult to know with certainty the emotion that we observe, especially from the outside.

1.2 Nuanced emotions

The understanding of emotions is strongly influenced by the categories of emotions used, most often linked to standard models using the basic emotions of Ekman (1999), like the one proposed by Sonmez et al (2012) : « Angry (An), Contempt (Co), Disgust (Di), Fear (Fe), Happy (Ha), Sadness (Sa) and Surprise (Su) » or by Calvo et al (2016) : « Anger, Disgust, Surprise, Happiness, Sadness, Fear ».

The relatively low range of options spontaneously used by ordinary respondents when discussing their emotions, rarely goes beyond these basics categories. This reduces the emotional resolution of the simulation to its capacity to reproduce stress or pleasure. We would then simply talk about emotional low resolution.

In psychiatry, more sophisticated models are in use, based notably on the three parts model of Watson & Clark (1988) which states the possibility of feeling simultaneously positive and negative emotions as well as surprise. The richness of these models based on a few dozen nuanced emotions enables a much more precise description of a person emotional stat in psychiatry (Pelissolo et al. 2007, Pelissolo 2011).

1.3 Emotions in crisis simulations

The emotions that games generate are mainly the pleasure of playing linked to a certain stress : the apprehension of not attaining the goal of the game, the fear of losing one's stake, the frustration of failure, the feeling of not being good enough,... Fear itself can generate a certain

pleasure like the one derived from horror movies or video games, from one's capacity to manage fear (Lin et al. 2018, Bantinaki 2012) or by generating a form of courage (Rachman 1984, 2004, Muris 2009) which is not a removal of fear but a capacity to overcome it, a source of great satisfaction which enhance the lessons learned in these circumstances (Prleuda et al. 2015).

More broadly, Mullins & Sabherwal (2018) highlight the simultaneous presence of positive and negative emotions during simulations which increase the engagement with the game.

However, all types of games are not conducive to the display of emotions (Jones 2004). Mastering one's emotions might be considered a professional requirement (Martin & Alvarez 2018), especially for crisis management (Mellers et al. 1998, Gaudine & Thorne 2001, Loewenstein et al. 2001, Starcke & Brand 2012, Kustubayeva 2012, Fallon et al. 2013). The feeling of being assessed, the wish to perform well, the culture of the company can be barriers to the immersion of the player into the game (Martin 2015).

Inhibiting his emotions during the game require an effort from the player, creating an emotional tension (Goffman 1961) that can free up an emotional outpouring (laugh, swear word,..). Through the observation of these emotional outpourings, we can thus detect the changes in the opposition between the suspension of disbelief needed for the game and how close the simulation adheres to reality (Goutx 2021).

Emotions can be physiological or socially constructed, more or less intentionally, and described in more or less sophisticated ways. They certainly arise in situational games, because of the situations themselves or the fact of playing them. The challenge is to observe emotions and characterize the degree of emotional resolution of crisis simulations. The emotional highest resolution of a simulation would be the capacity of a simulation to create in participants the whole gamut of emotions that the real situation simulated (here) would.

2 How to observe emotions during simulations

In order to observe emotions during simulations, three tools have been used: a questionnaire, a debriefing and a quantitative video analysis. Each generates a different type of information which enriche the overall analysis of emotions.

2.1 Questionnaire on positives and negative emotions and surprise

We have used the 31 items positive and negative emotions questionnaire (in short EPN 31) (Pélissolo et al. 2007) which lists 31 emotions, positive ones, negative ones as well as surprise : affection, love, anxiety, benevolence, happiness, grief, anger, confusion, guilt, discouragement, disgust, embarrassment, astonishment, pride, fury, shame, humiliation, worry, irritation, joy, nervousness, fear, pleasure, regret, satisfaction, loneliness, surprise, astonishment, sympathy, tenderness, sadness.. We removed the item "love" which would have impacted the credibility of the questionnaire when used to describe crisis management exercises. Henceforth the questionnaire will be called EPN-30.

The person filling up this EPN 30 questionnaire notes the frequency of each emotions over a defined time period using a Likert scale with 5 levels.

The questionnaires filled up at the end of the simulation enables us to catch the playful emotions of the participants. However, these emotions vary all through the game and so, their measurement during the debriefing do not give an exact result and it is difficult to try and catch them during the simulation without running the risk of taking the player out of the game.

2.2 Qualitative video-analysis of ludicity

Another way to analyse the emotions erupting during a crisis simulation is to use the qualitative video analysis protocol we presented during ISAGA2019 (Goutx et al 2021). Qualitative video analysis consists in considering video recording not only as a means of capturing and analyzing sociological situations and information, but as material for a fully ethnographic method of

analysis capable of informing the observer beyond what is simply seen through the eye of the camera (Knoblauch 2012).

We designate by this word of ludicity (Goutx 2022), the playful attitude adopted – whether consciously or not – by a participant or a group of participants in a playable situation.

Our grid (see table 1) has 28 items of ludicity divided into 6 categories.

Our observation protocol (see figure 1) consists of 5 steps:

1. Review the video until an emotional outpouring (swear word, laugh, exclamation, annoyed gesture) appears.
2. Go back one minute, then another and another until the start of the sequence is detected thus defining the sequence to be observed.
3. Do the qualitative video analysis of the sequence, doing this as many times as they are active participants, each time focusing on one participant as if he was the main character of the sequence.
4. Write down the information (time, player(s), type of ludicity) in the timeline of the simulation.
5. Analysis of the ludicity.

Table 1. Summary of the different types of ludicity.

	A) exogeneous ludicity, linked to the playful environment	B) endogeneous ludicity, linked to playful attitudes of players
1) stabilising	A1) liminoidal space A1-1) entry into the simulation A1-2) agglutination of the liminoidal space A1-3) assignment of external information A1-4) healing of the liminoidal space	B1) playful pleasure B1-1) exploration B1-2) humour B1-3) exhilaration B1-4) solving a problem B1-5) relief of an anguish
2) stimulating	A2) dissonances A2-1) between players and animators A2-2) between groups of players A2-3) divergence in the allocation of meaning A2-4) malfunction of gaming gear A2-5) insufficient mastery of gaming gear A2-6) discredit of the simulation	B2) roleplay B2-1) difficulty understanding the role B2-2) roleplay error in the assigned role B2-3) conflicts between real and assigned roles B2-4) conflicts of authority B2-5) sliding the assigned role to an assumed role
3) destabilising	A3) game distance A3-1) antics A3-2) distraction A3-3) game breaker A3-4) spectator	B3) adversity B3-1) excessive, unrealistic B3-2) gamer mode B3-3) cheating B3-4) performance pressure

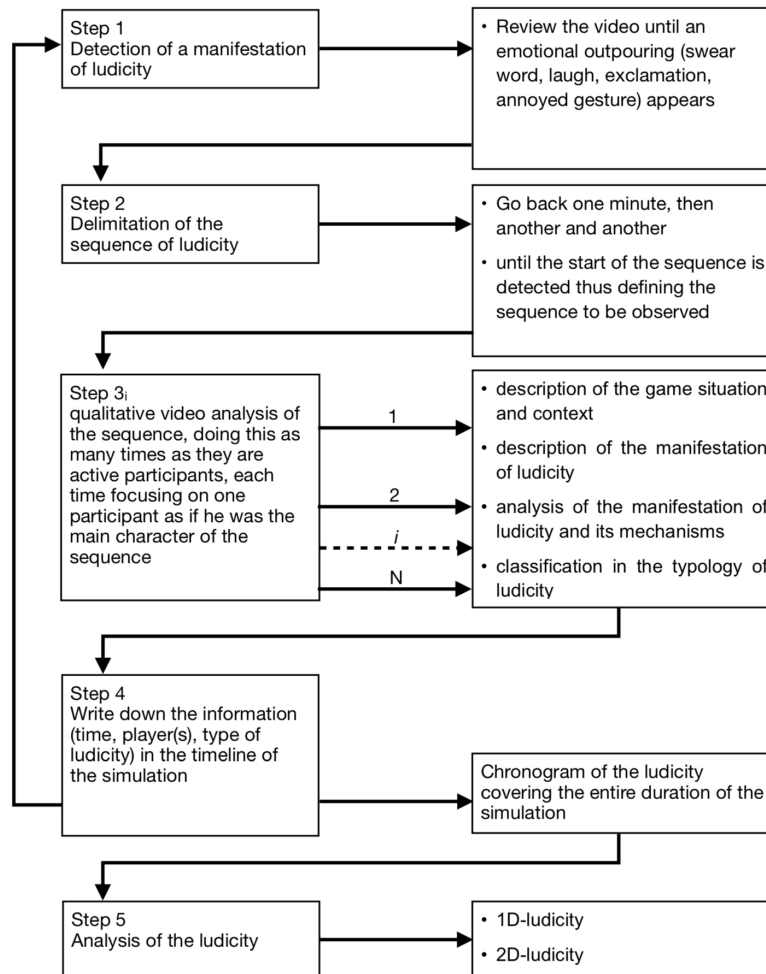


Fig. 1. A protocol for observing playfulness by qualitative video analysis

The protocol focuses on the expressions of strong and obvious emotions, the analysis making it possible to distinguish among them those which fall under the Physiological phenomena, the Social Phenomena or even the discrepancies between the subject and the situation in which he finds himself.

2.3 Debriefing of lived emotions

During the crisis management exercise, participants can feel various emotions including high level stress. According to the model of Hans Selye (1950), they can enter an alarm phase or even in a resistance phase. At the end of a crisis simulation, it is not unusual to find that participants are tired, who would then be in an exhaustion phase.

In order to share collective feedback, an immediate debriefing is done just at the end of the simulation. Numerous authors highlight that the debriefing is the most important part of the learning process for the participants (Crocq 2007; Fanning and Gaba 2007 ; Gabelica et al. 2012). They consider it a self-reflective and conscious learning process, where together the participants and the trainers take another look at the situation the participants had to deal with (Renou 2012).

During this part of the process, all the players are invited to discuss various points: their strong and weak points while sharing their experience of the simulation (it is the first part of the debriefing). This semi-guided period of expression can be interspersed with emotional outpouring by the participants. During the second part of the debriefing, this one dedicated to the collective analysis of the various situations that may have created an issue for the participants, questions to help them problematise and analyse certain specific points will also help identify associated emotions in an indirect manner.

Some trainers sometimes ask participants to share the emotions they felt. This is inspired by the defusing an emergency psychological intervention for people who suffered traumas (Bessoles 2016).

Within the frame of a crisis management exercise, the psychological consequences are not exactly the same due to the artificial nature of the simulation. However, this parallel allows us to understand the importance of opening up a space for participants to speak and listen so that they can express their emotions.

Finally, through all the different practices, it is possible to observe and listen to the feedback of the participants about the emotions they felt during the simulation. It is important to stay vigilant about the place of emotions in the debriefing as personnel issues can remain. The fear of being judged by the others (Renou 2012), of speaking in front of the group (Courtine 2005) might skew the results of the observations.

Besides these previous observations, it is important to mention the framework in which the immediate debriefing is conducted. Some circumstances can hinder the expressions of emotions by the players during the debriefing. Firstly, the person in charge of the debriefing influences the freedom with which the player can express himself. It is not unusual when the simulation is offered to a local authority, that the mayor or a town councillor wishes to lead the debriefing. In this case, it can be difficult for all players to express themselves freely because of the hierarchical links but also because of the lack of training in leading a debriefing and thus in making sure emotions are expressed.

Another obstacle that we noticed is linked to how well the speaking time is shared between the participants in the debriefing. It is often the case that the debriefing is done by going round the table asking each player to discuss the simulation they have just gone through. Without a reflection beforehand, the person leading the debriefing might be confronted with a premature end to the debriefing, as generally, after 8 people have talked, the other players have nothing else to add "everything has already been said".

The EPN-30 questionnaire provides access to a reflexive and ex-post quantification of the emotions felt by the participants, reduced to a finite list of emotions and without commentary. Qualitative video analysis makes it possible to qualify from the outside and during the simulation itself, the most expressive emotions. Debriefing, finally, allows for a reflective and open expression of memorable emotions after the simulation has ended.

3 Results from crisis simulations

None of the three devices presented can be sufficient on its own to deal with our issue, but they each provide keys to understanding emotions in crisis simulations.

3.1 Answers from questionnaires prove the high fidelity of simulations to reality

It is generally shown that the playful experience is not generated by the game environment but by the way the participants get into characters and how the simulation flows.

We show in figure 2 the answers from the questionnaires of 46 participants filled immediately at the end of a simulation compared to answers from the same EPN30 questionnaire filled up by 21 crisis managers who handled real situations similar to the ones described in the simulations.

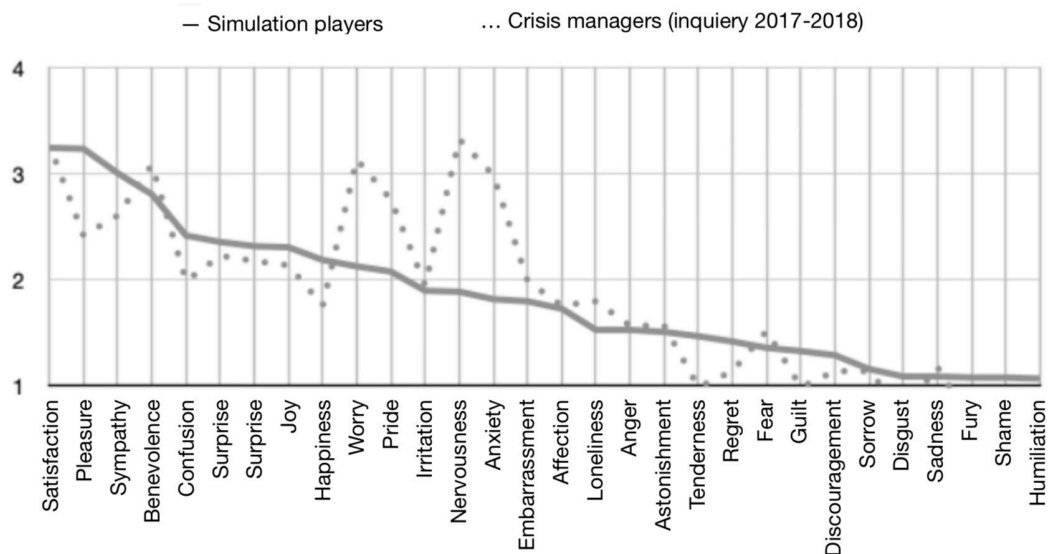


Fig. 2. Emotions transcribed on the spot by 46 simulation players compared to the answers to this EPN-30 survey questionnaire, made by 21 crisis managers.

The four most felt emotions were satisfaction and pleasure (natural results of a well-played game) as well as sympathy and goodwill (trademark of a good group spirit), with average scores between 2.80 and 3.24. The first two negative emotions are in 5th and 10th places respectively confusion (with a score of 2.41) and concern (with a score of 2.12), this shows the adherence of the simulation to reality (Sauvagnargues et al. 2019). The nine least felt emotions (fear, guilt, despair, sorrow, disgust, sadness, fury, shame, humiliation) have scores below 1.35.

We can see a high correlation for most of the emotions, between the emotions felt in simulations and the emotions felt by the crisis managers faced with real situations, this shows the emotional high fidelity of simulations.

More precisely, simulations generate a wide range of emotions with very similar level to the ones generated by real crisis, apart for six emotions, where the difference in level is explained first by the switch in emotions between reality and simulation (anxiety, concern and nervousness against playful pleasure) (Andersen et al. 2020, Tammy-Lin et al. 2017, Allison et al. 2015) and secondly, by an irreducible difference in the level of responsibility between a real situation (responsibility in a major mode) and a simulation (responsibility in a minor mode) (Tracy et al. 2010).

The crisis management exercises are a form of role-playing games with an emotional high resolution as would be said of LARPs (Live Action Role Playing games).

3.2 Qualitative video-analysis unveils four playful pleasures

The qualitative video analysis of 6 crisis simulations highlights four types of playful pleasure that have nothing to do with the usual optimal experience known as flow (Csikszentmihalyi 1990).

Firstly the heady feeling a player gets when he suddenly realise, for a brief moment, with a certain delight his full immersion in his character and he gets to grip with the difficulties of the simulation. It is the pleasure of being put in a difficult situation, to feel the problems as if the crisis was real without necessarily overcoming them. It shows a high stamina when facing problems: holding on, getting to the end of the simulation while playing one's role is an

achievement and is a source of pride. It is not unusual to see and hear participants applaud themselves at the end of simulations whether or not they achieved the objectives of the simulation.

Then, a pleasure found in the freedom given by the game of using it in one's own way and introducing in the simulation elements not planned by the game master. Bringing something in the simulation that was not already there, without the help of the trainers creates a pleasure that is not linked to the pleasure of competition against oneself or against others or to the pleasure felt when cooperating with others in the game. Moreover, this freedom in the game can also be found in the interactions between trainers and players in a simulation: in order to maintain the link between ludicity and learning, the trainer has tools to intervene (in that case). In other words, a trainer can intervene in an indirect manner, in a playful way, to limit divergences in the play that could create personal or collective issues that would affect the game experience. Depending on what emotions or behaviour an observer sees from the players, he can supply a card with a content aimed at generating questions linked to the divergence seen. For example: an observer has seen a player seeming stressed, he can then give the group leader a card pushing to wonder about this problem in an indirect way ("how was the workload divided within the group? Have you consulted all the group members about their potential needs or difficulties when facing the current situation?"). These methods help generate a certain bond between the players and the trainers which help with the learning part of the playful experience.

A third type of pleasure is taken from the togetherness coming from playing as a group (Kapp 2015) and so, on one hand the ease with which each player interacts with the components of the fictional universe of the simulation and on the other hand how well the exercise is designed as a learning tool. Collaborative, well intentioned interactions, either expressed verbally or through informal communications, attitudes, looks, are the signs of playful well-being in the game, which generates this playful collective pleasure. The game fellowship theorised by Huizinga (1938) can then be understood as a tight knit group of players linked together by a common playful experience be it positive or negative.

Finally, Incarnation: as soon as one as an individual and as part of the group, decides to adhere to the make believe, it is possible to move forward in earnest into a simulation that must be treated with all seriousness while constantly remembering that it is not real. The involvement of the player in the game which is first of all the involvement of the player in his character can be evaluated by how much the fiction is taken seriously against the awareness it is not real. All players move from one state to the other with their own rhythm (Kapp 2015, Caïra 2018) and the whole group is not necessarily in lockstep. The involvement of the player in his character gives it an affective charge that let the game affects him. Such an involvement that can generate a reasonable theatricality in the player's performance might bring the other along in a collective direction. We can see this type of interaction in all the type of playful pleasures of the roleplay that we have identified and described here : A player that uses theatrical gestures or attitudes to help his interaction with a trainer, to reinforce his requests or arguments, to obtain a kind of advantage, an ascendancy over the trainers on one hand, and at least one other player who is looking on this interaction as an observer or a supporter, delighting in the show when it is well done and pushing the actor to give his all, on the other hand. The player feels that by fully committing he can influence the situation in his favour.

3.3 A methodical debriefing to allow the expression of emotions

We have discussed the practical difficulties in catching these emotions which also shown in the recent work of Daoudi (2020) and some circumstances that can hinder the expressions of emotions by the players during the debriefing (see 2.3).

It is thus advisable that debriefings are led by the person in charge of the exercise or by an observer versed in leading debriefing so as to lead and guide the players to assess the points discussed previously.

Furthermore, two methods exist to push through this barrier and encourage each player to express themselves: the first is to continue going round the table, asking each remaining players questions about what they personally faced (linked to their personal objectives, specific issues they faced,..) making sure no to judge them. This approach is not the most satisfying as it forces the players talking at the end to discuss different points than the ones talking at the start.

The second method is to aim at the free expression of all players with an experienced moderator leading the debriefing making sure he is an active listener and facilitator. The role of facilitator for the moderator of a debriefing was introduced by Dismukes (Dismukes et al, 2000) who thinks that the moderator has to adapt his stance and his reactions to the level of involvement of the participants in the debriefing. Each is unique : the moderator allocates speaking time, manages the time, makes sure that all the points that need discussing are and that all participants had the opportunity to intervene. An experienced moderator sensitive to these practices is thus required.

The interviews we conducted with players after a simulation show that players free to use their own words to describe their emotions frequently use the lexicon of stress and anxiety.

And yet, what the players lived through is not easy to describe in a debriefing, as the players did not live through a story narrated by the trainers but through a series of event and adventures, they each tried to overcome as best they could without necessarily sharing an overall vision.

An edifying example comes from the simulation SI-TMD-FF-ALES-201706. During the debriefing, the trainers started by making the players talk, asking them to describe the situation they just simulated: "Can you tell us the story of the exercise?". But the participants listed the problems they encountered, each in their own roles: the fact that participants do not get together properly when they are supposed to collectively discuss the situation, how difficult it was to orient themselves in an unknown location and so on. When the trainers insisted that the players tell the story of the simulation they played, the (lady) player who assumed the role of the director of the crisis team catalogued without much enthusiasm a few of the events that occurred in the simulation. There is a real contrast between how laborious it was to get answers from the players, how anaemic the story they told was and the real enthusiasm of one of the player describing the simulation in a phone call made in the small break between the simulation and the debriefing.

" I am in Nimes, now, they are doing some crazy stuff... They have a whole room and it's like a local crisis centre, so they created this...there are screens everywhere... they gave us a road accident with a truck loaded with chlorine bottles so you got a toxic cloud and other things, a school to evacuate, it also started a forest fire we had to evacuate a whole neighbourhood, horses, an equestrian centre, it lasted two hours, mate, I am sweating like a pig... a complete nightmare! There are 14 of us in the room and there are 10 people as trainers, there is one... we were looking for a kid, he insulted him on the phone. I am telling you it is mad!..." and then he hangs up.

What this anecdote illustrates that the playful matter disappears rapidly at the end of the game and it needs a collective effort by the participant to put together their memories of the game to create a coherent narrative that all the players can adhere to.

The three observation tools have given strong results making some important points clearer when it comes to the emotional content of crisis simulations : 1) Answers from questionnaires prove the high fidelity of simulations to reality. 2) The qualitative video analysis highlights four types of playful pleasure that have nothing to do with the usual optimal experience known as flow. 3) The interviews we conducted with players while debriefing the simulations show that players frequently use the lexicon of stress and anxiety, which is a very limited part of the 30 nuanced lexicon of the EPN.

4 Discussion and perspectives

4.1 Limits of the Flow model in crisis management exercises

These simulations stage the difficulties of crisis the players have to deal with, which put them in uncomfortable situations, forcing to find or improvise solutions they know are not perfect. In these conditions, it is hard for them to feel a real satisfaction and even more to feel it strongly enough to express it.

In the theories inspired by the concept of Flow (Csikszentmihalyi 1990), players feel satisfied by overcoming these difficulties : a player using his competences and resources manage to surmount an obstacle to his progress. The playful pleasure becomes optimal when the player has to strain every sinew and use all his resources to just get over the obstacle in his path and then obtain some extra resources that enables to triumph of the next obstacle and so on.

In crisis management exercise, the hardships encountered by the players manifest as difficulties, partial information distributed between several participants that needs to be put together to make the right decisions. But the decisions themselves are not taken at the crucial moment: they are taken tentatively, with many hesitations, in order not to full steam ahead in a potential blind alley. And when a crucial decision is taken, no spectacular results appear: there are no great success. In the simulations we observed, making the correct decision does not highlight the right path at a fork in the development of the simulation.

Thus, it is hard to imagine that the players can feel this famous flow.

4.2 Genuine or performed emotions ?

We have highlighted how rich the emotions felt during the simulations we observed are, using the range of 30 emotions used by Pelissolo (2007) which goes much further than the usual six basic emotions seen in playful situations. Firstly, we note the powerful effect of words in opening up the range of possibilities. Indeed, the answers given in semi directed debriefing without the help of the EPN 30 are limited to surprise and stress, very little when compared to the plethora of emotions described with the EPN 30. Everything indicates that how the emotional experience is looked at and what words are available to describe it, determines how detailed the feedback will be. « When participants are offered a fixed number of emotion labels to indicate which emotion they perceive in a particular expression, successful recognition may be higher than it is in real life, where emotion perception is not aided by the availability of limited options » (Lange et al. 2022).

Not to have a detailed overview of the emotions felt is to stop yourself to appreciate the high fidelity of the simulation.

We have seen that the range of emotions described by the players after a simulation is quite similar to the ones described by crisis manager after a real emergency, with the exception of fear, felt in real crisis and very little in simulation, and pleasure, felt in simulation and very little in real crisis.

This supposes that if the players could be asked during the simulation about their emotions, they would talk about the fear they are feeling and not just about the pleasure they still feel after the simulation. In other words, the range of emotions recorded after the simulation might already be a kind of rearranging of the emotions genuinely felt during the simulation.

We have discussed the restraints that some players can feel to freely express their emotions in a field (crisis management), where they are not welcome and considered a hinderance to taking good decisions. The honesty of the players when filling up the EPN-30 questionnaire cannot be posited or verified.

We are more inclined to think that players feel emotions linked to the underlying stakes, like needing to perform well in the simulation to validate a course.

4.3 Strengthening materiality ?

In order to increase the emotional high resolution, the aim is not to try and generate more of the emotions that are felt in real situations but to help the players feel and express the emotions of the character.

Lappi (2004) thinks that how the player plays the game should not be just following the instructions contained in the pre-simulation information he received, but to bring forth in a consistent and coherent manner, what is perceived of the character from this information before he entered the simulation and so before the player started incarnating it. More precisely, still according to Lappi (2004), in role playing game, a player understands his character from the inside, making his own the character's motivations, thinking and range of actions. "A player doesn't role-play by facts but by reasons" (Lappi, 2004). Concretely, the player should be led to take over the goals of his character. "Basically, accepting the character's goals is one of the failsafe ways for the player to achieve meaningful action in a game." (Lankoski, 2004)

The player engages with the simulation to learn but maybe also to face off with a crisis or to show his ability to overcome. But these motivations are not those of the character. "Well-designed goals should be derived from the nature of the character and be reactions to situations. Vice versa, goals can be used to describe a character to a player." (Lankoski, 2004). Its motivations can be used to describe a character to the person that will play it.

These goals and motivations of a character that the new player will take over can be generated from the debriefing of previous participants that played the same character. Not only, would they feel more realistic and appropriate to the character but would make use of the repetition effect, where further iterations have a beneficial effect on participant's learning.

By managing to involve the player with the aims of the character and by making the player aware that he will be judged in part on how successfully he achieves the goals of the character, we will achieve what Banks et al (2018) call the materiality of the character. The materiality of Banks et al (2018) does not come from the visible, material aspects of the character (uniform, equipment, manner of speaking) but from the fact the character's fate is important to the player. "Characters are material because they matter" (Banks et al, 2018).

Besides, the fictional contract agreed before the start of the simulation must enable the trainers to immerse the players in a simulated crisis even if the players do not find it very credible and propose a crisis scenario with severe human, environmental and economical consequences. If the trainers can achieve this, they will not have to make changes to their scenarios to conform to the wishes of people or institutions ordering the simulations.

4.4 Completing the debriefing

The debriefing is a crucial and inescapable step to transcribe in a post-game reality the learnings taken from the simulation. It is at the same time a moment of reflection by the players and the trainers about the game that has just been played, a moment to put into words what has been played, to get to a shared understanding of what happened, what should have happened and what should have been done differently.

As we saw in 3.3, it needs a collective effort by the participant to put together their memories of the game to create a coherent narrative that all the players can adhere to.

Creating this narrative seems incompatible with the usual way debriefing are conducted where players feels their actions in the game are critiqued. It probably needs a discussion time between players without the trainers present. Anyway, we believe that debriefing should be planned with a way to specifically create a narrative that captures the playfulness created in the simulation before it disappear.

The idea to integrate playfulness in the debriefing itself should be discussed: we highlighted how hard it is to lead a debriefing as a facilitator, active listener. Inviting all the players to reflect on their actions, looking at themselves, can be an interesting way to help them express their experiences faced with a situation perceived as problematic.

The tool called C.REX©, created by RISCRISES, in collaboration with the ENSOSP (a French national school for firefighter officers), is in the form of a card game that help go through the five steps needed in reflecting on a situation during the debriefing: Describe one's situation (give de sequence of events) (step 1); describe one's reaction (understand one's emotions, one's reaction and behaviour) (step 2); describe the problems (what were the difficulties faced) (step 3); analyse how decisions where made, what leadership and teamwork were there, how good the communication and collective vision of the group was (step 4) and then synthetise (what learnings can we take and share) (step 5). This card game helps the players be better involved in the debriefing and gives the benefit to push them to reflect on the actions, behaviours, reactions, emotions they had faced with the simulated crisis.

5 Conclusion

Crisis simulation exercises as we orchestrated and observed them at the IMT Mines Alès have all the hallmarks of emotional high resolution : the entire range of emotions can be shown and what is observed is very close to the real crisis management that the simulation uses as a reference. However, pleasure is unique amongst the sentiments felt as it is much more present in the simulation than in reality according to the feedback of crisis management experts.

However, feelings remain difficult to observe with all the necessary refinement, especially pleasure which is rarely seen on the faces of participants in crisis simulation exercises as they are concentrated on the complex tasks they have to accomplish. Our qualitative video analysis protocol enable us to pinpoint some manifestations of ludicity that effectively come from the four types of pleasure: Being up to the task, contributing to the richness of the simulation, sharing this peculiar situation with other in a group welded together trough adversity and embody a character immersed in a out of the ordinary situation.

Finally, the debriefing, a key moment in the metamorphosis of the virtual experiences lived by the participants into a long lasting knowledge usable in real situations, can capture the emotional dimension of crisis management exercises, as long as it is conducted using methods, supports and decryption keys, like the ones proposed in the C.REX© tool, helping the participants remember the emotions linked to each action done in the simulation.

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Player Personality Profile Grid (PPP Grid)

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Abstract. The purpose of this article is to propose a model called the "Player Personality Profile Grid" (PPP Grid) to help an instructor assess the profiles of the players he or she is likely to encounter in his or her learner audience. Specifically, this means addressing games that emphasize competitive aspects for competitive audiences (killers) or collaborative games for audiences that are more interested in dialogue and exchanges (socializers). The goal is to maximize the chances of making an edutainment session as efficient as possible. The approach resulted in a first iteration of a model. This model was constructed and derived based on statistical analyses of 1126 individuals who completed a questionnaire about their personality, age, gaming profile, and weekly gaming time. From this data, we constructed personality profiles and attempted to match the DiSC model with player profiles from Bartle's classification. This is an initial approach that will need to be tested later. At this point, in order to allow the reader to appropriate the PPP Grid model, we propose an example of its use. The idea is that it can be used to prepare edutainment sessions by suggesting the types of games that could be used with the learners involved.

Keywords: Profiles, Players, Personality, Learners, Typology

1 Introduction

The DiSC® model [1] is used by some actors in the field of recruitment and management, although it has been criticized and considered scientifically unfounded¹. Based on the work of William Moulton Marston [2], this model proposes to identify the main strengths, weaknesses, motivations and challenges of employees in order to better understand and communicate with them [3]. Specifically, in its simplified version, the DiSC® model identifies 4 main profiles categorized by:

- "D" for "Dominance": Extroverted and task-oriented, such people would be considered "energetic" and "competitive";
- "i" for "Influence": extroverted and people-oriented, such people would be "communicative" and "passionate";
- "S" for "Steadiness": introverted and people-oriented, such people would be "empathetic" and "caring".
- "C" for "Conscientiousness": introverted and task-oriented, these people would be "conscientious" and "careful".

Each profile would have its own priorities. This could explain misunderstandings and tensions when different profiles communicate with each other. Based on this assumption, using the DiSC model would make it possible to identify the different profiles, understand their priorities, and thus be able to adopt adapted communication strategies. For collaborative games used in an edutainment setting, this could be useful to maximize the chances of keeping different groups of participants in the game activity until its resolution and thus hope to achieve the intended utilitarian goals. A graphical representation of the DiSC model according to ICAUDA and

¹ <https://www.vof.se/how-swedes-were-fooled-by-one-of-the-biggest-scientific-bluffs-of-our-time/> (accessed on May 6, 2022)

published by Wikipedia² suggests a division into two axes to identify the four profiles³. The vertical axis defines the "Extroverted" and "Introverted" poles, and the horizontal axis distinguishes the "Task" and "People" poles (see Fig. 1).

Of course, such a model has its limits in that we are plural [4] and can move from an extroverted to an introverted profile depending on the mood of the moment, the fact of being alone or in a group, the issues, contexts or frameworks. Thus, the same profile could theoretically be positioned on several colors. Moreover, other models are more popular today because they seem more robust, such as the "Big Five" model developed since the 1980s, which combines personality traits grouped under the acronym OCEAN: Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism [5]. Nevertheless, in order to overlap with Richard Bartle's [6] player model, we will continue to use the DiSC model. This is with the idea of understanding the responses obtained as a photograph of a trend taken at a moment T.

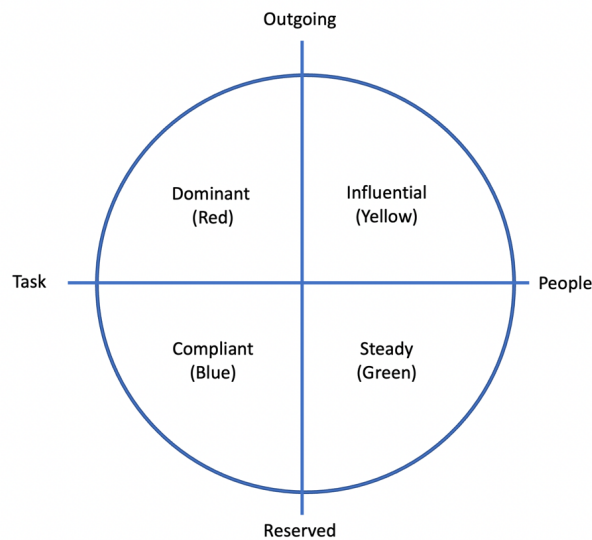


Fig. 1. Profiles based on the DiSC model as represented by Profile 4 (ICAUDA Company).

In the case of Bartle, the following player profiles are identified by the MUDs⁴: "achievers", "explorers", "socializers", and finally "killers". The first would play to achieve the best performance or to collect all the items in the game, the second would try to explore the universe offered by the game or even its functioning, the third would seek contact with other players, and the last would aim to defeat their opponents.

Even if research such as that of Jérôme Legrix-Pagès [7] still uses Bartle's model in statistical studies, we know from various authors [8,9] that Bartle's approach is limited. However, given the similarities found between Fig. 1 and Fig. 2, we would like to continue our exploration. By superimposing them, we obtain Fig. 3, whose axes and scales concatenate those of Fig. 1 and Fig. 2. Of course, this may be debatable, especially in the context of the sciences of psychology. It should also be noted that our mapping proposal, as illustrated in Fig. 3, is essentially based on lexical logic.

² https://en.wikipedia.org/wiki/DISC_assessment#/media/File:DISC_wheel.png (accessed on May 6, 2022)

³ <https://www.profil4.com> (accessed on May 6, 2022)

⁴ MUDs (Multi-User Dungeons), are role-playing games played online over the Internet that manage multiple players simultaneously. They are essentially played in text mode. MUDs can be considered the ancestors of MMORPGs (Massively Multiplayer Online Role-Playing Games).

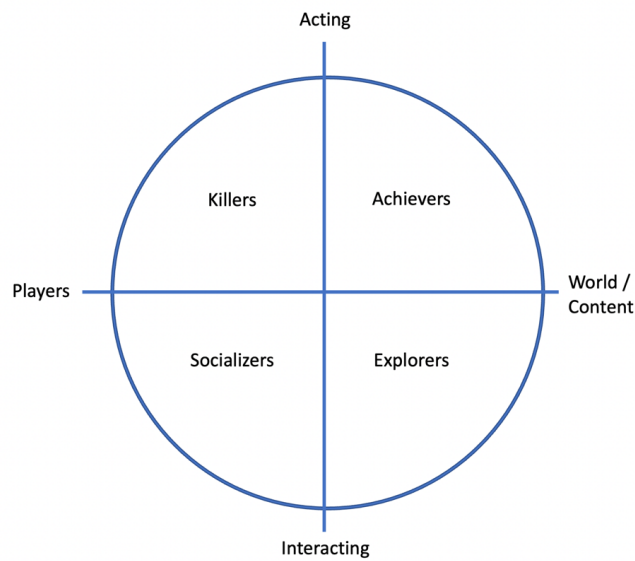


Fig. 2. Player profiles based on Richard Bartle's player profile model.

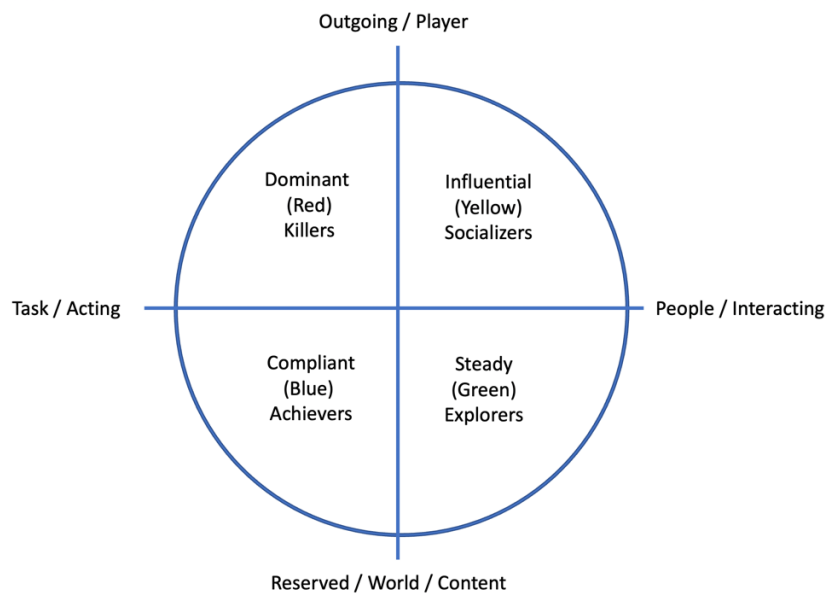


Fig. 3. Mapping DiSC models to Richard Bartle's player profiles.

These different concatenations suggest that it would be possible to deduce a person's DiSC profile from a player profile and vice versa. Furthermore, we could also take into consideration the poles of the different axes to deduce both the DiSC profile and the player profile of a person. These are hypotheses that we wish to explore as they would provide us with a simple and operational model for identifying learner-player profiles. The study is divided into three parts:

1. Methodology,
2. Statistical processing of a questionnaire based on 1126 responses,
3. Grid of results.

With these elements in hand, we will discuss our hypotheses.

2 Methodology

2.1 Questionnaire profiles, players & motivations

In order to test the hypothesis that DiSC and Bartle player profiles match, we submitted a Google Form questionnaire to Internet users to complete anonymously. It consists of 8 questions:

- Q1 - Do you feel more introverted or extroverted (on a scale of 1 to 4)?
- Q2 - Do you prioritize tasks and goals or people (on a scale of 1 to 4)?
- Q3 - Check the profile that fits you best (one choice):
 - a. Red: I like challenges, taking the lead. My motto: What's done is done!
 - b. Yellow: I enjoy communicating with others. I am often described as creative and bright!
 - c. Green: I like to listen to others and am empathetic. I need stability.
 - d. Blue: I like rigor and doing things by the book. I like to weigh my words.
- Q4 - As a player, I tend to be (one possible answer):
 - a. Achiever: I like to finish all the levels in a game, do all the available quests, have 3 stars everywhere!
 - b. Explorer: I like to see how a game works, to discover its universe, to find bugs that allow me to win differently...
 - c. Socializer: I like to interact with other players during a game. Winning is secondary.
 - d. Killer: I like to win, but usually against opponents. If I can eliminate them, that's even better!
- Q5 - (Not used)
- Q6 - I have...
 - a. Less than 10 years old
 - b. Between 11 and 17 years old
 - c. Between 18 and 24 years of age
 - d. Between 25 and 34 years of age
 - e. Between 35 and 44 years of age
 - f. Between 45 and 54 years of age
 - g. Aged 55 to 64
 - h. Over 64 years old
 - j. Don't want to say...
- Q7 - I am...
 - a. A woman
 - b. A man
 - c. Not specified or prefer not to say...
- Q8 - I play...
 - a. More than 10 hours per week
 - b. Between 5 and 10 hours per week
 - c. Between 2 and 4 hours per week
 - d. Between 0 and 1 hour per week
 - e. I do not want to say...

It is also possible for Internet users to leave a free comment at the end of the form. It should be noted that the subjects are asked to answer as quickly as possible in order to take a picture of the subject at a given moment. In fact, the more time spent on answering the questions, the more the subject could show fluctuations in his or her mood at the moment, or be disturbed or influenced by an element of context, and thus potentially switch from one state to another.

2.2 Q1 and Q2 Explanations

Questions Q1 and Q2 propose a scale of 4 possible answers, thus avoiding a median choice. The idea is to use the answers to questions Q1 and Q2 to create a "constructed profile" called "Qc". This concatenates the DiSC model and Bartle's player profiles as follows:

- If $A > 2 + B < 3$ then Qc = Dominant / Red / Killer;
- If $A > 2 + B > 2$ then Qc = Influencer / Yellow / Socializer;
- If $A < 3 + B > 2$ then Qc = Stable / Green / Explorer;
- If $A < 3 + B < 3$ then Qc = Conscientious / Blue / Gatherer.

Knowing that:

- If $A > 2$, the subject declares to be an Extrovert;
- If $A < 3$, the subject declares to be an Introvert;
- For $B > 2$, the subject declares to be oriented towards people;
- For $B < 3$, the subject declares to be task oriented.

2.3 Q3 and Q4 Explanations

Questions Q3 and Q4 correspond to self-positioning suggestions to directly select one's DiSC and player profile according to Bartle's model. To test our hypotheses, we want to see if the constructed profile Qc can match the answers to Q3 and Q4.

2.4 Q6 and Q8 Explanations

Questions Q6 through Q8 are designed to identify the age range of the subjects, their gender, and the estimated amount of time they play per week.

3 Statistical processing of the questionnaire

3.1 Panel and characteristics of respondents

The questionnaire⁵ was distributed on the Internet via the social network LinkedIn between June 2021 and March 2022. It was also sent by email to the members of the Immersive Factory company and to the students of the eSport association of the Université Catholique de Lille (France). Among the 1126 responses collected, we count mainly students, teachers, trainers, researchers, administrators, project managers and health actors. They are interested in serious games related to health, prevention, education or communication. The panel consists of:

- Women: 582 (51.5%)
- Men: 524 (46.5%)
- Uncertain or unwilling to answer: 20 (2%)

The age ranges are:

- Under 18 years old: 5 (0.5%)
- Between 18 and 24 years old: 178 (16%)
- Between 25 and 34 years old: 315 (28%)
- Between 35 and 44 years old: 324 (29%)
- Between 45 and 54 years old: 230 (20%)
- Over 55 years old: 68 (6%)
- Don't want to say / mistakes 6 (0.5%)

The duration of the subjects' playing is:

- Between 0 and 1 hour per week: 340 (30%)
- Between 2 and 4 hours a week: 317 (28%)
- Between 5 and 10 hours per week: 228 (20.5%)
- More than 10 hours per week 212 (19%)
- Don't want/mistake: 29 (2.5%)

⁵ Study data available at: <https://www.ludoscience.com/FR/diffusion/1673-Donnees-associees-au-Questionnaire-profil-joueurs-motivations-reponses.html>

3.2 Comparisons between constructed profile and self-positioning

The objective of this first statistical treatment is to verify a correlation between the constructed profile Qc and the self-positions Q3 and Q4. We verify this with classical statistical tools. All the following cross-tabulations are made on the data collected during our survey, based on 1126 individuals.

Constructed Profile and DiSC Self-Positioning

We compare the Qc profile with the self-positioning from question Q3 (see Table 1). The goal is to check if we get the following four correspondences:

- "Yellow" for a profile constructed as "Influential",
- "Red" for a profile constructed as "Dominant",
- "Green" for a profile constructed as "Steady";
- "Blue" for a profile constructed as "Compliant".

Identifying them would imply that the two approaches, constructed profiles and self-positioning, are interchangeable.

A simple calculation shows that 46% of individuals are well positioned and invites us to statistically process this intersection using descriptive statistics (row and column percentages) and probabilistic methods (Chi-square test). The size of the population of 1126 individuals allows us to consider a margin of error of 3% (with the classical risk of 5% of a survey in SHS).

Table 1. Cross-reference of DiSC self-positioning (Q3) and constructed profile (Qc)

	Influential	Dominant	Steady	Compliant	Total
Yellow	192	46	63	14	315
Red	63	58	21	52	194
Green	87	22	163	105	377
Blue	33	47	54	106	240
Total	375	173	301	277	1126

The Chi-square calculated after this crossing (see Table 2) allows us to state that questions Qc and Q3 are dependent⁶. To validate our hypothesis, we perform a chi-square analysis to identify the dependency [10] and validate our conjecture. To do so, we calculate the weights, expressed as percentages (see Table 2), of the pairs of modalities for which the sign of the deviation from independence is positive⁷.

We keep the four weights of the correspondences mentioned above:

- "Yellow" / "Influential": 23% [A1]
- "Red" / "Dominant": 8% [B1]
- "Green" / "Steady": 12% [C1]
- "Blue" / "Compliant": 12% [D1]

Table 2. Percentage contribution to Chi-square (in yellow/gray attraction) over Q3/Qc

	Influential	Dominant	Steady	Compliant	Total
Yellow	23	0	2	16	41
Red	0	8	6	0	14
Green	4	7	12	2	23
Blue	9	1	1	12	22
Total	35	16	20	29	100
Khi2=319					

⁶ At 5% risk, Chi-square read in the table is 16.919 with 9 degrees of freedom

⁷ That is, where the observed cross-sectional population is greater than the population expected if the variables were independent.

These four out of 16 possible matches represent 55% of the chi-square value. To better describe these matches statistically, we calculate the row percentages.

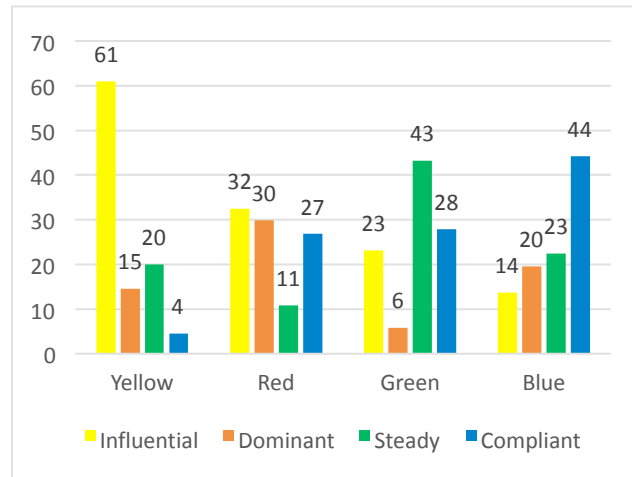


Fig. 4. Statistical Profiles of DiSC Self-Positioning (Q3) according to the constructed modalities (Qc).

From Fig. 4., we can see that the "Influential" profile significantly characterizes the "Yellow" self-positioning (61%). The same is true for the "Steady" profile and the "Green" self-positioning (43%), as well as for the "Compliant" profile and the "Blue" self-positioning (44%).

On the other hand, the "Influential," "Dominant," and "Compliant" profiles characterize the "Red" self-positioning almost equally (about 30%). However, a calculation of the column percentages allows us to complete the "Dominant" constructed profile. It breaks down as follows: 34% "Red", 27% "Yellow", 27% "Blue" and 13% "Green". In this case, the Red modality is clearly superior.

This first treatment shows that the self-positioning of individuals who define themselves as "Influential," "Compliant," "Steady," or "Dominant" at a given moment corresponds quite well with the profiles of the DiSC model.

Constructed profile and self-positioning of Bartle's players

We now cross-tabulate Qc with the responses from question Q4, for which subjects are asked to self-position using the "Socializer," "Killer," "Explorer," and "Achiever" items from Bartle's player model.

The purpose of such a cross-tabulation (see Table 2) is to check whether the responses obtained by self-positioning are consistent with those of the constructed profiles.

To validate this hypothesis, it is necessary to examine the following four correspondences:

- "Socializer" for an "Influential" profile,
- "Killer" for a "Dominant" profile,
- "Explorer" for a "Steady" profile,
- "Achiever" for a "Compliant" profile.

Identifying such correspondences would mean that Bartle's model of player profiles would be confirmed by our survey in that the positioning on the two axes "Extrovert / Introvert" and "Tasks / People" would correspond well to the fact of self-positioning with regard to the categories "Socializer," "Killer," "Explorer" and "Achiever".

A simple calculation shows that 34% of people are well positioned. Let's statistically process this intersection as before (see Table 3).

Table 3. Cross-reference of the self-positioning Bartle's player profile (Q4) and the constructed profile (Qc)

	Influential	Dominant	Steady	Compliant	Total
Socializer	126	20	79	21	246
Killer	36	27	25	27	115
Explorer	138	60	124	121	443
Achiever	75	66	73	108	322
Total	375	173	301	277	1126

The Chi-square calculated as a result of this crossover (see table 4) allows us to state that Qc and Q4 are therefore dependent (See note 6). In order to validate our hypothesis, we perform a Chi-square analysis to identify the dependency and to validate our conjecture.

We calculate the weights of the modality pairs and keep the four weights of the following correspondences:

- "Socializer" / "Influential": 24% [A2]
- "Killer" / "Dominant": 5% [B2]
- "Explorer" / "Steady": 0% [C2]
- "Achiever" / "Compliant": 10% [D2]

Table 4. Percentage contribution to Chi-square (in yellow/gray attraction) over Q4/Qc

	Influential	Dominant	Steady	Compliant	Total
Socializer	23	9	3	26	62
Killer	0	5	1	0	6
Explorer	1	1	0	1	3
Achiever	10	6	2	11	28
Total	35	20	6	39	100
Khi2=98					

These four out of 16 possible matches represent 39% of the chi-square value. To better describe these matches statistically, we calculate the row percentages. The histogram in Fig. 5 describes the statistical profiles.

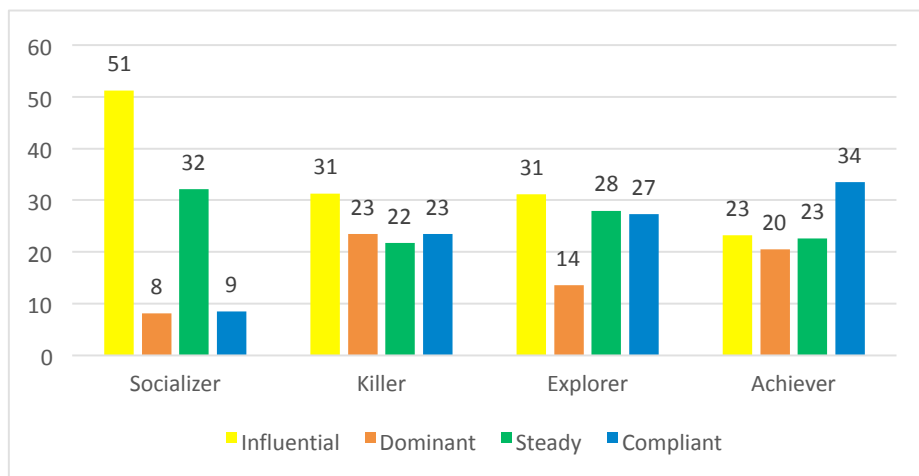


Fig. 5. Statistical profiles of Bartle's self-positioning profiles (Q4) according to the constructed modalities Qc.

We can see that the constructed profile "Influencer" significantly characterizes the "Socializer" self-positioning (51%). The same is true for the "Killer" (31%) and to a lesser extent for the "Explorer" (31%). On the other hand, the constructed profile "Conscientious" significantly characterizes the "Achiever" self-positioning (34%).

Our survey is less significant in validating Bartle's model of player profiles. Thus, when we cross the constructed profiles Qc with the selves-positioning Q3 and Q4, we have a higher probability of correctly identifying the different DiSC profiles than the different Bartle player profiles.

DiSC Self-Positioning and Bartle's Player Profiles

The purpose of crossing the Q3 selves-positioning with Q4 is to test the hypothesis that we could match the 4 categories of the DiSC model (cf. Fig. 1) with those of Bartle (cf. Fig. 2) as illustrated in Fig. 3. To validate this hypothesis, it is necessary to study the following four correspondences:

- "Socializer" for a "Yellow" profile,
- "Killer" for a "Red" profile,
- "Explorer" for a "Green" profile,
- "Achiever" for a "Blue" profile.

A simple calculation shows that 34% of the individuals are well positioned. The Chi-square calculated after this intersection (see Table 5) allows us to conclude, as before, that questions Q3 and Q4 are significantly dependent (See note 6).

Table 5. Cross-referencing DiSC Self-Positioning (Q3) and Bartle's Player Profiles (Q4)

	Yellow	Red	Green	Blue	Total
Socializer	95	22	96	33	246
Killer	25	45	26	19	115
Explorer	122	72	153	96	443
Achiever	73	55	102	92	322
Total	315	194	377	240	1126

To better identify these correspondences, we perform the chi-square analysis, expressed in percentages, to fine-tune the dependence and validate our conjecture (see Table 6).

Table 6. Percentage contribution to the Chi-square (in yellow/gray attraction) of the Q3/Q4 cross

	Yellow	Red	Green	Blue	Total
Socializer	12	12	3	9	36
Killer	2	40	5	2	49
Explorer	0	0	0	0	1
Achiever	4	0	0	10	14
Total	18	52	8	21	100
Khi2=80					

We keep the four weights of the games:

- "Socializer" / "Yellow": 12% [A3]
- "Killer" / "Red": 40% [B3]
- "Explorer" / "Green": 0% [C3]
- "Gatherer" / "Blue": 10% [D3]

These four correspondences account for 62% of the Chi2 value. This correlation is very significant if we compare it with the two previous crossings, which each reached 55% (Qc with Q3) and 39% (Qc with Q4).

The results obtained consolidate the relationships between the modalities of the two self-positioning: ("Yellow", "Red", "Green", "Blue") and ("Socializer", "Killer", "Explorer", "Achiever"). However, we did not find a significant relationship between "Explorer" and "Green". Thus, our hypothesis seems to be confirmed for ¾ of the expected matches. Although transitivity did not hold for the correlation, this result was still expected between the modality pairs:

- "Yellow" / "socializer" (see relations [A1] and [A2] => [A3]),
- "Red" / "Killer" (see relations [B1] and [B2] => [B3]),
- "Green" / "Explorer" (see relations [C1] and [C2] => [C3]),
- "Blue" / "Gatherer" (see relations [D1] and [D2] => [D3]).

3.3 Influence of playtime duration on profiles

At this point, the "Green" and "Explorer" profiles do not match. In parallel, Qc and Q4 show the lowest agreement with 39%. An explanatory hypothesis would be to consider the amount of time the subjects play per week (Q8). Perhaps playing a lot would allow for better self-positioning?

To test this, we recode question Q8. We divide our subjects into two classes:

- The first class, called "pJ" for "small players", groups together the subjects who report playing between 0 and 4 hours per week. It represents 657 individuals or 58% of the panel.
- The 2nd class, called "gJ" for "big players", includes the subjects who declare to play more than 4 hours per week. It represents 440 individuals or 39.5% of our panel.

We note that there are 1097 individuals instead of 1126. The loss is due to the deletion of subjects with an anomaly in the answer given for the duration of weekly play.

Study the correlation between game duration and self-positioning Q3

We compare the Q3 self-positions with the duration of the game in terms of the "pJ" and "gJ" classes (see Table 7).

Table 7. Cross-tabulation of Q3 self-positioning and weekly playing time ("pJ" and "gJ" classes)

Weekly playtime	Yellow	Red	Green	Blue	Total
pJ Class	196	111	217	133	657
gJ Class	110	77	152	101	440
Total	306	188	369	234	1097

Fig. 6. (row percentages) show similar rates for the two classes. We can therefore deduce that there are no significant differences.

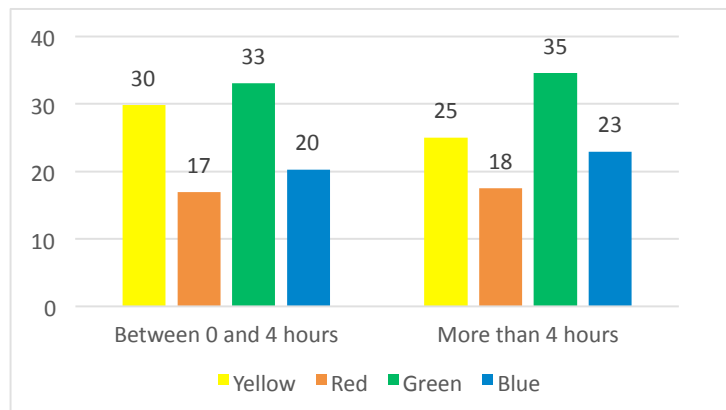


Fig. 6. Statistical profiles of the "pJ" and "gJ" classes according to the of self-positioning (Q3).

Study of the correlation between playing time and self-positioning Q4

Now let us see what happens to the cross between Qc and Q4 as a function of "pJ" and "gJ" (see Table 8).

Table 8. Cross-tabulation of Q4 self-positioning and weekly playing time ("pJ" and "gJ" classes)

Weekly playtime	Socializer	Killer	Explorer	Achiever	Total
pJ Class	161	66	263	167	657
gJ Class	77	46	170	147	440
Total	238	112	433	314	1097

The histograms in Fig. 7 (row percentages) show differences, but only for two categories of player profiles: "Socializer" and "Achiever", which seem to be related.

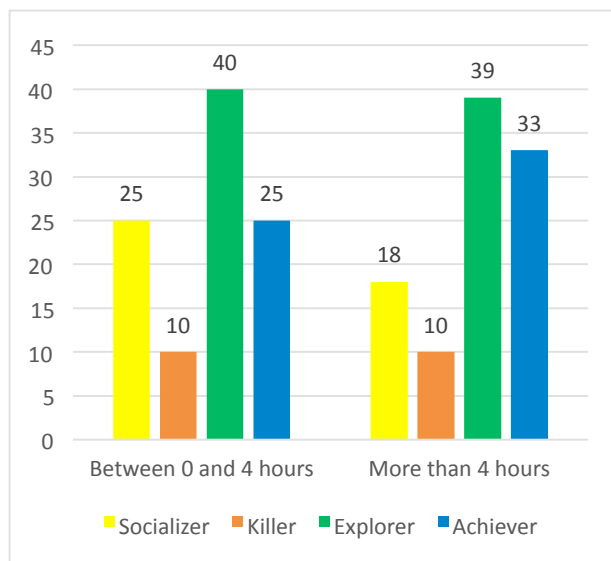


Fig. 7. Statistical profiles of self-positioning (Q4) according to the "pJ" and "gJ" classes

The Chi-square calculated (see Table 9) allows us to state that the questions Q4 and the length of weekly play are significantly related⁸.

We conclude that for subjects who play less than 4 hours per week, we are more likely to identify the "socializer" profile. Conversely, for those who play more than 4 hours per week, we are more likely to identify the "Achiever" profile (see Table 9). Note that these two profiles are diametrically opposed in Bartle's model, if we refer to Fig. 2. We can therefore speak of "antagonistic profiles".

On the other hand, for the "Killer" and "Explorer" profiles, which are also antagonistic, we find no variation between the "pJ" and "gJ" classes (see Table 9). However, we do not have a fine representation of the distribution of the profiles here. It seems interesting for us to study it in order to identify possible variations. Charts from Fig. 7 and Fig. 8 illustrate this distribution on the "pJ" (657) and "gJ" (450) strata for each of the "Socializer", "Killer", "Explorer" and "Achiever" profiles.

⁸ At 5% risk, Chi-square read in the table is 7.815 with 3 degrees of freedom

Table 9. Percentage contribution to the Chi-square (in yellow/gray attraction) of the Q4/game duration intersection)

	Socializer	Killer	Explorer	Achiever	Total
pJ Class	20	0	0	20	40
gJ Class	30	0	1	29	60
Total	50	0	1	49	100

Khi2=12

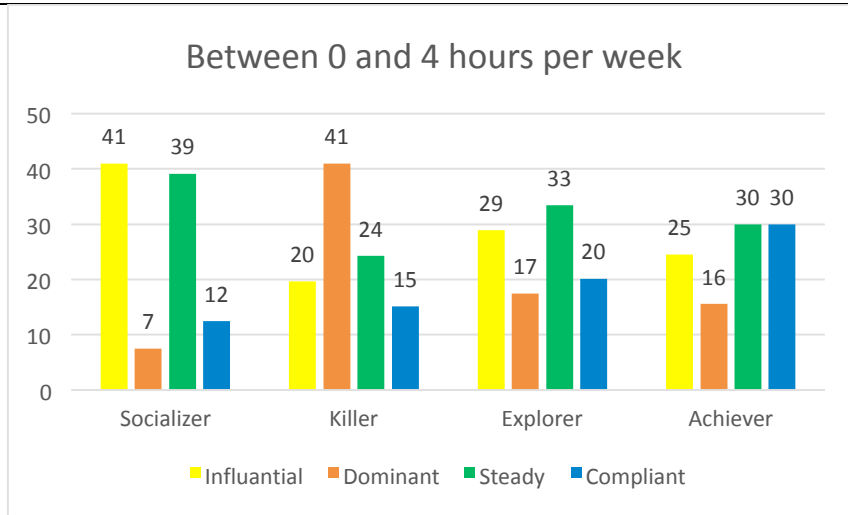


Fig. 8. Statistical profiles of self-positioning (Q4) as a function of the constructed modalities (Qc) ("gJ" class)

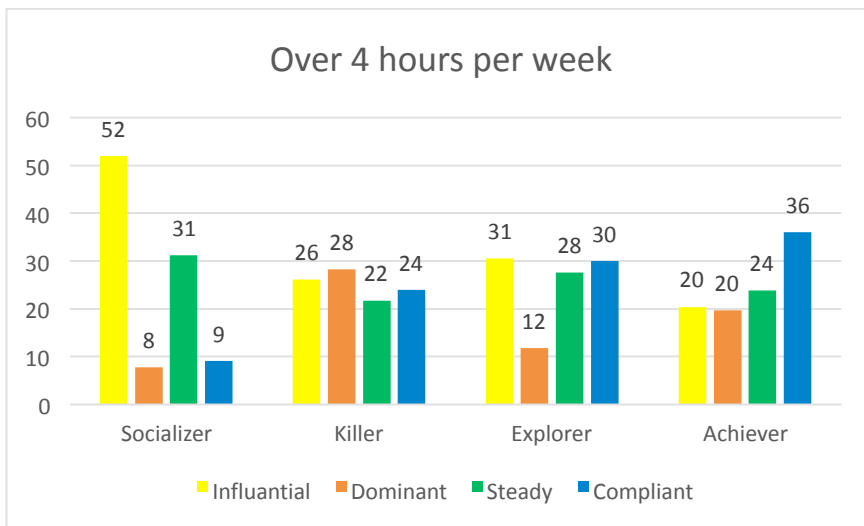


Fig. 9. Statistical profiles of self-positioning (Q4) according to the constructed modalities (Qc) ("gJ" class)

Fig. 8 and Fig. 9 show us that regular or irregular playing influences the self-positioning of subjects. Indeed, in Fig. 8, if we take into account the highest rate for each profile constructed (Qc) only, we identify the following set of modality pairs:

- "Influential" and "Socializer" (41%)
- "Dominant" and "Killer" (41%)
- "Compliant" and "Achiever" (30%)

However, the "Steady" and "Explorer" pairing is not verified. More surprisingly, the "Dominant" and "Killer" pairing is diluted with the "Dominant" profile dropping from 41% to 28%. Only the two couples "Influential" and "Socializer" (52%) and "Compliant" and "Achiever" (36%) are preserved and also reinforced.

3.4. Consider the age and gender of subjects

Since our hypothesis based on playing time does not allow the desired pairing of "Stable" and "Explorers" to emerge, let us see if the age or gender of the subjects can have a possible impact on the profile of the players.

Consider the age

The Chi-square calculated (see Table 10) is significant⁹, so we do a Chi-square analysis.

Table 10. Percentage Contribution to Chi-square (yellow/gray attraction) of Q4/Age Crossover

	Socializer	Killer	Explorer	Achiever	Total
Between 18 and 24 years old	8	44	0	2	54
Between 25 and 34 years old	2	0	1	8	11
Between 35 and 44 years old	0	2	4	2	7
Between 45 and 54 years old	8	4	2	0	14
Over 54 years old	7	5	0	2	13
Total	25	56	6	13	100
Khi2=64					

From this, we can derive the following matches, which account for 71% of the total in our panel:

- Between 18 and 24 years old 44% for the "Killer" profile
- Between 25 and 34 years old 8% for the "Achiever" profile
- Between 35 and 44 years old 4% for the "Explorer" profile
- Over 44 years old 15% for the "Socializer" profile

Consider the gender

The Chi-square calculated (see Table 11) is significant (see note 8), so we do a chi-square analysis: Gender differences are significant in all 4 player profiles. The gray/yellow boxes are those for which the contribution to the Chi2 is significant. These data confirm that in our panel:

- Women are more "Socializers" and "Achievers": weight 47%
- Men are more "Killers" and "Explorers": weight 53%

From Tables 10 and 11 we can conclude that the age and gender of the subjects play a significant role in the self-positioning of the subjects with respect to Bartle's player profile (Q4). We will now try to interpret what all this might mean.

⁹ At 5% risk, Chi-square read in the table is 20.026 with 12 degrees of freedom.

Table 11. Percentage Contribution to Chi-square (yellow/gray attraction) of cross Q4 with gender

	Socializer	Killer	Explorer	Achiever	Total
Woman	24	13	9	2	47
Man	26	15	10	2	53
Total	50	28	18	4	100
Khi2=12					

4 Results Grids

Table 12 summarizes the self-positioning of player profiles from Bartle's typology that we are most likely to encounter when we compare the constructed DiSC profiles (Qc/Q3) with weekly playing time ("pJ" and "gJ" classes).

Table 12. Player Profiles by DiSC and Weekly Playing Time ("?? " means "unspecified")

DiSC / Weekly playtime	Less than 4 hours (pJ)	Over 4 hours (gJ)
Influential (Yellow)	Socializer	Socializer
Dominant (Red)	Killer	??
Compliant (Blue)	Achiever	Achiever
Steady (Vert)	??	??

We found that age (Q6) and gender (Q7) can have an impact on the self-positioning of player profiles (Q4). While gender is in principle an invariant, this is not the case for age. So, one might think that player profiles should change with age. More specifically, given what we found for age and gender, we can extrapolate within our panel that with age:

- A majority of women will tend to move from an "Achiever" profile to a "socializer" profile.
- A majority of men will tend to move from a "Killer" profile to an "Explorer" profile.

It is interesting to note that these are both antagonistic player profiles, as shown in Fig. 2. Based on our analysis and extrapolation, we hypothesize that as players age, they will move from one profile to its exact opposite, as shown in Fig. 11. Female and male players would move from the "Act" axis to the "Interact" axis. However, a majority of the female gender will move from the World/Content axis to the Player axis, while a majority of the male gender will move in the opposite direction. We can also note that this evolution would start earlier for men (35 years and older) and a little later for women (45 years and older). This hypothesis also leads us to believe that women and men are mirror images in terms of their player profile (see orange and blue arrows in Fig. 11).

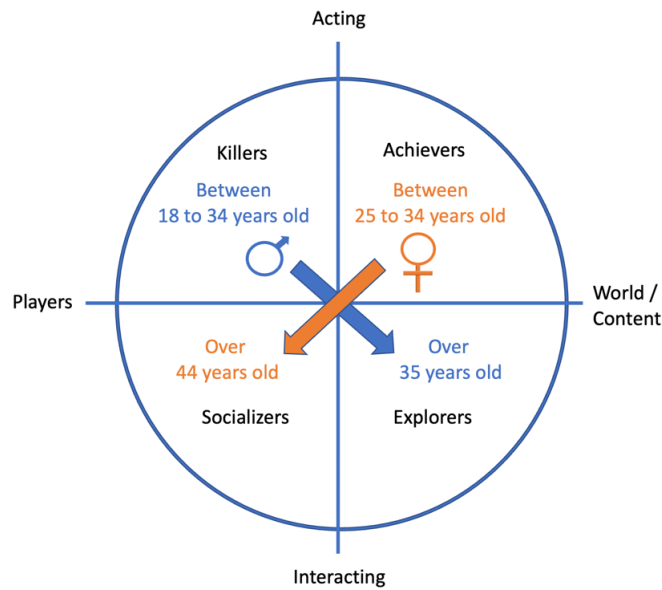


Fig. 11. Evolution of player profiles by gender and age

Table 13. Self-positioning of the player profiles we are most likely to identify in terms of age (Q6) and gender (Q7)

Age / Gender	Woman	Man
18 to 24 years	Achiever	Killer
25 to 34 years	Achiever	Killer / Explorer
35 to 44 years	Achiever / Socializer	Explorer
Over 44 years old	Socializer	Explorer

Future work should test this hypothesis and look for factors that might explain this phenomenon. In this regard, we believe that the writings of Srivastava and al. [11] are particularly illuminating. Indeed, their work shows that women and men can change their personality over time, including during adulthood. In the meantime, we hypothesize that Table 13 captures the self-positioning of player profiles from Bartle's classification that we are most likely to encounter when cross-referencing individuals' age and gender.

By juxtaposing Table 12 and Table 13, and using the information from Fig. 4 to 10, we construct the Table 14 named "Player Personality Profile Grid" (PPP Grid). This grid represents a first draft of a model designed to identify, among an audience of learners, the profiles of gamers we might encounter. This is done by taking into account the age, the duration of the weekly games and the declared DiSC profiles.

Table 14. Player Personality Profile Grid (PPP Grid)

Player Personality Profile Grid (PPP Grid)				
WOMAN	Less than 4 hours weekly playtime (pJ)			
DiSC / AGE	18 to 24 years old	25 to 34 years old	35 to 44 years old	Over 44 years old
Influential / Yellow	Socializer	Socializer	Socializer	Socializer
Dominant / Red	Socializer or Achiever	Socializer or Achiever	Socializer	Socializer
Compliant / Blue	Achiever	Achiever	Socializer or Achiever	Socializer
Steady / Green	Socializer or Achiever	Socializer or Achiever	Socializer	Socializer
WOMAN	More than hours weekly playtime (pJ)			
DiSC / AGE	18 to 24 years old	25 to 34 years old	35 to 44 years old	Over 44 years old
Influential / Yellow	Socializer	Socializer	Socializer	Socializer
Dominant / Red	Socializer or Achiever	Socializer or Achiever	Socializer or Achiever	Socializer
Compliant / Blue	Achiever	Achiever	Achiever	Achiever
Steady / Green	Socializer or Achiever	Socializer ou Achiever	Achiever	Achiever
MAN	Less than 4 hours weekly playtime (pJ)			
DiSC / AGE	18 to 24 years old	25 to 34 years old	35 to 44 years old	Over 44 years old
Influential / Yellow	Explorer or Achiever	Explorer or Socializer	Socializer	Socializer
Dominant / Red	Killer	Killer or Explorer	Explorer	Explorer
Compliant / Blue	Achiever	Achiever	Explorer or Achiever	Explorer or Achiever
Steady / Green	Explorer or Achiever	Explorer or Achiever	Explorer	Explorer
MAN	MAN More than 4 hours weekly playtime (pJ)			
DiSC / AGE	18 to 24 years old	25 to 34 years old	35 to 44 years old	Over 44 years old
Influential / Yellow	Explorer or Socializer	Explorer or Socializer	Explorer or Socializer	Explorer or Socializer
Dominant / Red	Killer or Explorer	Killer or Explorer	Explorer	Explorer
Compliant / Blue	Achiever	Achiever	Explorer or Achiever	Explorer or Achiever
Steady / Green	Explorer or Achiever	Explorer or Achiever	Explorer	Explorer

To put PPP Grid to work, let us take a concrete example. A teacher has to prepare two training sessions:

In case A, the teacher identifies a majority of young boys under the age of 20 who play an average of 2 hours per week and whose personality profiles are red.

In case B, the audience is more likely to be female learners over 40 who play more than 10 hours a week and have yellow profiles.

The teacher refers to the PPP grid table to find the matches:

Case A - With 20-year-old male gamers who play 2 hours a week with a "red" self-positioning, the PPP Grid shows that the learners are likely to be "killers" (light blue zone).

Case B - For 40-year-old female gamers who play 10 hours a week with a "yellow" self-positioning, PPP Grid shows us that the learners are likely to be "socializer" (dark orange zone).

Armed with these pieces of information, the teacher can better prepare these educational sessions by offering:

- For case A, competitive games based on adversity. They will undoubtedly have a more engaging aspect for the learners.
- In case B, collaborative games involving negotiation will be more appropriate.

5 Conclusion

Our PPP Grid model now needs to be tested by new experiments with new panels and associated with statistical calculations. In fact, some of the boxes are extrapolations that we have made based on our current results.

If this is verified, it would be good to develop the PPP Grid with respect to more current models such as the Big Five and HEXAD to study if the transposability is effective. Finally, in future work we would like to try to understand what factors may influence the self-positioning we have identified.

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Using Augmented Reality Games to Communicate Topics in Artificial Intelligence

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Abstract. As the use of Artificial Intelligence (AI) continues to grow, there is the need for highly trained professionals in this field. Traditional education and marketing tools may not effectively engage students in AI studies. In response, this paper proposes an augmented reality (AR) game that gives a playful introduction into the field of AI and aims to invoke interest in young students for various AI applications. We propose a holistic game experience that incorporates four AI topics as a series of minigames and offers a coherent storyline that engages the player. The minigames are played on AR markers and the experience is accompanied by physical booth installations. We use a personified AI character that players have to “train” to pass the minigames and finally graduate in a virtual AI campus. Implementation of the game was done using iterative prototypes and frequent playtesting sessions with high school and university students. In addition, feedback was gathered during trade and science exhibitions of the game. We found that the game was beneficial for people regarding learning about AI and invoking interest in the topic. In addition, we observed that game mechanics like a connecting story between AI topics, character development, customization and item reward collection can increase players’ emotional engagement with the experience. In addition, we discuss our learnings regarding game design and game architecture.

Keywords: Augmented Reality, Artificial Intelligence, Video Games

1 Introduction

Artificial Intelligence (AI) is a large research field that has a tremendous transformative impact on almost every aspect of our world. As academic and professional use of AI continues to grow, the need for highly trained professionals will continue to increase as well. While traditional marketing of university courses or classroom education can be limited in their ability to engage students in AI studies, AR games provide an excellent opportunity to promote the topic of AI. AR games can provide deeply immersive and interactive experiences that can be implicitly educational but also function as a catalyst to invoke interest in a field. In this paper, we present the AR game “Morph Tales” which was developed to promote university AI projects to young students. The game consists of four minigames that are related to four AI topics. Rather than directly modeling AI algorithms or concepts, the minigames are metaphors whose purpose is to spark interest in the respective AI topics and actual projects. The game is centered around a personified character called “Morph”, an AI student who must pass “tests” to be accepted to a prestigious AI campus called “Morphtopia”. The game is played in AR on tablet devices using image markers mounted on physical booths. The game was specifically designed to be used in physical venues to enhance the experience of visiting the event. While many educational AR games are focused on single subjects (Weerasinghe et al., 2019; Laine, 2018) or more abstract designs, we implemented an experience that connects multiple distinct AI subjects using a

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single character and a coherent story line that could be extended with further experiences. We show how the minigames and AI topics can be connected to a complete story and how the character is integrated into the experience. In addition, we provide the game design as well as technical implementation of the overall system and present the user feedback regarding the reception and effectiveness regarding learning about AI.

2 Related Work

2.1 Review Studies of AR games for Education

AR games and applications have been developed to support academic education and can be used as a tool to improve motivation, interest, and enjoyment (da Silva, 2019; Sahin et al., 2020; Li et al., 2017). Li et al. evaluate 111 studies in a review paper that explore the potential of AR, Virtual Reality (VR) and Mixed Reality (MR) in education and how these applications can be incorporated into the learning environment. They conclude that major benefits of using such applications are enhancements in learning outcomes related to understanding, long-term memory retention, physical task performance as well as motivation, interaction and collaboration. In addition, they also mention various challenges like usability issues, longer training time, cognitive overload as well as complexity of tasks and technical issues on AR devices (Li et al., 2021). Huang et al. also reviewed AR and VR applications for language learning and reported benefits, which include increase in motivation, improvement of learning outcomes, enhancement of interactions, and creation of opportunities for authentic language tasks (Huang et al., 2021). Majeed et al. provide an overview of AR applications in the education environment. They review articles from three journals between 2017 and 2019 and extract benefits based on the AR type of the application. 25% of the AR applications are categorized as “game-based learning” (GBL) applications. The reported benefits are faster and easier learning, more learning gains, improvement of collaborative learning, and improved preservation of memory (Majeed et al., 2020). Ullah et al. discuss the role of VR and AI for teaching science subjects like physics. They argue that the advancement of computer technology allows for new ways where students take more interest and allow for new tools to motivate them for learning. (Ullah et al., 2022).

2.2 AR Games for Education

Tsai et al. investigate an AR teaching system for primary logic programming education. They study a AR-based learning group with 22 students and a tradition based learning group with 20 students. The performance of both groups in terms of learning effectiveness does not differ significantly, however, the AR based learning group manifested significant higher levels of motivation, particularly in levels of attention (Tsai et al., 2022). Fidan et al. study the integration of augmented reality into problem-based learning and its effects on learning achievement and attitude in physics education. They note that student report that AR applications were more useful, realistic, and interesting for learning and helped them understand and analyze the presented problem scenarios (Fidan et al., 2019). Weerasinghe et al. present Amon Planet, a marker-based game with the intend to teach computational thinking through storytelling. The game also implements intelligent tutoring comports which are essential for real knowledge acquisition (Weerasinghe et al., 2019). Costa et al. propose an AR astronomy mobile game and show that this can be an effective way to capture children’s attention as well as to promote interdisciplinary subjects such as astronomy. The first part of the game is marker-based, and participants have to search for QR marker that when scanned provide information about planets as well as short quizzes (Costa et al., 2018). Kim et al. developed a marker-based AR app to teach AI to non-engineering majors and analyze the education effect. In their experiment, 88 undergraduates with no prior AI knowledge are given AI lessons in AI learning principles after which they have to solve 10 problems in the AR app.

They conclude that students are highly likely to accept and learn AR technology in AI education and that their software was effective in boosting confidence in learning.

2.3 Making Games for Learning

A different approach was investigated by Kafai et al. who study the benefits of making games for learning. They note that children's learning through making their own games has traditionally not been addressed by research and that constructionist approaches should receive greater research attention. Kafai et al. state that making games introduces children to numerous technical skills and allows them to connect these skills to each other (Kafai et al., 2015). Chatain et al. present a game creation app that allows the user to include photographed game content like hand-drawn characters or tiles. In addition, it offers an event-based, visual programming language that allows the user to create game logic (Chatain et al., 2019).

3 Our Game

We developed a game to promote AI to young adults by offering a fun introduction to different AI-related topics explored in a research institution. AI will likely play a tremendous role in shaping our society in the future and educating young people on this topic is essential. AR was chosen as a mode to have an engaging experience that encourages players to be at a physical location where they can acquire additional information if the game invokes their interest. In our design process, we focused on guidelines for AR experiences provided by Li et al. and Wetzel et al. (Li et al., 2022, Wetzel et al. 2008). Our game, called Morph Tales, is implemented as an AR game that is played mainly on a tablet device. During our playtesting and preliminary exhibition tests, the game was compiled and played on the iPad Pro. The game consists of four minigames that are played on physical image markers in a predefined order. We will refer to the minigames as MG1 to MG4 throughout this paper. The application introduces the game and guides the player through the various challenges. Each minigame is related to a real AI research project and has some connection to aspects of the actual project in terms of story and gameplay. Having a specific connection to an existing AI project makes them more relatable and anchored in the real world. The fields that are covered by the minigames are smart farming, drug design using generative AIs, autonomous sailing, and finding the origins of life on exoplanets. Figure 1 shows a schematic representation of our game depicting its core loop between the so-called base layer and the retention layer. The terms were introduced by Lovell and can be defined as follows: the base layer is the moment-to-moment gameplay defined by a core game mechanic (e.g., steering a vehicle in a racing game or solving a puzzle in a puzzle game). The retention layer on the other hand is what keeps players playing the game for a long time (unlocks, leaderboards and achievements are good examples for retention layers). The connection between the base layer and the retention layer is referred to as the "core loop" (Lovell, 2018).

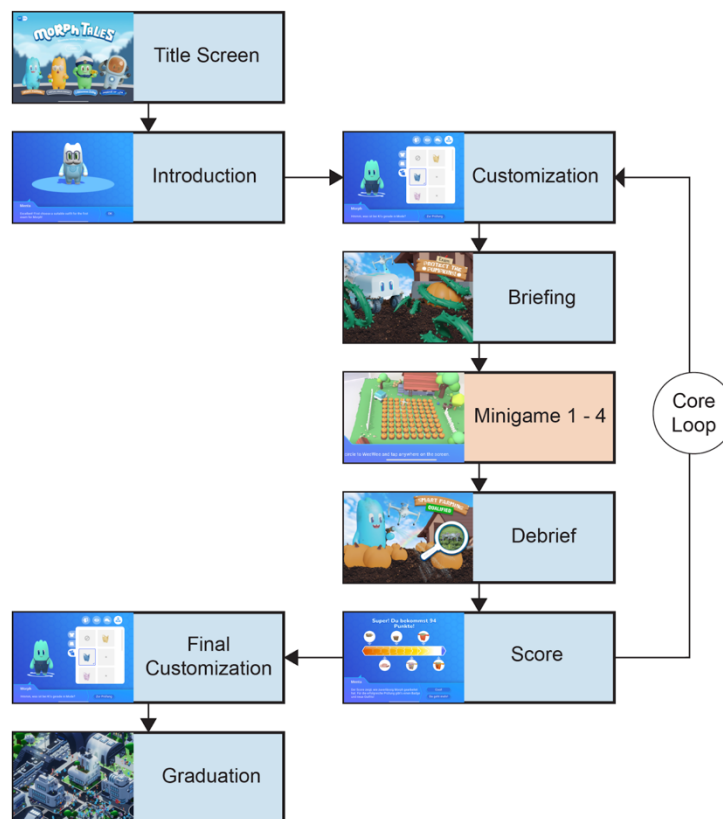


Fig. 1. Schematic overview of our game. The core loop always consists of character customization, briefing, minigame, debrief and score. The minigames represent the base layer. The customization and score sections can be regarded as the game’s retention layer while the briefing and debriefing screens are the transition between base layer and retention layer. (Lovell, 2018).

3.1 Story

To keep the player engaged and to create smooth transitions between the AI topics, a story was constructed that introduces an interesting, emotional framework. The story revolves around a young, personified AI called “Morph” who must pass a series of “exams” (the minigames) to be accepted at the prestigious AI university “Morphtopia”. The name Morph was chosen as a metaphor for an AI performing all types of distinct tasks, hence, “morphing” into various machines and objects. The player acts as a “trainer”, which again is a metaphor for the training process of an AI. The players’ task is to help Morph pass all tests by controlling aspects of the minigames. An additional character called “Menta” is included in the story, who serves as an experienced guide and story narrator who explains the world to Morph and the player. The character of Menta was necessary since the player has no knowledge of the world and Morph, as an inexperienced AI, cannot know details about what is going to happen. After Morph and Menta are introduced to the player, Menta guides the player and Morph through the minigames. After the fourth minigame Morph has passed all her exams and the player can “upload” the customized Morph to the Morphtopia campus. Uploading means that the customized Morph is persistently stored in a database and is displayed at the Morphtopia booth which can be revisited by the player. The narrative follows the classical hero’s journey where a hero goes on an adventure, learns a lesson and with that newfound knowledge is transformed and returns home. The entire

story is told in monologs and dialogs between Morph and Menta. In addition, Morph and Menta break the third wall and talk to the player who is referred to as “trainer”.

3.2 Minigames and Associated Research Projects

Each of the four AR minigames is connected to a research project. While initially there were considerations for the games to model processes of the actual research, during iteration and development of Morph Tales it was deemed much more effective to implement fun and engaging game mechanics first and connect the AI topics in a metaphorical way.

MG1 “Smart Farming” is related to a project that investigates the use of drone-controlled robots to remove weeds from fields to avoid the necessity of pesticides. The player steers a drone that discovers triangulation points indicating a weed. There exist three triangles each of which has three triangulation points and a weed at its center. After all the weeds have been found, a victory animation is played during which pumpkins grow on the field and the minigame is complete.

MG2 is called “Virtual Drug Design” and is related to research work that uses generative AI to discover models for drug design that have certain desired properties and activities (Schneider et al., 2019). The metaphor chosen for the game is the sorting of marbles on a machine with various tubes and conveyor belts. A molecule generator synthesizes new molecules with various attributes. Morph possesses the machine and learns to distinguish between “useful” molecules to keep and “useless” molecules that are sent to the trash bin.

MG3 is inspired by a research project that focuses on modeling, controlling, and simulating autonomous sailing boats. It is implemented as a multiplayer game but can also be played as single player with the addition of bots. The game consists of a 2-minute session in which the player must steer a sailing boat and collect as many randomly distributed buoys as possible. The maximum number of players is four. Players compete to collect as many buoys as possible while a randomly moving dolphin tries to steal them.

MG4 is called “Origins of Life” and represents various existing and hypothetical research projects concerning the discovery of life on exoplanets. The game mechanic is modeled by the classical “runner” game mechanic where the player steers an endlessly forward moving space rover and must move between three lanes to collect molecules and avoid obstacles. Specifically, the player must collect water and nucleotide molecules as well as a rare planet molecule to score high in the game. The game is semi-metaphorical in the way that the discovery of complex molecules on exoplanets can give the indication of life. Finding a “plant”, however, is currently science fiction.

Figure 2 shows the AR view of the “Smart Farming” minigame played at the respective physical booth. Figure 3 shows a screenshot of each of the four minigames.



Fig. 2. Each minigame is played in AR on an iPad using a fixed, visual marker. The size of the game world is determined by the marker size. Each minigame represents a real life AI research project and

contains elements that are inspired by the actual project.

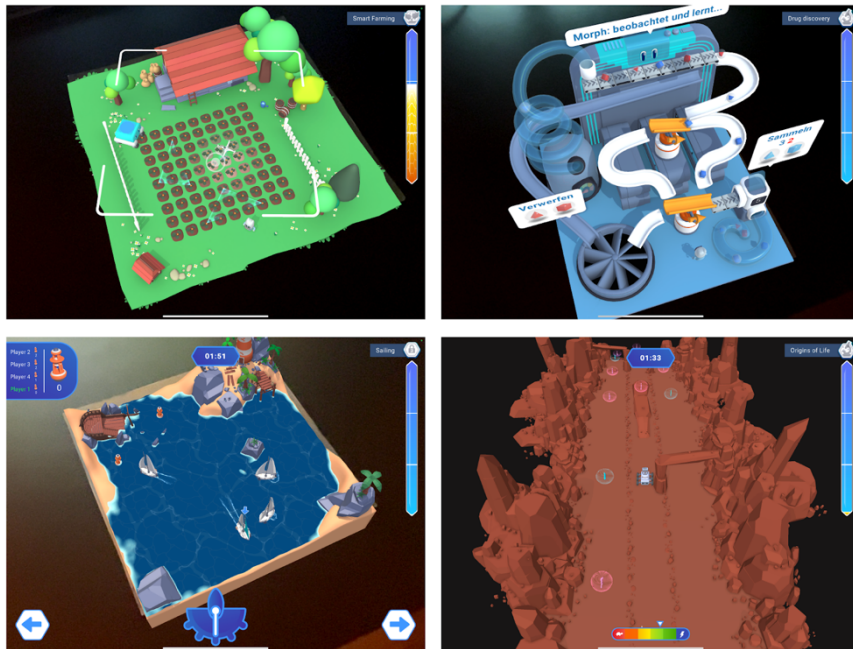


Fig. 3. Screenshot of each of the four minigames: Smart Farming (MG1, top left), Virtual Drug Design (MG2, top right), Autonomous Sailing (MG3, bottom left) and Origins of Life (MG4, bottom right).

3.3 Base Layer And Retention Layer

Regarding the game design model proposed by Novell (Novell, 2018), aspects of the game can be divided into the base layer and the retention layer. The base layer of Morph Tales consists of the minigames each of which incorporates its own basic game mechanic, which can be regarded as “fun” on its own. In our game design we tried to address a diverse group of players and used the player types proposed by Bartle (Bartle, 2008) to support our game mechanic decisions. In abstract terms the minigames can be regarded as follows: MG1 is a puzzle and exploration game (Bartle type: explorer). MG2 can be regarded as a reaction and collection game (Bartle type: achiever). MG3 is a game of skill and competition (Bartle type: killer) and MG4 is a reaction and collection game (Bartle type: explorer). MG3 is also a multiplayer game and could hence also be regarded as a game appealing to the Bartle type “socializer”. In the game itself the players only interact through the game mechanics but in reality, they are standing around the AR marker and can interact directly. The score system and subsequent item collection after each minigame can be regarded as part of the retention layer. Each minigame yields various new items depending on the score of the player. The higher the score the higher the chance of the player to acquire especially rare items. The items can then be used to customize the character Morph. The final customization after MG4 is also persistently stored in a cloud-based database and the customized character can then be viewed at the Morphtopia campus. In addition, each completed minigame rewards the player a badge that shows the game was completed. Before each minigame an illustrated briefing screen is shown and after each minigame a respective debrief screen is shown with information about the game and the research project. These screens notify the player about the transition between base game and retention layer.

3.4 Physical Booth

The physical booth consists of six booths: the “Train-A-Morph” introduction booth, the four minigame booths as well as the “Morphtopia” booth (see Figure 4). At the “Train-A-Morph” booth the player is introduced to the main character, Morph. It is usually placed at the entrance of the entire Morph Tales booth. Currently, a monologue of Morph, who introduces herself, is shown to the player. The screen is a touch screen and the player can advance the dialog by pressing a virtual button. At the end of the monologue, the player is asked to collect a tablet and Morph “beams” herself onto the tablet of the player. Each minigame has its own separate booth. The minigame booths consist of a themed backdrop that is related to the game as well as a horizontally placed lid AR marker (see Figure 4). The player walks from booth to booth in a defined order to complete the game.



Fig. 4. Physical booth with the TrainAMorph welcome screen, three out of our four minigame platforms as well the Morphtopia standee.

Morphtopia is the final booth of the game. It consists of a large screen that is always on during an exhibition and shows the virtual Morphtopia campus and the “uploaded” and customized Morphs (see Figure 5). After the fourth minigame, the player is instructed to stand in front of the Morphtopia screen before pressing the upload button. When the customized Morph is uploaded to Morphtopia, the player can see her appear cheering and waving at the player. The Morphtopia booth is also useful to create on-site interest. The virtual campus is populated with uploaded, customized Morphs and the campus itself is filled with animations and artistic detail. In addition, the large, lid Morph Tales banner attracts audiences attention.



Fig. 5. The Morphtopia campus is displayed on the large Morphtopia booth screen. Customized Morphs that have been previously created and uploaded populate the streets and create a great visual interest point.

4 Evaluation and Results

Our game was developed over a period of two years and involved regular playtesting and gathering of player feedback. The main concerns were balancing the game, whether the game itself is fun and engaging, and whether players discovered new information about AI or became curious about the topic. We asked for feedback immediately after testing sessions using electronic feedback forms. After finishing the game, we asked players if they would be willing to answer some questions and we included a button in the app that leads the player to the form. We assessed player satisfaction with the games, which steadily increased with each revision and subsequent playtesting. In addition to having a good understanding of the reception and difficulty of our games, we focused on the communication of the AI topic.

4.1 Trade Fair Player Response

Morph Tales was exhibited at a large trade fair. The exhibit lasted one week and we received a total of 99 player assessments. The number of total players is likely to be much higher but because it was voluntary, not every player submitted feedback. Figure 6 shows a percentage overview of answers to the question “I have learned a lot about the topic of artificial intelligence”. The question was answered on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Note that while there were no links to the actual scientific projects yet in this version of the game, the participants may have acquired additional information by themselves or by asking attendees at the fair. However, in our understanding this is still a valid result as the game should generally be a tool to invoke interest and subsequent learning about AI. We asked additional questions regarding the appeal and difficulty of each minigame. More than 50% of players answered the question of whether they liked the game with 5 (absolutely true) for each of the games. More than 55% selected 4 or 5 as an answer to the question whether the games are easy to play.

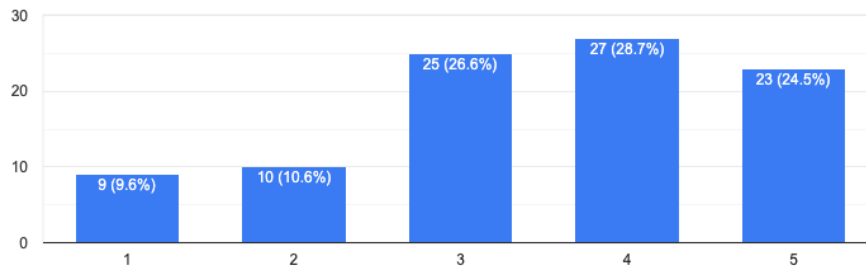


Fig. 6. Percentage overview of answers to the questions “I have learned a lot about the topic of artificial intelligence” on a scale from 1 (not true) to 5 (absolutely true). The data was acquired using Google Forms during a one week exhibition at a large industry fair in Switzerland and contains 99 participants.

4.2 Impact of Physical Installation

We did not conduct a formal study regarding the impact of the physical installation, however, from observation it can be stated that the booth was well received by the audience. Most visitors who noticed the physical installation also visited the booth and played the game, passively observed other players or spent time at the Morphtopia screen. We concluded that having an installation with a strong visual presence and the promise of interactivity can invoke a positive audience response and results in additional interest in the promoted topic.

4.3 Game Design Learnings

We started working on MG1 first and initially tried to model the game mechanics to the technical descriptions of the actual project. This is a valid approach if the goal of the game is to solely be a learning software for specific academic subjects. However, the goal of the game is to invoke interest in players who potentially have no prior affiliation with AI or computer science and who might need a general overview of the field first before diving into technical details of specific subfields. In addition, the strategy is risky because it requires the invention of novel, untested game mechanics that yet need to prove to be “fun”. An added difficulty is that there has to be ongoing dialog and agreement between various stakeholders of the project, which delays development even further. For example, in MG1, we implemented the game as a puzzle and exploration game where the player steers a drone using the tablet in order to find positions that might indicate weeds. Initially, only the drone would provide visual clues about the position of indicators, however, these subtle clues would result in the game to be extremely difficult and frustrating. We had to go through various iteration stages and added additional visual clues until the game was at an acceptable difficulty level and feedback in the playtesting sessions improved. This approach is time consuming and tedious and should only be considered if it is a requirement to accurately model scientific processes in the game. We concluded that while games that, for example, replicate algorithms can be fun and it is possible to make educational games that teach specific scientific concepts, it is much harder to create small games that maintain both a level of playability as well as scientific accuracy. The remaining minigames were developed by first considering the game mechanic with only a light attachment to the algorithms or technical details of the project. Hence, the minigames became metaphors to spark interest in the AI topics so that at a later stage we were able to give the players more information about the scientific reality. Here, the debrief screens create a connection to the AI research project as well as an incentive to acquire more information about the scientific reality.

5 Conclusion

In this paper, we presented our game “Morph Tales”, the purpose of which is to communicate and attract interest in AI topics. The goal is to attract young adults to the field of AI and computer science studies. The game uses a personified AI character named Morph to establish an emotional connection and uses AR technology and physical booths to create minigames that are linked to actual AI research

projects. We chose the AR approach and the creation of physical booths to enhance the experience of people at real-world venues. Various works exist on using AR games for education in various fields. There are also various publications that show how interactive AR applications can improve customer experiences or be used to advertise products. Almost all papers report that games can be used to improve education and communication in some sense and make experiences more engaging or spark interest for complex subjects. However, we found little to no research on how AR games can be used to promote academic topics and academic research, specifically AI. In this work, we showed that our game is indeed able to communicate general ideas about AI and that it can invoke further interest to gain knowledge on the topic. During the development and iteration process we learned that simplification and metaphorical game mechanics to communicate AI topics is a valid and time efficient approach. Indeed, we learned that it is easier to start with a basic, proven game mechanic and then build the story and scientific connection around that. With regard to technical considerations, we focused on implementing small, self-contained systems that can be tested independently. These smaller systems can then be connected to form the larger game. In addition, implementing a good communication structure around these systems that keeps coupling very low is crucial for an efficient development process. We believe that our process and results can benefit educators in the AI field by offering an engaging and interactive way to promote AI to young adults.

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A serious game to foster deliberation, social learning and the sustainable transformation of territorial food systems.

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Abstract. The urgent transformation of food systems towards social and ecological sustainability requires a better consideration of the territorial scale and of social learning processes at play that allow actors to better grasp both the complexity and the impact they can have on the food system. For this, deliberation among local actors appears as a useful approach to gather a diversity of experiences and visions. This article presents a conceptual framework and a serious game that seeks to create such deliberation on the topic of how food-related practices have an impact on the territorial food system. Having put the game to test three times in the context of an action-research project, we present some elements of observation that show how deliberation and social learning take place during the activity, and discuss the implications it can have to support the said learning and transformations.

Keywords: Territorial Food Systems, Transformation, Deliberation, Social Learning

1 Introduction

The territorial scale is increasingly seen as the right one to promote sustainable and just food systems, both by scholars [1]–[3] and international organisations [4]. A territory is an evolving social construction not necessarily circumscribed to administrative lines. It is the place where practices, direct relationships, collective action, and a common cultural view rooted in a historic evolution exist [2], [5], [6]. It is also the scale at which transitions to sustainability can more easily and organically take place, and territorial approaches allow bringing together diverse actors and therefore contribute to the construction of shared visions of sustainability and justice. Given the cultural specificity of food, work aimed at changing practices towards a better incorporation of sustainability needs a better consideration of the local scale than what is currently done [7].

The sustainability of territorial food systems (TFS) requires more than just technical shifts, and asks for social innovation and systemic restructuring [8]. Thus, changes in actors' behaviours, values and relationships are just as central to territorial sustainability as can be technical improvements for less polluting forms of production, or more efficient ways of irrigation, packaging and recycling. **The notion of transformation, a radical and profound change at the individual and collective level spanning different scales [9], [10], thus appears as a necessary element if sustainability is to be achieved.**

The literature on participatory research often discusses the issue of collective and social learning, perceived as instrumental in fostering such transformations [11]. Deliberation is seen as a particularly useful way of fostering social learning in a participatory setting, namely in the area of sustainability assessment [12], [13]. Moreover, participatory and deliberatory methods for sustainability issues tend to have a better consideration of the territorial scale (often carried out at the level of a city or rural area), than do their top-down counterparts [14].

Although an important proportion of individuals currently agree on the need to change their food practices towards a better incorporation of environmental and social issues, namely with regards to consumption, the literature and day-to-day experience find that their actual change in behaviour is often limited [15]. Part of the explanation for this is that behaviour is dependent on

social norms [16], and so behavioural change needs to be anchored in social interaction and learning [17]. The evidence suggests that games are effective tools to support learning and change [18]–[20], and so they offer a promising potential to help tackling socially-dependent sustainability issues, including this intention-behaviour gap.

With all this in mind, we conceived a serious game with the concrete aim of creating an engaging space of argumentation and deliberation around the issue of how our food practices impact the territory we inhabit in its ecological, social and economic dimensions. The intention behind it is to foster social learning on this issue, with the ultimate goal of supporting change and the sustainable transformation of a TFS.

The article is structured as follows: Section 2 introduces elements from the literature on deliberation, social learning and transformation, in order to operationalise their definition around a common framework of the sustainability of TFS. Section 3 presents the game we conceived. Section 4 offers a number of observations gathered from its three implementations, in terms of the game's objectives (create a situation of deliberation, promote social learning, and support change and the transformation of the TFS). Finally, Section 5 discusses the implications of this for researchers and practitioners working on sustainability transitions of TFS.

2 Deliberation, social learning and transformation

Defined as an exchange of arguments through which individuals can change their views [21], [22], deliberation is deemed as a useful way to look for consensus, produce knowledge and orientate action. In a paradigm of post-normal science [23], the value of deliberation is not derived from its capacity to give definitive solutions to problems identified, but from the equal footing in argumentation that concerned participants have [24], [25], and the inclusion of diverging views and values that can help reaching a common understanding of the social and ecological causes of problems, and desirable pathways out of them [26]–[28]. Participation and deliberation are deemed as potentially having a strong transformative effect on TFSs [29], [30]. Contrary to other areas in which a sustainability transition is also needed (such as energy or transport), food is chiefly a cultural phenomenon, encompassing dimensions well beyond the satisfaction of specific nutritional needs. In this, creating spaces where individuals can safely exchange and explore common views on how to co-create a sustainable TFS is of utmost importance, and perhaps more urgent than in other areas.

Participatory deliberation is closely linked to the notion of social learning, which has progressively become a new paradigm in adaptation and sustainability [31], [32]. Deliberation and social learning are linked in that the former produces learning effects “that go beyond individual and predefined interests and/or values, and create opportunities for a shared understanding and joint action” [33].

Social learning is difficult to conceptualise, and the entirety of sources checked for the purposes of this article coincide that its definition remains a matter of debate—when not something researchers choose to avoid outright [19], [23], [24], [32]–[35]. In the context of participatory approaches to complex problems with multiple stakeholders, [36]¹ define social learning as “a convergent change in the stakeholders’ perspectives on the problem and its possible solutions and risks, as well as on their own and the other stakeholders’ position² and responsibility with regard to solving the problem”. This definition³ is of interest when applied to TFSs, where a multiplicity of daily decisions on the part of actors impact their sustainability, therefore calling for an increased awareness of the interdependencies and uncertainties at play, as well as responsibility and ownership with regards to the issues at stake (“systems thinking” [33]).

¹ In their case, natural resource management.

² This can be related to the notion of *relational reflexivity*, studied by [37] in the context of value-based food chains.

³ The definition is compliant with the conditions of [35]: change in the understanding of involved individuals that is situated in wider social units resulting from the exchange of ideas, arguments and information.

Another central concept in a sustainability transition at the territorial level is that of transformation. Policy and research arenas insist more than ever on the importance of societal transformations to tackle the sustainability challenges of the 21st century. Transformation has been defined in the ecological economics literature as a rupture producing a non-linear and lasting change towards more desirable socio-ecological systems [38]. It implies changing the rules, paradigms and values that underpin deep system properties [39], fundamentally changing the way we think about the complex systems that sustain us [33], [40], including our food system.

Based on a thorough review of social learning in ecological economics, [32] claim that transformative change is supported by the creation of new relationships and the strengthening of old ones. A transformation is thus also a reinforcement of the sense of community and of local embeddedness, something that implies a depart from the evolution of western secular societies over the past few centuries [27], [41]. In this, deliberation, social learning and transformation form part of what has been termed a “new Galilean Shift” [33], [42], where a change in the centre of attention from self to community and environment takes place, and where the primacy of scientific reductionism and calculation gives way to the coherence of narratives and interpretations.

To sum up:

Deliberation is

- an exchange of arguments
- giving participants equal footing in argumentation
- including diverging views and values

Social learning is

- a convergent change in perspectives
- bringing about an increased awareness of interdependencies
- creating a responsibility and ownership of issues at stake

A transformation is

- a non-linear and lasting change to a more desirable system
- implying a change in the rules, paradigms and values that underpin system properties
- producing a shift from self to community and environment

Transformations play out at the level of individuals, groups and place-based socio-ecological systems. The collective and localised aspect of these changes have not been given as much importance as their individual aspect, which is coherent with a larger global paradigm of efficiency [27]. Nonetheless, transformations cannot be achieved by individuals in isolation and purely based on a system of incentives. The link between participation, social learning and transformation needs to be given more prominence: as the said rules, paradigms and values are the output of a social construction, having them changed inevitably needs to involve a process of collective learning.

We articulate these three elements in a common framework with regards to the sustainability of TFS from a post-normal science point of view. Participatory deliberation helps producing social learning which, under certain conditions, can help foster transformations. Such transformations, by increasing collaboration and the consideration of the collective interest raise the use of deliberation as a tool for learning and decision-making. Using a ternary structure, we can argue that change for sustainability of TFS has these three elements as its determinants, each of them including the three specific aspects highlighted above.

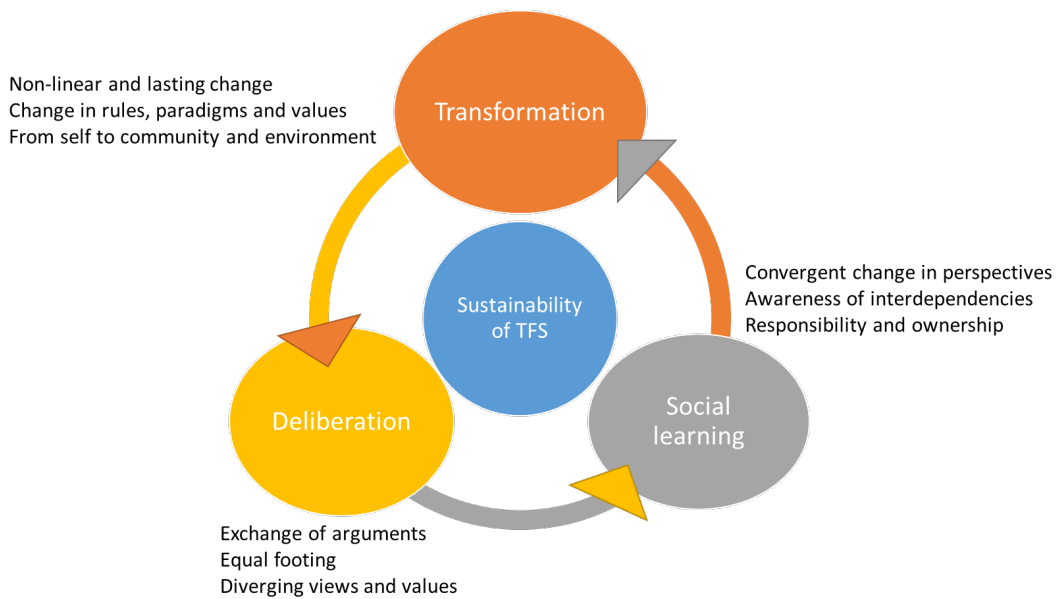


Fig. 1. Deliberation, social learning and transformation as a framework for the sustainability of Territorial Food Systems from a point of view of post-normal science.

3 Using a serious game as a deliberative tool for transformative social learning

3.1 Context and objectives of the game

It appears as useful to put to test tools and approaches that can have the elements of the above framework act together. Why using a game, though?

The importance of playing as a vector for learning has a long history in the field of developmental psychology [18], [43]. More recently, scholars working on sustainability issues have paid attention to the possibilities that playing offers in terms of social learning and transformative change [19], [44]. The literature refers to “serious games” as those whose primary purpose goes beyond entertainment, and where a rule-based, interactive environment, gives players the possibility of learning by taking actions, under the assumption that the learning that emerges can be transferred to and affects the world outside the game [44], [45].

Serious games can be useful tools for deliberation and learning on sustainability issues, as they can help dealing with situations that involve changing the mental models of actors [46], building trust and understanding the conflict dimension of a transition [19], [47].

The design of the game was done with a few objectives in mind, related to the elements exposed in the preceding section:

- O.0: The game is engaging and fun to play.*
- O.1: It recreates a situation of deliberation on the sustainability of the TFS.*
- O.2: It produces social learning.*
- O.3: It aims to contribute to a transformation of the TFS*

These objectives are, needless to say, increasingly ambitious. Objectives O.0 and O.1 were thought out from the conception stage of the game. O.2 contains more abstract notions that can, in the best of cases, be observed during the game and ex-post. O.3, the final objective, needs situating the game in a much larger context, to which we get in the discussion section.

We put the game to test twice in 2021 and once in 2022, all facilitated by the author of this paper. Each time we allowed for 45 minutes of play, which gave enough time for 7 rounds of argumentations and objections. On all occasions, we took an extra 15 minutes for instructions before playing. On the first and third occasions, we added 25 minutes to debrief at the end (we

only had 5 minutes to debrief the second time). The third debriefing was guided by a series of questions pertaining to the framework exposed in this article. Video recordings were made on all occasions after having participants agree to a GDPR-compliant charter, and a participating observer [49] joined each time.

Date	Venue	Number of participants	Mean age	Ratio Female	Field of activity
6 July 2021 (Group 1)	Plenary group, <i>l'Assiette et le Territoire</i> project ¹	13 players 1 Referee 1 timekeeper 1 observer	44.0	62.5%	Charity/NGO: 29.4% Farmers: 11.7% Local gvt: 47.1% Research: 11.7% Education: 0% Student: 0%
24 Sept 2021 (Group 2)	1 st Open Forum <i>local de l'alimentation</i>	11 players 1 Referee 1 timekeeper 1 observer	40 ²	64.3%	Charity/NGO: 42.9% Farmers: 14.3% Local gvt: 28.6% Research: 0% Education: 14.3% Student: 0%
9 Dec 2022 (Group 3)	2 nd Open Forum <i>local de l'alimentation</i>	4 players 1 observer	31.4	50%	Charity/NGO: 20% Farmers: 0% Local gvt: 60% Research: 0% Education: 0% Student: 20%

Table 1. Data on each of the times the game has been played.

Table 1 shows some descriptive elements for each of the times the game was played. Almost the entirety of players were adults with formal training (save for a teenage player on Group 3), with a predominance of women on Groups 1 and 2. In general, there was a predominance of actors from charities/NGO and from government agencies.

It is noteworthy that players were all voluntary participants to a project and forum dealing with food and territorial transitions, an aspect to which we get back later in the article. Group 1 participants were well-acquainted with one another, and had an expressed stake on the TFS, either as farmers, researchers, politicians, consumers, etc. Participants from groups 2 and 3 were for the most part unacquainted with one another. The role of each type of participant is explained in the following section.

3.2 Design of the game

Each team is composed of two or more players. Other than the players, there is a referee and a timekeeper, as well as the facilitator. The materials used in the game are:

- *Context cards.* 45 short phrases describing the characteristics of the TFS of southern Ardèche, based on participatory work carried out by the *l'Assiette et le territoire* project and partners. At each round, a team has to draw between 1 and 4 of these
- *Practice cards.* 35 different (non-exhaustive) possible actions regarding food, based either on an individual decision (e.g., which type of distribution to favour) or on

¹ <https://www.assiette-territoire.com/>. For more information on the inspiration and outputs of the project, see [48] (in French).

² We do not have exact data for ages with this group. We provide an estimate based on those we know.

collective forms of organisation (e.g., to organise group purchasing schemes). At each round, a team starts with two of these and have to choose one to play.

- *Wild cards*. Specific instructions designed to earn points outside of the main rules of the game. In rounds where wild cards come out, no new context or practice cards are played.
- Dice, board, markers (green, red and black).

Teams earn points by drawing links between the chosen *practice* card and any number of the *context* cards already on the board. A green link (2 points) is drawn when a given practice has an impact on a context card that is deemed as good for the TFS. A red link (1 point³) implies, conversely, a negative impact on the TFS. A link must be argued for briefly for it to be counted. For example, the practice purchasing in a chain store may be deemed as having an impact on the element of context several short circuit sales initiatives, and the team could argue that it is a red/negative one because such a practice will reduce the incentive for farmers to sell directly, which is something they value in the territory.

Teams can also object to the links drawn by the other team. Objections can be either because they deem the link as non-existing, or because they think it is not of the colour selected. Using the previous example, they may say that buying in a chain store should have a green link with the presence of direct sales points because it is important to concentrate food distribution in order to avoid car miles, therefore contributing to a low-emissions territory. When an objection takes place, it is up to the referee to determine whether it trumps the previous argument or not. If the objection does trump the previous argument, the link's points go to the objecting team.

A given round of play happens as described in the flowchart in Figure 2.

³ The choice of fewer points for negative links was done to promote a deliberation on practices positively affecting the TFS.

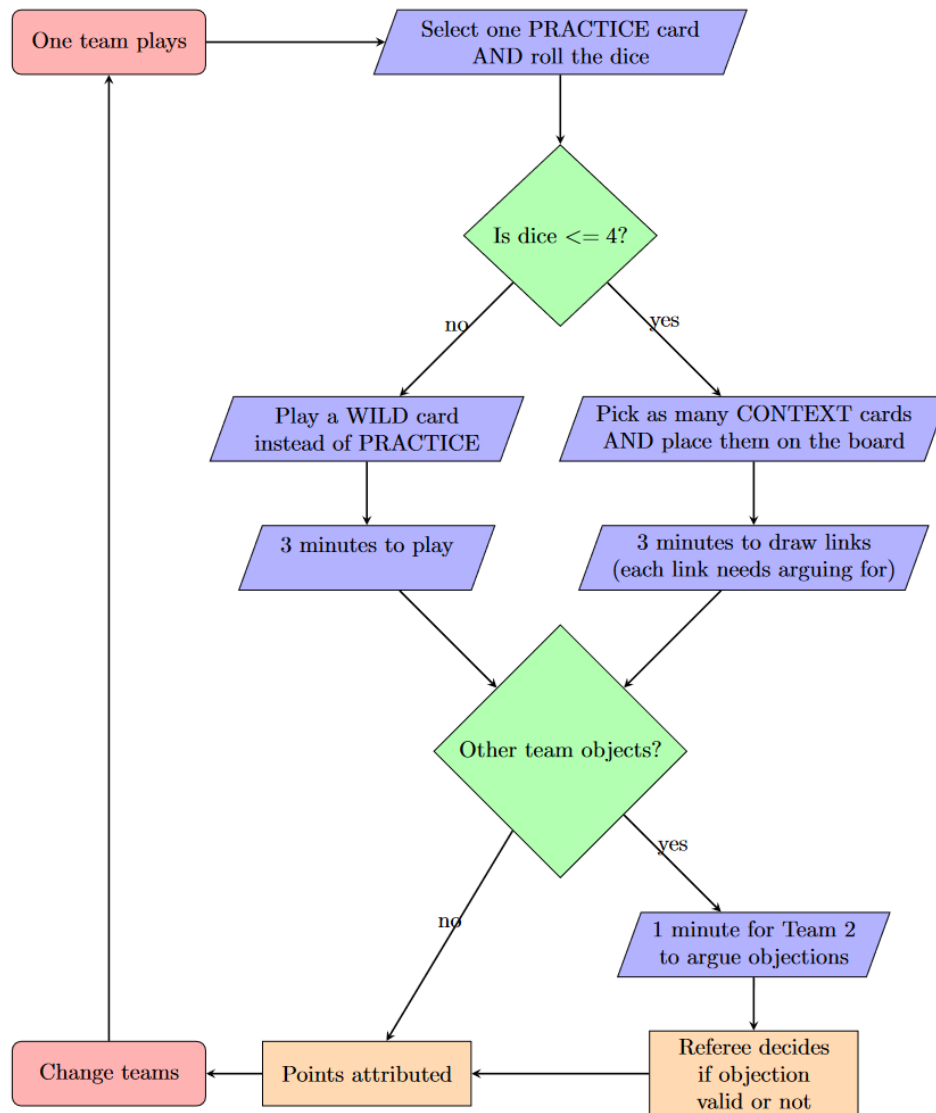


Fig. 2. Description of a round of play.

4 Elements of observation

Below, we classify some of the observations based on the framework presented in Section 2.

4.1 Engagement and fun (O.0)

The game turned out to be an entertaining and engaging activity for players. During both debriefings, participants were unanimous in saying that they enjoyed taking part in the activity, and both the on-site observation and the analysis of the videos show an atmosphere where the enjoyment and the pleasure of playing are present. Participants expressed appreciation for being given the opportunity to interact with others on issues pertaining to their TFS. Nonetheless, the appreciation was lesser in the third occasion, in which participants felt that teams were too reduced for allowing the emergence of a variety of views that could render arguments more solid.

4.2 Deliberation (O.1)

Exchange of arguments. Arguments were exchanged throughout the activity, both within teams and between them: within, when a team has to decide how to justify the links they are playing, between, when they bring arguments forward to play and eventually to have it confronted by an objection. Argumentation within groups was quick and leaning towards consensus, and so arguments were put forward relatively quickly and in a homogeneous fashion. Conversely, argumentation between teams proved more contentious and leaning towards divergence, and objections were placed on links at least once almost in every round.

Equal footing. We have reason to think that the game favours equal footing in argumentation, more than what can be achieved in a regular discussion on the same issues. Participants were remarkably active in discussions within and between teams, even those who initially mentioned a lack of knowledge or capacity to argue on the issues at stake (such as a young teenager who joined one of the activities). During debriefings, they showed appreciation for the space the game gives to exchange and express themselves. Conversely, we could observe that during instructions and debriefing, speech was less equitably distributed, with some individuals taking a more central role in the discussion—even creating a situation of tension whereby one participant had to ask “can you please let me finish my sentence” to another one, something that never happened during the actual game. The rules of the game favoured this equity, as each team is informed that they will have a time to counterargument *after* the three minutes of argumentation have elapsed, and since teams have an incentive to listen to everyone’s arguments so as to pick the most credible one.

Divergent views and values. Views expressed concerning the positive or negative impacts of practices played could differ, both within and between teams, and the professional interests of players had a visible role on this (an entrepreneur selling vegetable steaks and a farmer practicing extensive husbandry both gave counter arguments that implicitly defended their positions). The frequency of objections attests to the presence of divergence in *views*, although *values* appears as far more homogeneous (we saw no discussion playing out at that level, an issue we get back to in the discussion).

4.3 Social Learning (O.2)

Convergent change in perspectives. We could observe some convergence in perspectives during the activity, with players being confronted to an objection generally showing acceptance of the counterarguments presented. We witnessed a couple of moments where new insights were gained, such as when a person from a small village went against the idea that tourists were a favourable element for small shops and open air marketers, giving an argument based on an acquaintance’s personal experience with tourists—or when a vegetable steaks’ seller discussed the positive impact of a vegetarian diet on attenuating climate change “even when accounting for the negative effects of imported soya beans”. According to Group 3’s observer, the fact that teams are composed randomly was supportive of exchange and convergence, since it forced players to team up with people they may not have spontaneously chosen.

Awareness of interdependencies. By its very design, the game brings about an exploration of interdependencies between practices and elements of context, the final picture on the board being one of intertwined links (see figures 3 to 5 in Annex A). We could observe some capacity to explore and discuss impacts based on interdependencies that were not initially accounted for (such as a discussion on the interest of buying directly from farmers, deemed as very positive by one of the teams but objected as potentially having a negative impact on the local shops by the other one). Counterarguments were often based on an increased subtlety in exploring these impacts, and it was mentioned during the debriefing that the very fact of having cards with the different contextual elements brings about a propensity to explore the issue. At the same time, however, it was expressed also that the discussion remained within the boundaries of relatively known issues that are already common ground.

Responsibility and ownership of issues at stake. Regarding the possibility of the game increasing the players' responsibility and ownership of issues at stake, a discussion took place during the debriefing with Group 3 players, after asking the extent to which the game motivated them to act differently than they currently do. Responses to this question were elusive, giving reason to think that the game was at best mildly successful in increasing players' sense of responsibility and ownership of their TFS. At the same time, they showed some self-reflexivity by expressing that they were all acquainted with and sensible to the issues at stake, and that a better way to assess this item would be to play the game with people or in places less used to such reflexions.

5 Discussion: towards a transformation of a TFS

The observations presented above suggest that the game produces deliberation and, to some extent, social learning, therefore contributing to the transformation of the TFS through the dynamic framework presented in Section 2. Although transformation is the ultimate *design-in-the-large* [23], [50] objective of the activity, it would be excessively ambitious to claim that it can, by itself, produce a full-blown non-linear and lasting transformation just by having a handful of individuals playing and debriefing on it for 90 minutes. In this, its inclusion in a wider and longer lasting activity (the aforementioned action-research project) is central to any transformative potential it may have, inasmuch as the different outputs of the project—production of a common manifesto, better comprehension of the TFS's trajectory and levers for change, experimentations and organisation of local forums—all fit inside the framework described in Section 2. Nonetheless, this can render the game excessively context-dependent and with little external use if one is not able to devote considerable time and resources, and have enough human and financial support. A 'ready-to-use' version could be conceived so that its implementation is simpler on different contexts, although we have not worked on that as of yet—giving instead preference to its embeddedness.

This lack of external use notwithstanding, the activity gives reason to be hopeful with regards to the transformative shift from self to community and environment described above, as it appears that such a shift has to a large extent taken place at a cognitive level with the public chosen. As described in the observations, *value* divergence was virtually non-existent, and players could argue at ease with regards to the TFS sustainability from a social and environmental point of view. They all agreed to already having community and environmental issues as guiding principles in their daily actions—giving hope that a transformation may already be underway. Two points of caution need highlighting, however. First, our players are not necessarily representative of the territory, as such projects and forums bring together like-minded individuals sharing a common view against mainstream industrialised and globalised agriculture, with protection of nature and of local relations in the food system seen as key pillars. A different activity would certainly have taken place if more diverse players had joined, increasing the *divergence* component of deliberation. This would also be useful in terms of the game's impact and perceived legitimacy [24], [51], and potentially help bridging existing fractures between conventional and alternative networks that can work against territorial transformations [2]. One can also theorise that a higher diversity of views and knowledges can increase the *social learning* aspect of the activity, although until we do further testing this remains a hypothesis. Secondly, players expressed discouragement during debriefings as to the actual transformative potential of individual action, with stakes perceived as too large to be tackled without action at the higher levels and through public action. Indeed, the two times wild cards pertaining to collective or institutional action were played, the actions chosen were among the most impactful in terms of positive links created with the territory—despite being based on costly efforts such as purchasing land on a large scale to reorient the local production. The feeling is that individual and/or localised actions can have a relatively minor impact when compared to high-level policy ones.

Moreover, having relatively homogeneous players can reduce the exploration of the *conflict* element of sustainability, as not only players share views but also tend to be in similar socio-economic positions. The inclusion of more precarious publics, as well as of dominant actors from the production chain could have increased the level of disagreement, and perhaps give a more prominent role to the referee. We could see how players with a commercial stake (farmer, seller) were the among the few to bring actual new insight to the discussion, and so it would be an interesting thing to have more dominant players who positively benefit from the unsustainable state of the TFS [29]. On top of this, mainstream views and discourses on sustainability have tended to favour “win-win” views that hide the sacrifices and efforts that are needed in a transition [7], [52], [53]. Such narratives are present even in “alternative” groups such as the ones we played with, which we could amply observe during the rounds of argumentation, and is illustrated by the fact that practice cards tend to be associated to green-only or red-only links⁴. Learning how to deal with conflict-ridden situations has been identified as one of the key aspects of social learning for sustainability [33], and so a more direct inclusion of conflicting interests in terms of players could be a welcome addition, in a playing context that could foster conflict without real-life consequences [54].

The game also created a space for a meta-reflexion on the issue of how deliberation and social interaction can contribute to TFS sustainability, providing some support to the notion that social interaction is perceived as one of the forms of social innovation with the highest territorial impact. Towards the end of the activity with group 1, the card “participating in forums on the topic of food” came up. It quickly became the card with the most positive links on the board, with a total of seven (half of the context elements present on the board by then). Taking part in such forums was deemed as positively impacting the territory on counts ranging from the current lack of support for new farmers to the good availability of open-air markets in the territory. This is an interesting finding in terms of the game and its larger research context, which explores how social interaction can be a lever for change and transformation, instead of traditional monetary incentives or knowledge transfer that are more often discussed and promoted at higher levels.

The issue of knowledge transfer also deserves some discussion. The choice of not having a role of an expert in the game was a conscious one in order to favour the emergence of collective knowledge and reduce to a minimum any top-down or authoritative forms of argument. Nonetheless, players from Group 3 ended up calling for it, as they felt that the validation of certain key arguments became difficult or even impossible in the current setting. Further work should better tackle this issue, balancing the need for expertise and data, while being attentive to how it may affect the equally important need for equal footing in the deliberative setting.

Practically speaking, our three experiences give some lessons as to the number of participants needed for the game to work properly. The number of participants in Group 1 and Group 2 (10 and 9 players divided in two teams, respectively) seems to strike a right balance in terms of internal exchanges. Although we have not tested it, too many players would likely make it difficult for teams to sufficiently exchange before putting forward arguments in the limited time they are given. As mentioned above, we could see that having too few players (as in Group 3, where only 4 people played divided in two teams) also restricts the quality of arguments that are brought forward. We thus recommend playing the game with 4 to 5 players per team. Likewise, the absence of a referee was perceived as a drawback by Group 3, as consensus was often out of reach when objections were raised. This gives a potential avenue for exploration, as the role of a referee could be merged with the expertise and science discussed in the above paragraph.

The focus of the game is the environmental and social sustainability of the TFS. In this, it leaves out both individual interests (e.g. health) and planetary ones (e.g. carbon emissions), which can be at odds with one another and further create win-lose type situations and demand expert knowledge. Arguments on health and ecological issues did come up from time to time,

⁴ Only 5 links out of a total of 72 created in all three occasions appear as having a different colour than the rest of the links in the same practice card. See figures in the Annex.

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Current and future competencies of game facilitators

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Abstract. German universities widely use simulation games since the 1950s. They enable students to experience dynamic situations that are as close to reality as possible, and thus to deal with complex and challenging situations. Facilitating simulation games requires a high degree of teaching professionalism as well as a specific teaching approach and attitude towards students. Confronted with the unforeseen pandemic, facilitation of simulation games at universities became even more complex as all simulation games were transferred in virtual classrooms at very short notice, regardless of teaching and learning location and the type of simulation game. High quality teaching in unforeseen and complex situations requires a wide range of competencies. Teaching competence models are the basis for the development of target group-specific training programs in higher education teaching. In a Delphi study, facilitation experts described current and future competencies of game facilitators. The study resulted in a teaching competence model with four dimensions and detailed descriptions of individual competencies and their requirements. It also includes differences in the competencies of virtual and face-to-face teaching. Supplemented by the identification of concrete fields of action for the development of teaching competencies, the results offer a good starting point for the development of a target group-specific training program and consulting services for game facilitators.

Keywords: Facilitation, competence model, quality of teaching, teaching competency development.

1 Introduction

With the first lockdown in Germany in March 2020 universities faced major challenges. Teachers had to find suitable digital formats for lectures and thus for all simulation games within a few days. At first glance, universities managed this process in a smooth manner and most seminars took place. But, the impact of this change on the quality of teaching is still largely unexplored. However, initial studies suggest that, at least in the beginning, the quality of teaching was reduced [1]. Peter B. Vaill (1998) described experiences like these as "permanent white water". He uses it to describe situations of uncertainty, unpredictability and complexity that permanently demand new approaches to solving them [2]. Like a navigator on wild sea universities and teachers were confronted with complete new situations they never faced beforehand and which forced them to find innovative and new solutions. The situation-adequate and professional handling of such challenging teaching situations only succeeds if teachers have the necessary competencies [3]. The further development of competencies and the preparation for the challenges of tomorrow are the goal of teaching competency development. This field of action within personnel development is increasingly important at universities, as it is an important component of quality development in teaching [4]. The development of a competence model can be the first step in a strategic needs analysis. It maps the necessary competence dimensions that build the basis for instruments and measures for competence development [5].

Therefore, this study explores the following questions: Which dimensions of teaching competence are important for the facilitation of simulation games? What are the differences in competency requirements between virtual and face-to-face game settings? Which difficulties face facilitators in virtual simulation games and what significance does this have for the competence requirements of facilitators? Which competencies could gain additional relevance in the future? Which offers of education training can help facilitators to improve their individual performance?

2 Background

Three points of reference essentially determine the work of facilitators - institutional guidelines of the university (curricula, study model, teaching model etc.), the method of experiential learning by using simulation games and the pedagogical-didactic approach of facilitation.

2.1 Game-based learning - the methodological frame of reference

By using game-based learning methods students recognize the connections between theoretical and contextual knowledge, apply learned knowledge, share knowledge with others, and learn directly through feedback on their actions while playing the game [6]. It is about the holistic understanding of complex systems and the active design or experiencing of learning situations that are as authentic as possible.

Both constructivism and experiential learning bring students in situations that require a lot of self-activity on the part of the learner and that allow the learner to be actively constructive [7].

The theory of experiential learning has its foundation in works of some very well-known scholars who have studied human learning and the development of the individual, including William James, Kurt Lewin, Carl Rogers, Carl Jung, John Dewey, Jean Piaget, Lev Vygotsky, and Mary Parker Follet [8].

The application of the simulation method has various implications for the teaching activities of facilitators and result in the following requirements:

- Show the connection between theoretical models and practical professional relevance.
- Encourage systemic and complex thinking of students.
- Place students in situations that create tension and challenge them both emotionally and cognitively.
- Make references to students' lifeworlds to increase motivation to learn.
- Allow students to make their own experiences, even if they are painful and stressful.
- Create opportunities for reflection. Make different perspectives and approaches visible through communication and enable joint learning.
- Encourage interaction between students.
- Give students the opportunity to experiment.
- Enable collaborative development of concepts.
- Enable students' cognitive development through contradictions and problem-based learning.
- Enable exchange and interaction in groups; thereby increasing productivity and creativity with increasing heterogeneity and interdisciplinarity.

2.2 Facilitation – the pedagogical frame of reference

The art of facilitating simulation games includes a special attitude and mindset. There are differences in the interaction between lecturers and students in comparison to normal lectures. And a range of values shapes the work of game facilitators. As early as the 1960s, Carl Rogers with his "Theory of Facilitation (1969) and Paulo Freire with his "Pedagogy of the Oppressed" coined the term facilitation and their understanding of the role of the teacher, the interaction between teacher and learner, and the process of learning. However, the term "facilitation" is also used as a synonym for small group facilitation. Here, Heron's "six-category intervention analysis (1976) and Schwarz's "The skilled Facilitator" (2017) had a great impact on the overall outcome of a group. In summary, these requirements can be described as follows:

- Arouse students' curiosity and encourage self-initiated learning.
- To make students aware of the process of lifelong learning and to convey to them that knowledge is ephemeral.
- To bring one's original being into the relationship with students in the sense of "being real".

- To show appreciation, recognition and trust to the students and to perceive them in their entirety as a person.
- Putting oneself in the students' shoes in a non-judgmental way.
- Have a basic trust in the students' ability and willingness to learn.
- Awaken intrinsically rooted motivation to learn by making content meaningful to the student.
- Put yourself in the role of learner and learn from students' ideas.
- Encourage dialogue and allow students to critically question previous assumptions.
- Provide structure while remaining flexible enough to adapt the seminar to the needs of the participants.
- Using values such as transparency, accountability, and compassion to create a climate that leads to greater engagement, higher motivation, and increased satisfaction [9,10, 11, 12].

2.3 Learning Site – the institutional frame of reference

In addition to the method of the simulation game and the didactics, facilitators must also take into account the requirements of the university or the learning location:

- Know and strive for the curricular learning objectives and teaching content of the respective course of study.
- Recognize and pay attention to group dynamic processes resulting from the composition of the participants.
- Bringing in own and current practical examples from the own professional activity.
- Tying in with different previous knowledge of the students.
- Contribute to the students' competence development through the simulation game.
- Respecting the diversity and heterogeneity of the student group.

3 Current state of research and methodology

3.1 Current state of research

The influence of teachers on the performance of learners has so far primarily been studied in the field of educational science and has been extensively described by Hattie (2009) in his meta-study [13].

The role of the facilitator has been extensively described by Kriz (2010), Jansen and van Zelst (2021), Ronde (2015), Ronde & Geurts (2012), Kortmann & Peters (2019), and van Laere, Lindblom, and Wijse-van Heeswijk (2021). Thus, the facilitator takes different roles in the different phases of the simulation. At the beginning, he gives an introduction to the game. The focus is on structure and hints. In the course of the game, the facilitator creates dynamics in the game by answering open questions, motivating participants and unsettling them with unforeseen events or interventions. He takes on the role of a coach. In the final phase, the facilitator encourages self-reflection and promotes the transfer of what has been learned into reality [14,15,16, 17, 18].

Closely related to this are the different tasks of a facilitator, which Scholtz and Hughes (2021) summarized in a systematic literature review [19]:

- Preparatory activities (clarifying learning objectives, providing technical support to participants, etc.).
- Methods for structuring teams (role assignment, group dynamics processes, etc.)
- Didactic interventions (case studies, scenarios, etc.)
- Actions that stimulate participation of participants (promoting competitive nature, self-organized learning, etc.)
- Exercises to promote collaborative learning
- Actions to stimulate critical reflection on one's own actions (reflective practitioner)
- Coaching and mentoring (learning from mistakes, role plays, etc.)

- Facilitation of feedback and debriefing phases
- Measures to evaluate participants

A first attempt to develop a competence model for game facilitators was made by Kortmann and Peters (2018) [17].

Baalsrud Hauge, Söbke, Bröker, Lim, Luccini, Kornevs, and Meijer (2021) also used a multi-method study to address the questions of what competencies facilitators need. In an initial discussion, they identified the following competencies:

- Digital skills
- Leadership skills
- Knowledge of cognitive science
- Motivation skills

With the help of expert interviews, these competencies could be divided into technical and organizational competencies:

Technical competencies

- Knowledge of the business game and its content
- Ability to handle the technical infrastructure
- Ability to link the game to the learning objectives

Organizational competencies

- Active listening
- Ability to react to group dynamic processes
- Application of different strategies, such as motivational methods, team leadership or consensus building methods
- Empathy
- Conflict resolution
- Flexibility

By comparing the results with those of Stewart (2006), who assessed competencies of facilitators for (small) groups, it was found that very few competencies were rated more important for leading simulation games than for facilitating small groups. The authors attributed this to the fact that the game already prescribes or assumes many of the tasks of a classic facilitator. Thus, the following competencies remain:

- Recognizing and rewarding performance
- Motivating others to participate actively
- Motivating others to achieve goals
- coaching
- Planning and organizational skills

They supplemented their study with the question of what training methods are currently used to train simulation leaders at universities. They found that the majority had not undergone any formal training before leading a simulation for the first time. 87% said they had learned to do so by "learning by doing," and another 57% by shadowing colleagues. Only 33% had attended formal training in higher education didactics by then [20].

Both studies provided a more nuanced picture of the competencies of facilitators, but not yet a complete profile of competencies. Several authors advise more research on facilitation competencies [21,18,20].

3.2 Methodology

Answering the research question requires, on the one hand, a qualitative approach that uses open-ended questions to obtain as broad an opinion as possible from experts on the necessary

competencies; on the other hand, the approach should enable forecasts to be made on future developments. The empirical method of a Delphi study lends itself to combining these two approaches.

Classically, Delphi studies are used to reach a consensus from a circle of expert opinions. Alternatively, the Delphi method can also be used to generate ideas. In this context, the survey is not carried out using a quantifiable method; instead, qualitative results and assessments of the experts are evaluated and reflected back to the experts in a suitable manner. Thus, verbal statements are obtained over several rounds and communicated to the other experts after each round. This results in a step-by-step qualification of the statements [22].

The focus of the study was not to create consensus on a topic, as is usual in classic Delphi studies, but to generate an opinion of selected experts. The statements were to represent as broad a spectrum of opinion as possible.

Over the course of three rounds, the participating experts were asked to list necessary competencies, describe particularly challenging situations in online games, venture a forecast for the future, and finally make an assessment of the need for continuing education:

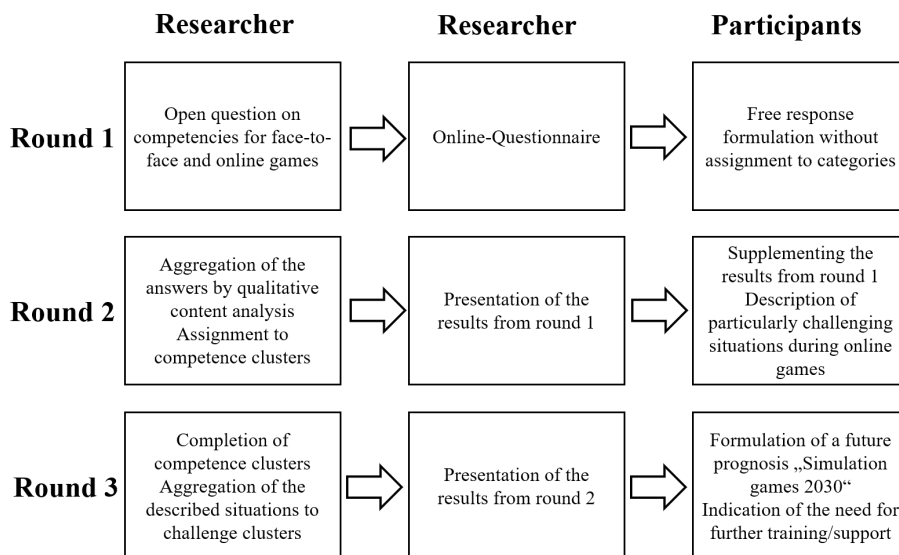


Figure 1. Procedure of the Delphi study

The experts were surveyed in three rounds between March and June 2022. After each round, the participants received an evaluation of the statements, which served as the basis for the next survey round. All three rounds of the survey were conducted via online questionnaires.

At the start of each round, participants were informed that they could participate even if they had not participated in the preliminary round(s). They could therefore participate in the rounds or skip rounds as they wished. This was intended to increase the motivation of the participants, as answering the questions in Delphi studies usually involves a great deal of effort [22].

Sample

The sample of the Delphi study consisted of two groups of people. On the one hand, lecturers from Cooperative State University (DHBW), Stuttgart/Germany, were interviewed, and on the other, a small group of experts from the broader simulation and gaming environment. A total of 104 people were interviewed in each round.

Without exception, all of the DHBW Stuttgart lecturers interviewed are active as facilitators at the Center for Management Simulation and can be classified as experts based on their experience in the facilitation of simulation games. Since different types of simulation games are used at the

Center for Management Simulation, both in terms of the game mechanisms and content, it can be assumed that this provides a broad knowledge base on the topic.

The selection of experts from the broader simulation environment was based on the criteria of publications on the topic of simulation games, activity in the design or development of simulation games, and high credibility in the simulation community due to affiliation with one or more simulation game professional associations. The opinion of these experts was intended to obtain a more heterogeneous opinion and to counteract the possibly limited and DHBW-influenced image of DHBW lecturers.

The teaching activity of the participants with simulation games varied between 1 and 35 years with a median of 10.2. The number of teaching hours with simulation games per year also showed a variance between 2 and 300 or 560 hours in one round, with a median of 92.0.

Since the study focused on generating ideas through a qualitative and subject-oriented survey, Mayring's qualitative content analysis was chosen to structure the content of the results from the survey rounds [23]. At the beginning, the category system was deductively divided into the categories "personal competence", "social-communicative competence", "professional-methodical competence" and "activity and action competence" following the KODE Competency Atlas of Heyse and Erpenbeck (2004) [24].

Subcategories were assigned to these categories during the review of the material. These were also largely deductively based on the competency atlas by Heyse and Erpenbeck (2004), but were inductively supplemented by additional subcategories [24].

The competence atlas on which the category system is based was developed from its survey of 150 people in the fields of personnel management, adult education, and learning psychology and contains 16 sub-competencies per competence dimension, i.e., a total of 64 individual competencies [24].

4 Results of the Study

4.1 Necessary competencies for the facilitation of simulation games

In round 1, the participants were asked to name all the necessary competencies of game facilitators. They were asked to distinguish between online and face-to-face setting. Since in round 2 the participants stated that the competencies for online setting would also apply to a setting in presence, the distinction was subsequently dispensed with.

According to the feedback from the experts, the subcategories listed in this model can be applied both to simulation games conducted in presence and to virtual simulation games:

Table 1. Overview of Personal Competence

Personal Competence	
Self-Management	
Self-Reflection	Stress Management Skills
Resilience	Endurance
Serenity	Courage
Humour	Positive Aura
Personal Responsibility	Ambiguity Tolerance
Own role understanding	
Charisma	Authority
Self-awareness	Credibility
Critical Thinking	Willingness to learn
Authenticity	

Value Orientation	
Tolerance	Fairness
Openness	Trust
Idealism	Empathy
Value neutrality	Sensitivity
Willingness to help	
Productive Settings	
Persistence	Accuracy
Creativity	Holistic Thinking
Spontaneity	Complex Thinking
Strategic Thinking	Readiness

The subcategory empathy was mentioned very often by the participants (n=16). However, it gains particular importance during online implementation, since due to reduced facial expressions and gestures, physical distance, and possibly also cameras that are not activated, the perception of the mood in the student group is significantly more difficult for the facilitator.

Another point that seems to be more important for online implementation is the competence "serenity". This is due to the fact that online implementation adds another dimension with the technical environment. This makes the task of leading the simulation more complex, and at the same time, failures, technical malfunctions or a lack of media competence on the part of the students can lead to delays and tension in the process.

As a third point, the experts referred to the competence "creativity", which in this context, however, is not to be understood in its original sense of creative design, but in the creative use of different methods and media in online teaching. Since attention wanes more quickly in online events, this can be an effective means of keeping students' attention levels high.

Table 2. Overview of Activity and Action Competence

Activity and Action Competence	
Interaction with Students	
Motivational skills	Ability to inspire
Giving impulse	Sensitivity
Active inactivity	Goal-oriented Leadership
Knowledge of group-dynamic processes	
Goal-orientation	
Self-motivation	Ability to inspire
Optimism	Agility
Process Orientation	
Active Action Capability	
Flexibility	Ambiguity Tolerance
Ability to concentrate	Quick thinking
Multitasking Ability	Decision-making Ability
Improvisation skills	

The competence "Flexibility" was mentioned very often, especially for online execution. It could be one of the key competencies, as it was also mentioned in connection with other competencies such as time management, etc.

In addition, motivational ability also plays a major role in online games, which describes both the motivation of students by the facilitator and the self-motivation of the facilitator. Here, the distraction possibilities in the home environment of the students, which distract them from the simulation and the active participation, are referred to above all.

Finally, the competency "multitasking ability" is important. It describes the ability to operate several digital media that are used simultaneously in such a way that long waiting times do not occur and the facilitator is not perceived as unprofessional.

Table 3. Overview of social-communicative competence

Social-communicative Competence	
Cooperation	
Adaptability	Consulting Capability
Ability to experiment	Ability to work in a team
Relationships	
Relationship Management	Appreciation
Integration Capability	Intercultural Competence
Communication	
Communication Skills	Eloquence
Consensus	
Problem solving skills	Conflict resolution skills

In terms of relationship management, the experts described the difficulty of establishing a relationship with the students across the distance of the virtual space and with a far smaller repertoire of body language. With seven mentions, the ability to communicate was also attributed greater importance for implementation in the virtual space. Due to the physical distance to the students, communication becomes more important.

Table 4. Overview of Professional-methodological Competence

Professional-methodological Competence	
Didactics	
Knowledge of designing interactive seminars	Knowledge of media didactics
Teachability	
Analytical-systematic Action	
Planning capability	Organizational skills
Analytical skills	
Expertise	
Professional and industry-specific knowledge	
Methods	
Experience in dealing with the simulation game	Experience in dealing with the simulation software
Knowledge of visualization techniques	Moderation knowledge

Knowledge of questioning
techniques

Media Competence

Knowledge of Debriefing methods

"Media didactics" also came to the fore in the question on online games. The same applies to "knowledge of visualization technology" for documenting work results. Both referred on the one hand to the mastery of suitable tools and on the other hand to their meaningful use in teaching, for example as support in feedback phases. Finally, in the case of "planning ability", the emphasis is on a good structure and a good time management, since many tasks take longer in the virtual space. In addition, planning for breaks was emphasized, as students are more challenged in the virtual space and therefore more breaks make sense.

4.2 Challenges in facilitating virtual simulation games

In round two of the Delphi study, the participants were asked to describe situations that they experienced as particularly challenging in the facilitation of simulation games in the virtual space. In doing so, they were asked to be as precise as possible about their subjectively perceived difficulties.

The results were aggregated into challenge clusters. The classification was made into challenges that lie on a personal level either with the facilitator, the students or in the interaction between the two. Two additional categories resulted from challenges with the game itself, but also with the technology in use when conducting the online games.

Table 5. Challenges in facilitating virtual simulation games

Challenges for the facilitator	
Participant enthusiasm for the simulation	Lack of participant feedback
Time management/break planning	Multitasking (technology, simulation, technical content)
Motivating participants	Self-motivation (lack of video images)
Concentration on technology instead of content	Coordination/preparation between two facilitators for a smooth process
Sympathetic effect in the online room	
Media didactics	
Challenges for the students	
Low motivation	Screen fatigue (tiring online sessions)
Limited media literacy	Distraction by environment
Active participation of all students	Participants' fear of being observed, video recorded, written word (chat)
Participants with higher media literacy are more actively involved	
Possibility to hide	
Challenges in the interaction between facilitator and students	
Integration of all participants	Communication with limited gestures and facial expressions
Activation of participants (also through physical movement)	No "visible" participation in the absence of video images
Building relationships in the digital space	Conflict management with limited body language, no simultaneous speaking possible
Conveying content	
Unclear formulation of goals	
Understanding of explanations	
Technical challenges	
Dealing with different tools	Problems with WLAN, own technical equipment at home
Technically overloaded tools	Non-functioning technology
Not working passwords	
Trust in technology	
Challenges with the simulation game	
Problems with the simulation software (cloud not available, participant login)	

4.3 Forecasting the future – simulation games in 2030

Another question asked the experts to estimate how the simulation world would develop by the year 2030. They were able to describe their assessment of this with an open question.

Future prediction #1: Teaching scenarios - online, offline or hybrid?

According to the experts, it is conceivable that blended learning will become the standard and that simulation games in presence will have to offer significant added value in order to continue to exist. In any case, simulation games will take place online much more often.

Future prediction #2: Business simulation events - more international, interdisciplinary and free?

One aspect is the internationalization of simulation events, as online formats will allow more joint events to be held with foreign universities in the future. Events with participants from different disciplines could also be realized more easily online. Overall, the events could become freer in their implementation.

Future prediction #3: Business game content - the big issues?

In terms of game content, the experts named very specific topics: Sustainability, risk management, new work, digital transformation, ethics, compliance, automation of production.

Future prediction #4: Integration of new technologies - for more realistic and interactive simulation experiences?

The fourth aspect predicted by the experts is greater integration of new technologies such as virtual reality, augmented reality and other virtual worlds. They expect to be able to make simulation games even more realistic and interactive. They agree that haptic board games will continue to be used in the future. However, they repeatedly emphasize that these will be supported in the future by technical media, such as Google glasses.

5 Discussion

Results of qualitative interviews are always tied to a specific context and shaped by the situational perception of the interviewee and the interviewer. Therefore, the results of the study presented here have to be considered critically under the following aspects:

Size and composition of the sample.

In selecting the experts, an attempt was made to counteract the one-sided consideration of the questions by the DHBW lecturers by involving experts from the broader simulation environment. Since participation in the survey was voluntary and anonymous, however, it remains open whether they took part.

With 104 experts contacted and a relatively small number of participants (R1: n=26, R2: n=21, R3: n=13), the results cannot be extrapolated to the entirety of planning game leaders. They must always be considered in the context of the DHBW type of university and here in the environment of simulation leaders for simulation games in the context of business administration.

Bias of the experts

The results of Delphi studies are also always subject to cognitive biases by the participants [25]. Thus, in this case, both the degree of teaching experience as a simulation leader, the imprint of one's educational career, and the type of game and its use may have an influence on the responses and thus on the reliability of the results. The correlations between experience as a game leader and the type of statements in the individual questions were not examined in the context of this work.

Lack of opportunity for dialogue

The researcher did not have the opportunity to enter into dialogue with the participants. Unclear formulations could not be questioned. Thus, the results are very much subject to interpretation by the researcher. The classification of the questions is also subject to individual interpretation by the participants.

Quality of the results

The advantage of Delphi studies is seen in the fact that a higher reliability of the results can be achieved through the participatory and interactive principle of questioning in several rounds. However, it cannot be ruled out that, at the end of the survey, an opinion may exist that has been formed without any discussion among the experts and thus gives the wrong impression of a supposed consensus [25].

Through participants' self-report, social desirability may have influenced the experts' responses. Participants may not have written what they really thought.

Scope of questions and high dropout rate

Having a relatively high dropout rate, as the number of those who opened the questionnaires but then did not respond, could be due to several reasons. The type of questioning in the form of open questions, which demanded a high degree of cognitive effort, could have been one reason. The scope of the questions to be answered could also have deterred experts from answering them.

Lack of student perspective

In continuing research activities, it is imperative that students' perspectives on necessary competencies of plan game leaders be considered.

Reproducibility of the study

Due to the heterogeneity of the participants, replication of the study is practically impossible. It would rather be recommended to have the results of the study discussed by a group of experts, e.g., in the form of a workshop.

The present study can thus be regarded more as a snapshot and will certainly require further development of the competence model simply because of changing competence requirements.

6 Conclusion

The competence of teachers has a great influence on the quality of teaching and thus also on the learning outcomes of students. Personnel development measures for the development of academic teaching competence are accordingly increasing at universities and are intended to contribute to quality development and assurance. Teaching competence models form the basis for the design of a training program and the development of curricula. These describe the competence dimensions as well as the associated requirements for teaching activities. On the basis of a Delphi study, it was possible to develop a teaching competence model that specifically addresses the field of activity of game facilitators. An overall model was developed that reflects the theory-based requirements from the method of simulation games, the theory of experiential learning, the didactic concept of facilitation and the institutional requirements.

Nevertheless, it is a snapshot and the future requirements predicted by the experts will make it necessary to adapt the model. It would make sense to continue the survey in the form of a workshop with experts to further discuss the results and include the perspective of students.

In conclusion, it can be said that the teaching activities of game facilitators are a complex field of action. It is necessary that further research efforts be made in this area at universities. Good examples can be found in secondary education, where comprehensive results are already available.

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Transition from Face-to-Face to Online Teaching. Differences and communalities from the perspective of participants of simulation game courses

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Abstract. The Corona pandemic triggered a major change in the use of simulation games. Within a very short time, it was necessary to convert simulation games designed for face-to-face teaching to online teaching. Due to the complexity of the simulation game method, the challenge was particularly high. This paper analyzes the similarities and differences in the use of face-to-face and online simulation games in higher education based on evaluation data. Thus, a contribution is made to close a research gap and to be able to make evidence-based decisions on the use of simulation games in the future. For this purpose, data of 2119 students from a total of 124 simulation game courses with 30 different simulation games were collected in this study in the period from May 2021 to August 2022. The survey was conducted using the ZMS Inventory for Simulation Game Evaluation, which was developed specifically for the evaluation of simulation game events and captures the perspectives of both students and instructors.

The comparison of the results of face-to-face and online simulation game courses shows significant but rather small differences in several dimensions (e.g. instructor behavior, student collaboration, teamwork). The authors conclude that the transformation of simulation games into the digital space can be considered successful overall. However, there are empirically significant deviations in the case of board games, which make it advisable to conduct them face-to-face if possible.

Keywords: face-to-face teaching, online teaching, evaluation, simulation game

1 Introduction

Business games have been established as an important instructional design in university teaching (Meßner et al., 2018; Muno, 2020). Due to the corona pandemic, lecturers were faced with the challenge of converting simulation game courses to an online format within a very short time. Considering the specifics of simulation game lectures as a complex learning method, this was a particular challenge. For example, lecturing using simulation games is characterized by a high degree of interaction, often requires cooperation in groups, is based on specific material that often contains haptic elements. The aim of this study is to identify differences and commonalities between face-to-face and online simulation games courses in order to make evidence-based decisions on the use of simulation games in the future.

1.1 Simulation games in higher education

Simulation games can be described as a teaching and learning method in which aspects of reality are modeled (simulation). In this simulation, learners take on roles and act, taking into account the rules of the game, in order to deal with simulated problems (Kriz, 2011). Thus, simulation games contain elements of simulation, rule play and role play, but cannot be completely assigned to them (Kriz, 2011). A typical characteristic for simulation game courses is the sequence of briefing, game play and debriefing. In longer round-based simulation game lectures the process

of briefing, game play and debriefing is repeated several times. In literature, simulation games are discussed as problem-based (Mandl, 2004) and experiential learning methods (Geithner & Menzel, 2016; Schwägele, 2015). This classification corresponds to the characteristic alternation of activity/experience on the one hand and reflection of experience on the other. In order to situate simulation games in the larger context of university teaching, the model of academic teaching according to Reinmann (2016) can be used. In this model, three different types of teaching and corresponding types of learning are distinguished and divided into “spaces”:

- In the information space, knowledge is imparted. This can be problem- or case-based, but students learn receptively what is imparted. Classical lectures and seminars can be located in this room.
- In the testing space, students are encouraged to actively engage with knowledge: On the basis of projects, cases, or problems, they work on learning objects. Reinmann (2016, 229) describes this as productive learning based on complex problems in which concrete artifacts result as solutions to problems.
- In the exploration space, students go through entire research projects, with the potential not only to learn but also to generate new knowledge (“learning through research”).

Simulation games can be seen in the testing space of the model of academic teaching. Students are active and can test their knowledge and competences. They learn productively according to the scenarios designed in the simulation games, whereby also artifacts are created (decisions, elaborations, game results, etc.).

2 Simulation game courses face-to-face and online

Ideas and concepts of digitally supported teaching existed long before the outbreak of the Corona pandemic in spring 2020, but with it, such concepts have gained an unexpected urgency. Probably also due to this urgency, very fuzzy discussions and terms to describe certain constellations of digitally supported learning have emerged. In the following, we therefore explicitly describe what is understood by face-to-face and online teaching in the context of this paper. For this purpose, we refer to the two-dimensional categorization of forms of teaching according to Entner et al. (2021) (Table 1), in which on the one hand the distinction physical/virtual and on the other hand the distinction synchronous/asynchronous are made. This results in four fields for the differentiation of forms of teaching:

Table 1. Two-dimensional categorization of teaching forms, own representation according to ENTNER et al. (2021)

	Synchron	Asynchron
Physical space (Offline)	Lectures in classroom	Lecture notes
	Tutorials in the small group rooms	Task sheets
Virtual space (Online)	Lectures in live stream	Lecture recording
	Exercise chat	Exercise discussion forum

3 Research questions

As described above, simulation games are a learning method in which students are encouraged to learn actively (taking on roles, making decisions, solving simulated problems) and productively (producing results, artifacts). Moreover, simulation games are a highly interactive method. Both the game phase and the debriefing are based on communication and social discussion. Against this background, the question arises how successfully such a complex and interactive form of teaching can be implemented in online teaching and how satisfied students are with it. Specifically, this paper will answer the following research questions:

Research Question 1: What are the differences in simulation-based face-to-face and online teaching courses in terms of student engagement and teamwork?

Research question 2: What are the differences in simulation-based face-to-face and online teaching courses with regard to lecturers (communication, comprehensibility)?

Research question 3: What are the differences in simulation-based face-to-face and online teaching courses with regard to the assessment of the simulation game (comprehensibility and practical relevance)?

Research question 4: What are the differences between simulation-based face-to-face and online teaching in terms of student learning and satisfaction?

4 Empirical Study

The basis for this study is a model for the evaluation of simulation-based teaching that was developed at the Center for Management Simulation (ZMS) of the DHBW Stuttgart (Trautwein & Alf, 2022). The model combines general aspects of university teaching with specific factors influencing simulation games. It is based on the influencing factors described by Rindermann (2003) (students, teachers, framework conditions) and complements the simulation game and teamwork as relevant factors for simulation based teaching. All aspects together contribute to learning and satisfaction in simulation-based courses (cf. the model at a glance, Figure 1).

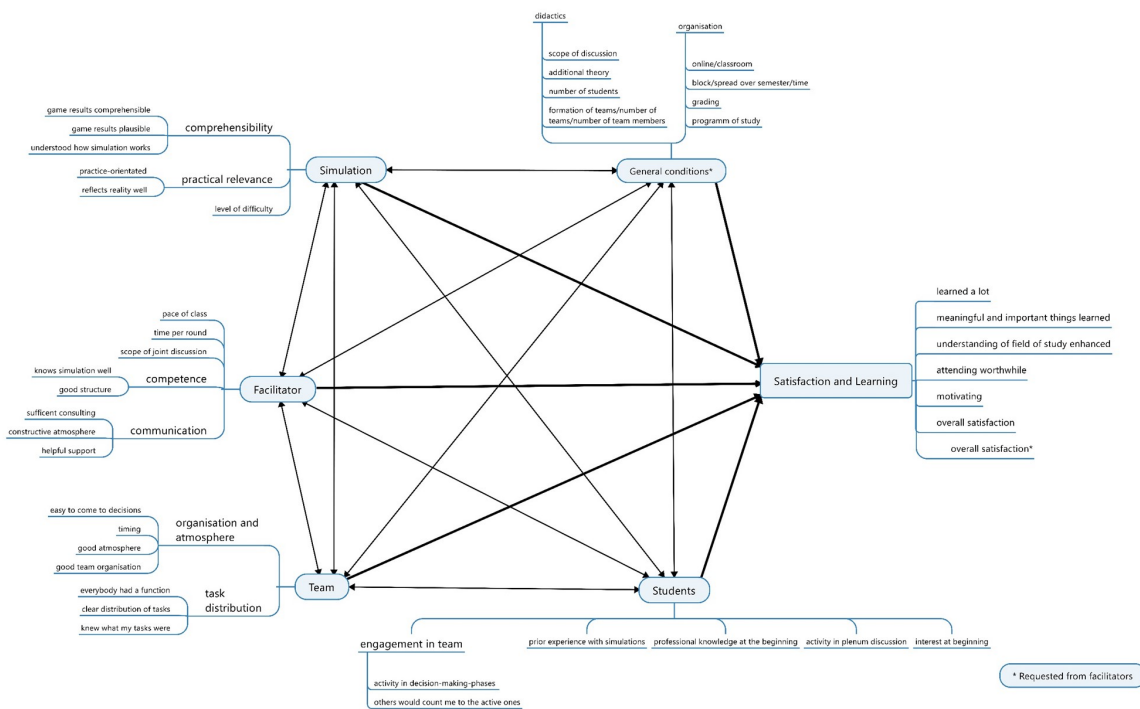


Fig. 1. Model for the evaluation of simulation-based teaching, own presentation¹

In accordance with the model, 8 scales were formed from 27 Likert-scaled items for this study. All questions were answered on a six-point Likert scale, mostly ranging from “do not apply at

¹ The questionnaires based on the model for participants as well as facilitators are available on <https://zms.dhbw-stuttgart.de/forschung/forschungsprojekte/>

all” (value = 1) to “fully apply” (value = 6). Two scales deal with aspects of the simulation game: how well the game is understood by the learners (comprehensibility) and how well the simulation represents the real world (practical relevance). For both scales, the data used in this study show good values for Cronbach’s alpha of .833 and .861. Two scales with two and three items measure teaching-specific aspects of the facilitation: on the one hand, the perceived competence of the facilitators (alpha .782) and, on the other hand, their communication with students (alpha .895). Two other scales survey aspects of teamwork: Organization and Atmosphere summarizes items that indicate how “easy” or “good” teamwork is (alpha .815). The Task Distribution scale provides information about functions and tasks within the team (alpha .814). The Engagement scale indicates how intensely students are involved in the game and shows an alpha value of .783. In the logic of the model, the Satisfaction and Learning scale is the dependent variable because it represents the goal of teaching. It consists of three items related to learning and three items related to overall satisfaction and has an alpha value of .938.

The present study incorporates data from 2119 students from a total of 124 simulation game courses with 30 different simulation games. All data were collected from May 2021 to August 2022 at DHBW Stuttgart. The simulation games used are predominantly business simulation games. Among them are 20 computer-based simulation games and 10 haptic simulation games. In the case of haptic simulation games, the simulation takes place on a game board on which figures and symbolic materials (money, goods, etc.) are moved. Computer-based simulation games, on the other hand, work with input masks in which decisions are transmitted. The simulation then takes place via programmed computer calculations. In particular, the implementation of haptic simulation games in online teaching presented teachers with major didactic challenges and required many adaptations. To ensure that haptic simulation games could also be used during pandemic online teaching, specific settings were developed by the ZMS and made available to instructors. For the most part, digital collaborative whiteboards were used to digitally recreate what were actually haptic processes.

All of the seminars evaluated here (face-to-face and online) are designed as block seminars and can last between half a day and a maximum of three days, depending on the simulation. In all cases, the seminar started with a briefing and ended with a debriefing, without any pre- or post-seminar work. During the entire time, instructors are on site or in the online meeting to guide and moderate the simulation and to be available for questions.

5 Results on the research questions

In the following the research questions raised in this study are analyzed and discussed on the basis of the empirical data. For better readability, not all data are reported in the text. A detailed overview of the empirical data can be found in Table 2, to which reference is made in each case.

		All simulation games					Computer-based simulation games					Haptic simulation games				
		N	Mean	Sig.	Mean Difference	cohen's d	N	Mean	Sig.	Mean Difference	cohen's d	N	Mean	Sig.	Mean Difference	cohen's d
Comprehensibility	Online	1137	4,85	0,291	-0,04		926	4,81	0,000	0,19	.206	211	5,04	0,087	-0,11	.141
	F-to-F	951	4,89				460	4,61				491	5,16			
Practical relevance	Online	1136	4,32	0,657	0,02		925	4,38	0,035	0,13	.121	211	4,06	0,001	-0,28	.264
	F-to-F	949	4,30				458	4,25				491	4,34			
Facilitation, Competence	Online	1136	5,43	0,000	0,19	.221	925	5,46	0,037	0,10	.123	211	5,27	0,038	0,16	.161
	F-to-F	949	5,23				460	5,36				489	5,11			
Facilitation, Communication	Online	1136	5,42	0,000	0,18	.215	925	5,46	0,000	0,17	.208	211	5,24	0,474	0,06	
	F-to-F	949	5,24				460	5,29				489	5,18			
Organisation a. Atmosphere	Online	1133	5,10	0,014	-0,09	.108	922	5,09	0,259	-0,05	.064	211	5,13	0,149	-0,10	
	F-to-F	947	5,19				460	5,14				487	5,23			
Task Distribution	Online	1132	4,47	0,000	-0,22	.179	921	4,41	0,041	-0,14	.114	211	4,71	0,310	-0,10	
	F-to-F	945	4,69				460	4,55				485	4,81			
Engagement	Online	1129	5,09	0,030	0,10	.096	918	5,11	0,386	0,05		211	5,03	0,277	0,09	
	F-to-F	945	5,00				459	5,06				486	4,94			
Satisfaction and Learning	Online	1129	4,41	0,003	-0,15	.132	920	4,49	0,479	-0,05		209	4,06	0,000	-0,52	.474
	F-to-F	945	4,56				460	4,54				485	4,58			

Table 2. T-Tests: Face-to-face (F-to-F) / Online

Research question 1: What are the differences in simulation-based face-to-face and online teaching courses in terms of student engagement and teamwork?

Significant differences between face-to-face and online simulation games are evident for both student engagement and teamwork. The atmosphere in the team (face-to-face 5.19 versus online 5.10 on the six-point Likert scale) and the task distribution in the team (face-to-face 4.69 versus online 4.47) are both slightly higher for face-to-face simulation games (Table 2). This result seems understandable. It can be assumed that the conditions for good teamwork in face-to-face seminars are better than in online seminars. It is less expected that teamwork in online events is rated only minimally lower than in face-to-face events. However, the result show that interactive elements can also work well in synchronous online teaching. It is also astonishing that the commitment of students in online courses is somewhat higher than in face-to-face courses (online 5.09 versus face-to-face 5.00). Possibly students see themselves as more independent and somewhat more engaged when they participate in online simulation games. However, a look at the mean differences and the effect size (Cohen's d^2) shows that the differences are very small. For all three scales considered here (engagement, team task distribution, team organization and atmosphere), Cohen's d is less than .02, so the differences have little practical relevance and should be interpreted very cautiously³.

Research question 2: What are the differences in simulation-based face-to-face and online teaching courses with regard to teachers (communication, comprehensibility)?

There are also significant differences in the assessment of lecturer behavior between face-to-face and online simulation courses. Remarkably, both the competence of the lecturers (5.43 versus 5.23) and their communication (5.42 versus 5.24) are rated slightly better in online teaching than in face-to-face teaching (Table 2). Even though the Cohen's d effect size is somewhat larger than for student engagement and teamwork (competence 0.221 and communication 0.215), the effect size is still small and the practical relevance is thus rather low. With regard to the reasons for the results, the present survey does not allow any empirically validated statements. With regard to communication in particular, it would be interesting to find

² According to Cohen (1988, p. 25), $d=0.2$ is a small effect, $d=0.5$ and above is a medium effect, and $d=0.8$ and above is a large effect.

³ The fact that the results are nevertheless significant despite their low practical relevance can be explained by the high number of cases, with which even (very) small overrandom effects can be elucidated.

out which factors are responsible for the better perception of communication in online courses and whether conclusions can be drawn from this for the further development of face-to-face teaching. It is possible that the slightly higher rating of the lecturer variables is also due to the comparison with other events during the pandemic-related online teaching. Lecturers in simulation games (through visits to breakout sessions, interactive briefings and debriefings) might be rated as particularly communicative, but not in comparison to face-to-face simulation games, but rather in comparison to immediately preceding online seminars during mandatory online teaching.

Research question 3: What are the differences in simulation-based face-to-face and online teaching courses with regard to the assessment of the simulation game (comprehensibility and practical relevance)?

At first glance, students do not seem to evaluate the simulation games in face-to-face and online teaching differently. Table 2 shows no significant differences across all simulation games for the two scales for the simulation game (understanding and practical relevance). However, if we differentiate between computer-based simulation games on the one hand and haptic simulation games on the other hand, at least small differences become visible: Both comprehension (face-to-face 4.61 versus online 4.81) and practical relevance (face-to-face 4.25 versus online 4.38) of the simulation game are rated better in online teaching with computer-based simulation games. For haptic simulation games, however, practical relevance (face-to-face 4.35 versus online 4.06) and tendentially (not significantly) comprehension (face-to-face 5.16 versus online 5.04) are rated higher when conducted face-to-face. These opposing effects between computer-based and haptic simulation games level each other out, so that no difference between face-to-face and online teaching is apparent when all simulation games are considered (Table 2). It is noteworthy that the haptic simulation games hardly perform lower in terms of practical relevance and comprehensibility in online than in face-to-face teaching and that the effect sizes are only small. This indicates that the didactically and methodologically challenging transfer of haptic materials into digital forms was so successful that the simulation games were still comprehensible and understandable for students.

Research question 4: What are the differences between simulation-based face-to-face and online teaching in terms of student learning and satisfaction?

If we look at all simulation game seminars examined, the face-to-face simulation games perform slightly better in terms of learning and satisfaction from the students' perspective than the online simulation games (4.56 versus 4.41 on the six-point Likert scale), again with a low effect size (cf. Table 2). However, a more detailed analysis with a distinction between computer-based games and haptic simulation games in face-to-face and online teaching shows that this effect can be attributed to the haptic simulation games in online teaching. If only computer-based simulation games are included in the comparison between face-to-face and online teaching, there is no significant difference. Rather, the reason for the slightly lower rating of online teaching for all simulation games can be found in the haptic simulation games in online teaching. For further analysis, groups were formed with four different ways of conducting simulation games:

- Online teaching with computer-based simulation games.
- Face-to-face teaching with computer-based simulation games
- Online teaching with haptic simulation games
- Face-to-face teaching with haptic simulation games

A comparison of the mean values of these groups with regard to learning and satisfaction confirms the previous analyses. While the variant online teaching with haptic simulation comes to a mean value of 4.1 for learning and satisfaction, the other variants cluster around a mean value of about 4.5 (see Table 2 and Fig. 2). Accordingly, the one-factor analysis of variance (ANOVA) turns out to be highly significant (Sig. <.001) and confirms the graphically visible result. Pairwise mean comparisons (post-hoc tests: Bonferroni and Student-Newman-Keuls) verify that it is the online teaching with haptic simulation game variants that differs significantly from all other variants, while the other three variants do not differ from each other. Online

courses with haptic simulation games are evaluated noticeably lower by students than the other variants. The decisive factor is the obviously inappropriate composition of digital teaching and the (usually) haptic game material. Despite the complex transformation of the board games into the digital space, "haptic" simulation games can only develop their potential to a limited extent in online seminars.

Looking at the overall evaluation (learning and satisfaction) for haptic simulation games, in addition to the largest mean difference reported in this study (0.52 points on the 6-point scale), the largest effect size is also striking. With an effect size of $d=0.474$, this is an approximately medium effect that stands out from all other effect sizes (Table 2).

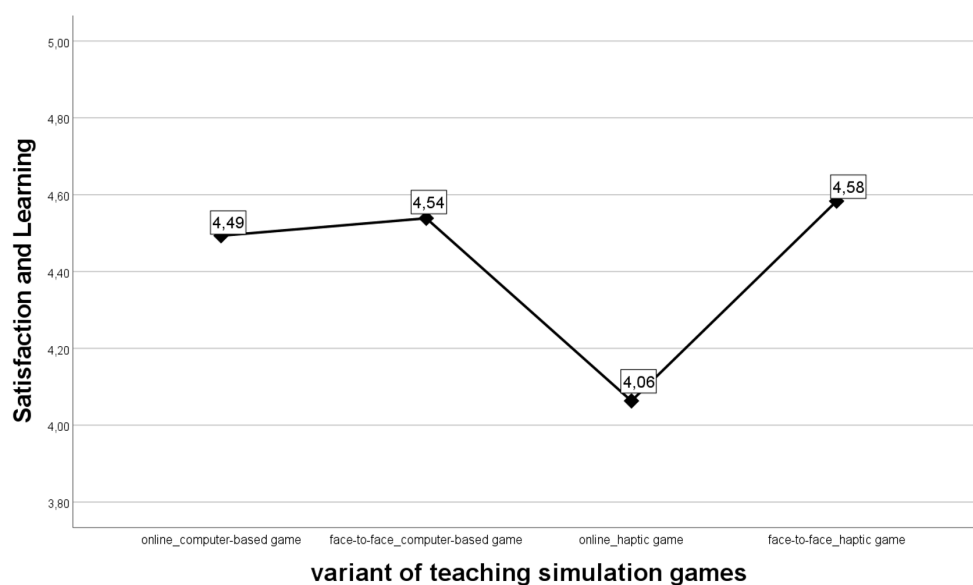


Fig. 2. Learning and satisfaction by type of simulation game implementation

In contrast to haptic simulation games, seminars using computer-based simulation games do not differ significantly in terms of face-to-face or online implementation. This opens up the possibility for lecturers not to be bound to one format in the future design of study and lecture plans, but to be able to decide between alternatives that are equivalent according to the current state of research.

6 Conclusion and discussion

With the start of pandemic-related online teaching at universities, concepts for the implementation of simulation-based seminars had to be developed within a short period of time. On the basis of a huge quantity of evaluation data, this paper aims to show and discuss to what extent this has been successful, and where similarities and differences between face-to-face and online teaching can be found.

Simulation games are a very complex teaching and learning method in which various components must come together: technical requirements and implementation of the simulation game, space for teamwork and decision-making, content-related and technical introduction to the simulation game by instructors, opportunity for interaction between individual teams and instructors, and opportunity for interaction of all teams with instructors in the plenum. Despite these high hurdles, the evaluation data show that simulation games as a complex learning arrangement can be implemented very successfully in online teaching.

At first glance, this result may seem surprising. Before the pandemic, most experts would probably have judged that simulation games could hardly be integrated in online teaching.

However, in an empirical comparison of distance learning courses with face-to-face courses, Gerhard et al. (2015) conclude that it is not the distinction between face-to-face and online teaching that is decisive, but rather the didactic preparation of the learning material and the quality of the media implementation. Lehner and Sohm (2021) take up this idea and emphasize that above all the "qualitative design" of the teaching is important and this is independent of the question whether face-to-face or online. In a qualitative research study on the characteristics of good online teaching from a student perspective, it becomes clear that social interaction with teachers (taking time, being available, responding to queries) in particular is seen as crucial (Hawlitsek et al., 2022). Especially in synchronous online teaching, social interaction can succeed well with video conferencing systems (cf. Kirchner, 2021). At the push of a button, it is possible to switch between plenary and small groups, and instructors can easily visit small groups to discuss issues. Accordingly, the question of face-to-face and online teaching is only superficially relevant. In both variants it depends on the concrete design of the course and the interaction. In the literature specific to simulation games (Kriz, 2010; Roungas et al., 2018; Schwägele et al., 2021), the importance of professional facilitation for the successful implementation of simulation games is frequently pointed out. Through questions, suggestions, and guidance, students should be enabled to learn based on the simulation game. Again, this aspect is not dependent on face-to-face or online teaching. In both variants, facilitation can succeed using certain methods and forms of communication. Being physically present in one place at one time does not make good teaching. It is the lecturer, the type of interaction, the didactic preparation and the in-depth examination of a subject that make for good teaching – face-to-face and online.

As a conclusion, it can be stated that synchronous online teaching with business games works well. In some cases, the results for online teaching are even slightly better than for face-to-face teaching: for example, the communication skills of the lecturers are rated better. Even if students value face-to-face teaching in terms of learning and satisfaction slightly more than online teaching, detailed analyses show that this effect is due to the constellation of online teaching with haptic simulation games. Overall, the differences found are rather small (only small effect sizes).

The distinction between face-to-face and online teaching is not very relevant for the question of "good teaching". Teaching can succeed well in both worlds. However, whether teaching is held in a face-to-face or online format is very relevant for the organization of game-based learning in the future. Whether it is the development of future university programs or learning in a business context, the experience from the pandemic should be used. Our research data suggest that the transition of simulation game courses from face-to-face to online teaching during pandemic was successful. This offers new perspectives for the organization of classes and trainings with regard to cross-faculty, cross-university, and even cross-state cooperation.

7 Restrictions

Even though the large number of data allows empirically well-supported conclusions for the use of simulation games in teaching, some restrictions have to be considered.

One aspect is that the data were collected exclusively from courses conducted at the Cooperative State University Stuttgart (DHBW). Due to the specific composition of the student body and the very close integration of theory and practice in studies at DHBW, the results cannot necessarily be transferred to simulation game classes at other types of higher education institutions (especially research universities, universities of applied sciences). In addition, there is an institutional aspect: At the ZMS, where the entire data collection took place, knowledge about simulation-based teaching is institutionally bundled. It is regularly deepened and shared in workshops for simulation game lecturers. Didactic concepts were rapidly developed and tested at the beginning of the pandemic. In addition, a large proportion of faculty at the ZMS have been active in game-based teaching for years. This institutional component may also contribute to the fact that simulation games in online teaching are evaluated similarly well as simulation games in

face-to-face teaching. To what extent this institutional aspect actually has an influence should be explored in further studies. In the already planned extension of the study, students from other universities and, according to the conception, also participants in simulation games in the context of further education events as well as in schools will be included.

Another aspect is that at the time when the simulation game lectures were facilitated online, most other seminars were lectured online as well, and at the time of the face-to-face simulation game events, the other lectures were mostly face-to-face as well. Accordingly, at this point in time, the study cannot make any statement about how online simulation games are evaluated when the majority of the other lectures take place face-to-face and vice versa.

The survey is also based largely on students' perceptions. Even if studies prove the high judgment competence of students (cf. Cronan et al., 2012; Rindermann, 2003) and the perception of students has significant advantages over an external assessment (for example, the perception of students is action-guiding for them and can also be more differentiated than would be possible, for example, through observation), this is accompanied by problems (Spinath & Seifried, 2018), which should be taken into account when evaluating the results.

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Towards Ludic Truths & Affective Interaction: The Rhetoric of Social Change Games

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Abstract. Social change games (SGCs) address a number of issues ranging from poverty and homelessness, to refugee crises and human rights. They strive to function as tools for social justice: capturing differences and inequalities, challenging status quo, and stimulating change. However, little is known about how these games work and what kind of rhetorical strategies they use. This study examines SGCs specifically related to humanitarian issues. Game design patterns are used as an analytical tool for understanding these games. The design patterns were instantiated from gameplaying and the consistent observation of mechanisms pertaining to these games. Through our analysis, we identified key organizational patterns driving the games forward, through reconstructing personal experiences, or through the design of a documentary narrative and subsequent gameplay. Thereafter a number of patterns sustaining the games are further defined: those conveying the authenticity of issues presented in the games, stimulating players' emotions, and bridging the game to the players' world. We discuss how these games are situated within a framework of humanitarian rhetoric and thereupon function to captivate players. Then, we discuss issues and limitations of SGCs. SCGs should engage players in a journey of transformation and stimulate change. Thus, by elaborating these game patterns, we aim to provide conceptual tools for critical reflection and to support the design of engaging SCGs.

Keywords: Social Change Games, Game Design patterns, Rhetoric.

1 Introduction

Social Change Games (SCG) approach a range of contemporary social problems including political instability and war, human rights, or socio-emotional issues connected to endemic poverty. For example, SCGs attempt to address the crucial issue of refugee or homelessness visibility, by describing the endemic conditions they suffer and prejudices they received. Some SCGs are intended as social commentaries, bearing witness, and providing empathic documentation. SCGs produce vicarious emotional experiences, allowing spaces in which players can experiment, grow, and learn to sustain change. SCGs reach different audiences like the younger "YouTube generation", or those feeling disfranchised by more traditional media.

In this paper, we studied a subset of SCGs dedicated to humanitarian issues. Thus, to better understand how these games might work, we propose to identify some of the strategies at play involving key issues pertaining to SCGs. We analyse social change games and their dynamics through the elaboration of game design patterns. The game patterns that we have developed are instantiated from gameplaying and the consistent observation of mechanisms supporting humanitarian game design. Identifying game design patterns enables us to highlight rhetorical strategies at the heart of these games.

The results of our analysis, the most fundamental game patterns that emerged from our investigation, are presented here. We discuss how social change is structured in SCGs through the REPORTER and VICTIM AS LIVED EXPERIENCE patterns. Issues are substantiated to give the games credibility through INFORMATION SOURCES. Engagement and affective interaction are sustained through EMPATHY FOR VICTIMS and TAKING PHOTOS. By contributing conceptual tools in the form of game design patterns, we aim to stimulate critical reflection about such games, as well as provide devices to develop engaging SCGs.

2 Background – Social Change Games

Although we refer to social change games in this article, such games have also been labelled as games for change or social impact games. Moreover, there is some overlap between SCGs and some persuasive, transformational, documentary, or news games. While some of these games focus on humanitarian issues most do not. Their emphasis is much broader, dealing with environmental, health, or current political subjects.

More generally, humanitarian SCGs deal with issues related to critical threats to the health, safety, security, or well-being of a group of people, often those living at the margins of “modern” society, or vulnerable populations confronted by major disasters (www.humanitariancoalition.ca). SCGs explore social issues and questions, thus adopt specific perspectives to represent issues in distinct and compelling ways. SCGs, therefore, strive to engage players on a meaningful level.

Flanagan and Lotko [10] first argued that fundamental social values can be transmitted through critical play. Dahya [9] discussed some of SCGs’ failures and successes, emphasising the importance of translating the games’ objectives into meaningful playable elements. Lavender [16] looking at *Homeless: It’s No Game*, established that players can become more attuned to homelessness if they find the game more realistic and credible. Rao [21] looking at persuasive strategies in SCGs, proposes that simulation of experiences as well as anchoring the games in real-life actions might work. O’Brien and Berents [20] studying three games aiming at raising awareness about human trafficking focused on the role of individualised narratives and storytelling devices. They highlight the stereotypical effects that those devices might have on the representation of the victim. Navarro-Remesal and Zapata [18] critically analysed refugee games depicting journeys taken while fleeing. They argued that these games portray the refugees’ experiences, and are supported by representations of suffering.

3 Game Patterns and the Study of Social Change Games

SCGs seek to convey humanitarian issues by embedding specific rhetorical arguments through game play, game rule-sets, game mechanics, and representations. To explore design strategies and devices at the heart of humanitarian SCGs in more depth, we turn to game patterns as a methodology to analyse those games. Moreover, identifying game patterns could also sustain future developments.

Alexander et al. [1] first developed design patterns in the context of architecture. Since then, they have been applied to user interface design, video games, and serious games. Game design patterns are a way of codifying design knowledge. A design pattern is often defined as a general reusable solution to a commonly occurring problem. Through their uses, they become general principles that are then adapted to specific contexts.

Game design patterns have also been utilised as an analytical tool for understanding the design of computer games or player experience [4]. For example, Kelle et al. [14] – proposing a methodology for the design of games for lifelong learning – matched patterns to learning functions. Argasiński and Węgrzyn [2] looked more specifically at affective serious games, and new ways of using patterns to enhance affective learning.

To investigate humanitarian SCGs, we elaborated game patterns to identify key mechanisms involved in their designs. To do so, we first collected and investigated a large number of social change games from well-known portals such as *Games for Change*, (<https://www.gamesforchange.org/>), and *Serious Game Classification* (<http://serious.gameclassification.com/>), a catalogue of more than 3,000 games. We also consulted websites from Non-Governmental Organisations (NGOs), foundations (e.g., Knight Foundation), companies specialising in this domain (e.g., Global Conflict), and game labs (e.g., MIT Purposeful Games for Social Change).

Games were selected based on their critical reception and relevance to the humanitarian area. SCGs were examined through game walkthroughs and playing them, taking screenshots, and making short clips, as well as writing extensive notes throughout. Game patterns were then

identified, describing the patterns as prescribed by the methodology proposed by Björk and Holopainen [4]. Typically, the template includes the NAME of the pattern (written in small caps), then documents a problem or design goal, the solution chosen, and how it works concretely through examples.

The examples for each pattern were chosen for their reoccurrence, saliency, and critical design potential. The patterns are not intended to be prescriptive, but rather to capture common elements, which can be re-used in new creative ways. We present game design patterns pertaining to two fundamental aspects of humanitarian games:

1. Those associated with documentary narrative, gameplay, and ludic truth.
2. Those connected to personal experiences and affective interaction.

4 Game Design Patterns in Humanitarian SCGs

We can see SCGs as a rich set of signs with the gameplay involving a kind of social semiotics. The representations of situations, people, and their behaviour within the game world can be understood by players based on their experience in interpreting signs transmitted by media, as well as, their understanding of the real world.

4.1 Documentary Narrative, Gameplay, and Ludic Truth

By developing documentary narrative strategies through the REPORTER pattern, SCGs can be structured to emphasise human issues at stake. Through engaging game mechanics and convincing arguments for uncovering facts, SCGs thus aim to supply alternative readings of the real world and stimulate social justice. Moreover, they need to be able to convey an impression of authenticity and legitimacy, hence specific patterns are used such as INFORMATION SOURCE for creating credible and convincing accounts. TAKING PHOTOS is a tool for reporting but also acts as a source of evidence and reflection bridging the game world to the world beyond its frame [3].

REPORTER

Definition: REPORTER is the use of a journalist or photographer following an investigation as the player's avatar.

Problem/Goal: To enable players to understand complex issues and socio-cultural problems, the game should support the integration of information from a variety of sources, formats, and modalities. The gameplay should be organised and rendered in a way that enables exploration, supports discoveries, and engages players.

Solution: Using a REPORTER following an investigation provides a powerful metaphor for organising and advancing the gameplay. The public understanding of journalistic investigations and its practices such as researching issues, interviewing witnesses, and uncovering hidden truths is used to structure the gameplay and advance arguments. Moreover, journalistic dramas in films and books also supply the emotional structure that helps to sustain the gameplay. Climax is built through suspense and empathy as the quest for truth progresses, enabling a variety of emotions such as horror or disgust, but also excitement and satisfaction with each discovery until resolution.

In that way, SCGs can progress in a dramatic manner through the game environment. This pattern provides a powerful tool for engaging players as they identify with reporters and their experiences, and along the way get to know intimately the plights of victims.

Examples: In *Pictures for Truth*¹, the player is a journalistic photographer sent to help their best friend Jun Shen, a human right activist in China, whose mission is to uncover and document human right violations at a computer dump (see also TAKING PHOTOS). *Inside the Haiti Earthquake* deals with repercussions from the disaster looking at issues arising while moving

¹ All the games discussed in this paper are cited at the end, in the ludography section

forward. The player can choose to play as a journalist trying strategies and experiencing resulting consequences while reporting.

Most games of the Global Conflict Series are constructed around this pattern such as *Sweatshops or Checkpoints*. *Sweatshops* takes place in Bangladesh and addresses social issues surrounding children's labour and children's rights. In *Checkpoints*, where the player investigates human rights violations on the Israel/Palestine border, players have to choose from which perspective to tell a story. Besides human rights, the game also raises issues of media objectivity. Other examples include *1979 Revolution: Black Friday* (about the 1978 uprising against the Shah), *Ground Reporter: Darfur* (i.e., conflict in West Sudan).

The use of reporter has also been documented by Wai and Yu [15] in *Eyewitness*. The game relates to the Nanking Massacre in China in which the player takes the role of a cameraman assigned to report on the Japanese invasion. More generally, REPORTER is also found in serious games and in video games (e.g., *Beyond Good and Evil* where the main protagonist Jade is an action reporter) although with different aims and effects.

INFORMATION SOURCE

Definition: INFORMATION SOURCE refers to the inclusion of documentary evidence in the design of SCGs such as news articles, stock or archival footage, and photos as primary and secondary sources of information.

A primary source provides direct or first-hand evidence about an event, object, or person. A secondary source cites, comments on, or builds upon primary sources.

Problem/Goal: SCGs strive to convince players to pay attention and reflect on specific social issues conveyed through the gameplay as a "real" problem that needs to be solved. Thus, they aim to supply an objective connection to the reality depicted in the games and/or to the veracity of the arguments presented in the games. Moreover, if we expect to transform dispassionate players into engaged citizens, SCGs should appear as genuine and as credible as possible.

Solution: To include documentary footage, photos, and other historical archives, as well as eyewitness reports to authenticate the issues and legitimate the game in the players' minds. It creates an effective link between the gaming world and the real world.

The use of documentary footage contextualises the game's problem, provides information, and enhances emotional engagement. The rhetorical value of this pattern is better understood by looking at its function in documentaries which use these artefacts as evidentiary value, i.e., as witnesses to particular events. INFORMATION SOURCE lends verisimilitude and credibility to SCGs.

Rather than including documentary evidence directly in the game as a primary source, it can be synthesised as a secondary source and embedded in games through diverse game objects, characters, and dialogues. Moreover, if the pattern is used in conjunction with REPORTER – with the player's avatar gathering information from different sources including carrying out ersatz interviews – taking photos can provide authority and trustworthiness associated with journalism. This, in turn, helps to make the game's viewpoints and issues appear more credible. Part of this pattern's strength is conveying to players that they are playing/being exposed to "real evidence."

Besides rhetorical functions associated with truth, credibility, and authenticity, INFORMATION SOURCE can add a dramatic dimension to shock or engage players. The inclusion of testimonial and eyewitness reports can add substantially to the game by creating emotional empathy between the player and the plight of victims. Using this pattern can enhance players' motivation and engagement, creating possibilities for dramatic and transformative play.

Examples: We have found INFORMATION SOURCE at the beginning of games such as *Food Force* and *Against All Odds*, depicting disasters and images of war-torn countries. *Food Force*, a game about the logistical challenges of delivering aid during a major humanitarian crises, also integrates cut scenes of the World Food Program's work in the field between game missions. *Against All Odds* aims at letting players experience what it is like to be a refugee. By depicting the horrific situations faced by victims, this game highlights the urgency of the situations and

need for change. *Food Force* and *Against All Odds* derive a semblance of authenticity from the footage kernel at their core, they create an “illusion of realism.”

Another interesting instantiation of this pattern is found in *Mission*, a 2D platformer, in which players have to overcome the daily obstacles and reach goals to improve the lives of Andre or Jeff (i.e., real homeless persons). Testimonials of their aspirations and lives are spread through the game and are delivered in the form of sound bites and pictures (allegedly written and designed by the homeless themselves).

A number of SCGs claim to use accurate INFORMATION SOURCES in their design such as *Homeland Guantanamo* and *Hurricane Katrina: Tempest in Crescent City*. *Homeland Guantanamo* depicts a detention centre for asylum seekers in the US. The game is based on the real-life story of a detainee who died there and thus integrates a number of authentic facts and events related to the deceased. *Hurricane Katrina: Tempest in Crescent City*, connected to the crisis in New Orleans relies most heavily on information, facts, and quotes from secondary sources, as well as, from primary sources. The designers felt strongly that the game needed to be historically accurate, thus used online news articles as sources. They also consulted with a friend, a Katrina evacuee, about the game design.

TAKING PHOTOS

Definition: TAKING PHOTOS is when players capture photos from the game with a tool (e.g., camera) embedded in the game, as a source of evidence to be used as part of the gameplay and beyond.

Problem/Goal: Chronicle the progress of an investigation, thereby keeping track of game events, which can be used to affect the gameplay and/or may produce results that transcend the game world. The mediation between the gameplay and the real world is especially crucial for social advocacy, where reaction and then action is needed to transform players into activist citizens.

Solution: TAKING PHOTOS is a natural artefact of a journalistic investigation and it has a dual role (within and outside the gameplay). TAKING PHOTOS has different game functions such as triggering events or changing the outcomes of a game, thus also affecting the players' experiences.

Beyond their roles within the game mechanics, the three main rhetorical functions of TAKING PHOTOS are mnemonic, informative, and affective. The photos form a memento and act as a sign of the gameplay. By seeing the photos, a player should be able to remember the gameplay more vividly. These photos can be associated with the emotions triggered by the gameplay experience. This function can have important implications for debriefing by allowing players to reflect on their gameplay choices and affects.

TAKING PHOTOS links the gameplay and the real world, pushing the boundary of a game further. Thus, TAKING PHOTOS can be used to stimulate the willingness of players to create interesting artefacts from the gameplay for affective learning and/or activism.

Examples: The game *Pictures of Truth*, anchored in the game purpose REPORTER, engages players “by investigating, taking pictures, and publishing your articles ... to solve the problems you encounter and eventually save your friend!”² Similarly, *The Invisible Hand*, challenging the fairness and equity of the free market, gives players a smartphone so they could record, film, take photos, and gather precious information from the gameplay to spread the message. *1979 Revolution: Black Friday* also used photos of the repression experienced, for example by non-player characters during the gameplay.

More powerful utilisation of TAKING PHOTOS are found in *Eye Witness* and in video games. In *Eye Witness*, as a cameraman TAKING PHOTOS, the player acts as a witness and documents events. However, these photographs influence the outcome of the game (e.g., who is being prosecuted). The more integrated the photos are in the gameplay, the higher the chances that players take and pay attention to them.

² Quote taken from within the game.

4.2 Documentary Narrative, Gameplay, and Ludic Truth

Games have the power to reconstruct personal affective experiences [5]. As Rao [21] as well as O'Brien and Berents [20] discuss, some SCGs are based on simulating experiences. SCGs are thus structured to emphasise human issues at stake as in *VICTIM AS LIVED EXPERIENCE*. Galloway [11] parallels such games giving “documentary like attention to the everyday struggles of downtrodden” to neorealist cinema. The game experience should take players on a journey of personal evolution, which includes the motivation for caring and acting. Thus, emotional experiences should be carefully crafted into SCGs, as an essential element for developing social awareness.

Empathy is a complex process involving both cognition (perspective, role taking) and emotion (experiencing somebody else's emotions), which helps to develop socially and emotionally responsible action [7]. Thus, *EMPATHY FOR VICTIMS is an important pattern that needs to be fostered in the games to motivate prosocial behaviour.*

VICTIM AS LIVED EXPERIENCE

Definition: *VICTIM AS LIVED EXPERIENCE* provides a window into the struggles and experiences of people living and confronting difficult situations, hardships, or social injustices.

Problem/Goal: In order to promote social justice, players should understand some of the complexity or intricacy of social issues, through exploring causes and effects and getting insights into socio-emotional traumas faced by victims, reaching conclusions, and acting for changes. The goals of this organising pattern range from creating awareness and producing emphatic documentation to criticism and desire for changes.

Solutions: The game is centred on victims and is designed to simulate the lived experience of asylum seekers, refugees, war victims, homeless, etc., showing as in cinema vérité, the authenticity of life as it is lived.

SCGs use their simulative powers to give players the compelling and personal experience of being thrown into desperate or even life-threatening situations. *VICTIM AS LIVED EXPERIENCE* should connect emotionally with players to reveal hidden truth, urging an active response and challenging them to act. This pattern can be situated within the tradition of social documentaries and neorealism cinema, revealing situations in which people are confronted by conditions perceived as discriminatory, unjust, or harmful, etc.

The game world, game mechanics, and game events should all function to demonstrate the real-life struggles of victims, their tribulations, and their problems. By resolving dilemmas with them, players are confronted with complex hardship dynamics and the disempowerment faced by real people. Dramatising social issues in a meaningful way through gameplay should lead players to a greater understanding of the social issues and thus, in turn, stimulate social changes.

Examples: This pattern was found in *Against All Odds*, *Escape from Woomera*, *Ayiti*, *Change: A Homeless Survival Experience*, etc. In these games, players follow the day-to-day life of a teenage immigrant, a refugee, a victim of oppression, or an impoverished inhabitant.

In *Ayiti*, the game characters (a family) must face adversity and disasters and accumulate enough wealth through hard work and bad working conditions to remain healthy and to get educated to improve their chances. Indeed, this is nearly an impossible task.

As described by the designers, *Escape from Woomera* invites players to 'live' through the experiences of an asylum seeker by simulating their daily life. Players thus will grasp the horrendous conditions and struggles of the camp's inmates, their helplessness, and their desire to escape. Similarly, *Change: A Homeless Survival Experience* is described as a “homeless survival simulator” where the player has to survive by managing hunger, hygiene, depression and then escape homelessness.

In *Against All Odds*, the player plays a teenager running from persecution in their homeland. Players thus follow the teenager's perilous journey, from their escape to safe haven, going through the asylum-seeking process, and finally to their life in a new country. According to the

designers, the game is intended to increase students' awareness and knowledge about refugees – where they come from, what situations they have faced and how they adapt to their new lives.

EMPATHY FOR VICTIMS

Definition: EMPATHY FOR VICTIMS involves a degree of identification with victims, thus experiencing, in some measure, the feelings, perspectives, or attitudes of someone else.

Problem/Goal: In most cases, the experiences that refugees or asylum seekers experienced are far removed from the reality of the majority of the games' target audiences. Players should not only be moved by the plight of the characters depicted in the game, but should come to share their feelings and reactions, and understand the complexity of the situations that confronted them.

Solution: SCGs intend to foster a degree of EMPATHY FOR VICTIMS, and subsequently to motivate players to play the game and then act. SCGs can foster empathy for others through character development. Characters are provided with a history of personal tragedies such as personal events (e.g., death, trauma, adversity) which explain their actions and support the social issues depicted in the game. Moreover, by playing as a refugee or immigrant, etc., and interacting with other victims, players can better understand how situations faced by the character affect them, and so become attuned to their predicaments. However, in most SCGs character design does not generally lend itself to affective mimicry, most characters are curiously flat without visible emotional reactions.

Examples: In *Homeland Guantanamo* the player is sent on a quest to uncover the fate of Boubacar Bah (i.e., character name), who died in the asylum centre. Thus, to increase empathy, the player is given a picture of the character and some of his personal history. Letting the player discover facts leading to the character's doom as the gameplay progresses supports tension. *Hush*, a small SCG connected to the Rwanda ethnic conflict, creates a strong sense of emotional empathy with the dilemma of a mother whose crying baby is attracting the attention of the militia. The tempo and the success of a player in a matching letters minigame are tied up with, and act as metonymy for the increasingly urgent situation faced by the mother and ultimately in their survival.

Role-playing games are perhaps the most suited for emotional empathy, as they have more complex game mechanics, which can lead to the expression of a strong range of emotions. In games such as *Sweatshop*, the player encounters different victims and tormentors to become gradually attuned to the victims' problems, thus developing some degree of empathy toward those victims. Finally, the players should be moved to take some actions to mitigate or resolve issues presented in the game.

4.3 On Game Patterns and SCGs

It is important to understand the relationships between some of the patterns. REPORTER and VICTIM AS LIVED EXPERIENCE are high-level organisational patterns, leading to the use of INFORMATION SOURCE, TAKING PHOTOS, or EMPATHY FOR VICTIMS to support social awareness. As can be expected, TAKING PHOTOS is often linked and used in connection to REPORTER. However, in some cases, diaries are used to extract and store pieces of information collected in the game instead of TAKING PHOTOS as tools of investigation. Moreover, TAKING PHOTOS can be found in games independently of REPORTER.

We have presented here a limited set of game patterns but are finalising and developing others. SCGs are still evolving in terms of technology, design, as well as the socio-political context in which they are situated. We have noted, for example, the multiplication of games about refugees, while human trafficking also starts to receive more attention. This, in turn, entails that new game patterns will surface.

Game patterns are not prescriptive but should be used creatively, so utilising them as design solutions in new games will hardly lead to identical games. Indeed, *Pictures for Truth*, *Checkpoints*, *1979 Revolution: Black Friday*, *Ground Reporter: Darfur*, or *Inside the Haiti*

Earthquake all use the REPORTER pattern but are hardly identical. Moreover, innovative interpretations as well as fresh and new ways of combining patterns can be crafted from existing patterns.

5 Discussion

In this paper, we have presented examples of game patterns connected to documentary narrative, gameplay, and ludic truth to personal experience and affective interactions. In this section, we highlight rhetorical strategies at the heart of SCGs, and consider some of their pitfalls.

5.1 Documentary Narrative, Gameplay, and Ludic Truth

SCGs seek to reveal (social injustice), persuade (players), or question (social mechanisms). SCGs are situated within a framework of humanitarian rhetoric. The playable reality of these games is connected to real world events, crisis, and problems represented through discursive practises established by news media, activists, NGOs, and other humanitarian organisations.

Victims, perpetrators, and saviours such as journalists and aid workers are at the centre of humanitarian causes [22]. Victims in SCGs are refugees, civil rights activists, asylum seekers, child soldiers, and so on. Their oppressors are clearly defined (or implied) such as authoritarian regimes or militia groups. The victim-oppressor relationship is often strong and operates in dynamic tension to drive the gameplay forward (e.g., *Darfur is Dying*, *Hush*). Within this dialectic, SCGs, like *Doctors without Borders*, are engaged in bearing witness to injustices and their underlying causes and effects.

Real-world issues are conveyed by the game design through emotional and rational elements instantiated through rule sets, role-play, and affective interaction. Much like social documentaries, SCGs can provide alternative points of view, ways of reconstructing historical events, and ways of questioning interpretations of power [19].

The game rhetoric and affective interaction all work to invoke feelings in the players, point out struggles and inequalities, and urge an active response to help. SCGs have the ability to reconstruct personal experiences rather than just describing them. They can function as a kind of emphatic documentation that can move players. The emotional events that occur in the game itself and the feelings that the game evokes or provokes such as empathy or altruism are essential for social change to be effective.

5.2 Ethics of SCGs and Digital Humanism

We need to be cautious when using SCGs as a tool for change. SCGs only provide limited information or perspectives on issues, some can be quite superficial in their approach, with unfortunate results. *Darfur is Dying* has been criticised for its simplistic moral narrative [13]. As O'Brien and Berents [20] pointed out in relation to SCGs dedicated to human trafficking, those games often choose young and innocent girls as victims thus entrenching stereotypes around the 'perfect' victim. Therefore, SCGs can also perpetuate detrimental stereotypes through gameplaying and their depiction of victims, perpetrators, or saviours [6].

Moreover, we should really think carefully about the ethics of being able to "play" a victim or gamified versions of their experiences. What pitfalls should these games avoid? As discussed, SCGs are often based on victim-oriented rhetoric, depicting vulnerability, and suffering and then demanding action through benevolent emotion-oriented patterns. By showing helpless victims, are we really designing for change? Or are we simply sustaining stereotypes and promoting status quo? As players are we participating in dehumanising spectacles, where sufferers merely become the objects of our play? SCGs should entail social responsibility, to address the cause of injustice besides depicting them and implementing design solutions responsibly.

Some of these criticisms are addressed somewhat by some SCGs albeit in a limited fashion. SCGs are often integrated into websites and linked to various sources of complementary

information. Others, meant to be played in a pedagogical setting, provide a didactic framework to generate meaningful activities and discussions after playing the games.

Instead of being speechless, refugees and homeless can be given voices, as they participate in the game narrative and commentary (e.g., *Mission*), or are involved in the design itself through a participatory design process. Grounded in collective pedagogy and a collaborative game-design process, Jackson [12] proposed an initiative for disfranchised school students to design SCGs that matter to them. Through a series of workshops and the assistance of Omnium lab, a software company specialising in digital media, *Survival* was created with young refugees to recount their migratory experiences.

Ultimately, the goal of SCGs is to motivate players into becoming informed and engaged citizens in collective and community-based efforts, thus in participating fully in social activism. Thus, many SCGs include in the game framework suggestions for actions that follow activism practices such as petition, or donate money, etc. While it might be a small step in the right direction, the efficacy of such suggestions remains doubtful.

The remaining core issue concerned evaluation. Very few games are assessed for the efficacy of their interventions (including commitment to actions), and even less for their ethical quality. As Maler [17] discussed in her Game Developer Conference talk, there can be quite unintended and undesired consequences to some design choices. Thus, as Culyba [8] advocated, an assessment plan should be integrated in right at the start of the game design process.

If we want SCGs to become a powerful tool for change, we should include and integrate ethics within their core design and evaluation framework, not only for the game itself but with respect to a broader societal perspective. Finally, we, as designers, activists, or players, might need to become more respectful in our games' consumption.

6 Conclusion

Situated within a framework of humanitarian rhetoric, SCGs strive to function as tools for capturing differences and inequalities, challenging interpretations of truth and stimulating change. We discussed important organisational patterns, VICTIM AS LIVED EXPERIENCE and REPORTER, which advance the game through neorealism, empathic documentation, and/or journalistic investigation. SCGs endeavour to position themselves as an alternative source of information. A game pattern like INFORMATION SOURCES, following documentary conventions, steps toward ludic truth, by inscribing the believability and authenticity of the issues presented within the games. By creating affective interaction through EMPATHY FOR VICTIMS or TAKING PHOTOS, SCGs provide links to the real world and hopefully engage players in a journey of transformation and activism. Finally, we discussed some of the shortcomings of SCGs and how they might be addressed. By studying the design of SCGs through game patterns, we aimed to supply conceptual tools for reflection as well as for designing innovative SCGs.

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Blooming Engagement in Flower: Computational Analysis of Player Experience on Steam

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Abstract. We investigate player experiences focusing on environmental engagement in the environment-theme game, *Flower*. The research is conducted by analyzing data from Steam, a video game digital distribution platform. A joint computational analysis of reviews of the game and player profiles of the reviewers is conducted. The results and analysis suggest that 1) visuals and music have high importance towards immersive player experiences; 2) embedding environmental messages in a game can provoke environmental awareness but technical and control issues can hinder such messages; 3) players have reflected on environmental issues, and it seems that players having a higher level of creativity tend to reflect more on environmental awareness.

Keywords: Environmental engagement · Player experience · Text analytics

1 Introduction

Environmental issues have become prominent for society. Particularly climate change has been widely recognized a critical issue [23] which can lead to environmental impacts such as extreme weather patterns, rising sea levels, and natural disasters, adversely affecting both human health and well-being, as well as ecosystems and biodiversity [33]. Communicating and raising awareness on such critical issues has become increasingly relevant, and the potential of digital games for these purposes is being explored: the use of digital games to engage players with environmental issues and raise awareness has attracted growing attention both in and outside of academia [1, 2, 7, 12].

Games and play have become a primary cultural form in modern human society [9]. Video games have been advocated as one means to respond to challenges posed by climate change in terms of engaging players and to enhance awareness [3]. The quality of storytelling and interaction makes games a suitable tool to communicate issues that are relevant to human-environment relationships to the public. By offering players playful experiences and engaging them with recreational experiences, games can help to raise awareness, and potentially encourage, inspire, and motivate players to take actions and make changes [26, 35].

This work is devoted to understanding player experiences in *Flower* [40], an environment-theme game. In the game players control the wind to navigate in a environment of simulated nature. It is worth noting that there are no human characters in the game and the players' main task is to restore the nature throughout the gameplay. We study player experiences in *Flower* through player-written reviews on Steam. We collectively analyze the game reviews and the corresponding player profiles of the reviewers. The findings of the analysis aim to discover patterns and characters of player experiences, provide insights, and further contribute to a better understanding of the interplay of environment-theme games on players.

This paper is organized as follows. Section 2 discusses the research background; Section 3 describes the research method with a focus on the text analytical techniques; Section 4 displays the modeling results; Section 5 discusses the implications of the findings and finally, Section 6 offers conclusions, limitations and future opportunities.

2 Background

2.1 Environment, Video Games, and Flower

Using digital games to raise environmental awareness has attracted increasing academic attention [11] [36] [38]. It has been suggested [12] that the “technomediated natures” in video games shape the conceptions of individual and collective agency in relation to the environment. On the other hand, [3] has pointed out that there is a lack of representation of climate change in digital games but digital games possessing messages and signals related to a broader notion of human-environment relationships, e.g., environment as backdrop, resource, antagonist, or text.

Flower is an environment-themed game where players control the wind as it guides a flower petal through different simulated landscapes. The goal of the game is to collect other petals and bring color and life back to a gray and desolate environment. Players use the controller’s motion sensors to move the wind and guide the petal through fields of flowers, interacting with various environmental elements such as flowers, trees, and water. Along the way, the player can collect other petals, which will change the game’s music and sound, and will also change the appearance of the environment, making it more vibrant and colorful. The gameplay is mostly based on exploration and discovery, with no real objectives or enemies, giving the player a sense of freedom to roam around and enjoy the game’s visuals and sound. The game also encourages the player to explore and interact with the environment, as doing so will change the game’s musical score, adding a dynamic layer to the experience. The game is relatively short, but it provides a unique and peaceful experience, with a focus on the beauty and fragility of nature.

Flower has been previously studied in academia with a primary focus on its aesthetic aspects. [12] contends that *Flower* is an example of environmental idealism as it emphasizes “nonhuman and environmental interaction”. The music in the game is analyzed in [34], where the author examines its modularity and how different musical components can dynamically combine during gameplay, while also discussing broader methods for analyzing video-game music and its indeterminate and interactive qualities. Another study [15], uses a Deleuzoguattarian lens to highlight the unique aesthetic and play elements that enable transformative experiences and moves beyond traditional representation-based models of video games to a model of multiplicity and becoming, specifically exploring the potential for “transversal becoming” known as “becoming-imperceptible”. The work [27] analyzes *Flower* together with another game *Shadow of the Colossus* [39] and further connects the notion of “Emancipated Player” [17] and the notion of “literature as cultural ecology” [47], arguing that emancipated play of aesthetically complex videogames can be considered a condition for videogames to work as a form of cultural ecology and serve as a regenerative force in a cultural context. Despite these earlier studies, to our knowledge, the game has not been studied from the perspective of player experiences.

2.2 Player Experiences and Factorized Topologies

Player typologies and player experience are two intertwined notions. Player typologies refer to the different ways that people approach, engage with, or experience video games. The notions have been used to classify players and infer their motivations, preferences, and behaviors. Player experience, on the other hand, refers to the overall feelings that players perceive, and can include perceptions like enjoyment, frustration, challenge, and immersion. It is notable that not all playful experiences are pleasurable [32].

The examination of player experiences cannot be complete without considering player typologies, as different player types may result in diverse perceptions of the game elements [22]. Additionally, player experiences are often personalized and unique [10]. Thus, analysis of player experiences must take player typologies into account to provide a comprehensive understanding.

The notion of player typologies is rooted in the notion of making segmentations of players [5]. However, this notion has received criticism for being dichotomous and overtly simplified as players can have simultaneous motivations and traits [24, 21]. Recently, various player typology

frameworks have been proposed based on computational factorization models, in which the player typologies are the captured latent dimensions [20, 42, 44, 45] and each player is seen as a composition of several different factors. In particular, [28] has further used Steam profiles to extract the player factors. This approach extensively harnesses the availability of online data but is not limited to using survey questionnaires.

3 Method

3.1 Data Collection

Steam is a popular digital game distribution platform that provides not only purchasing and downloading services, but also serves as a platform for online gaming communities where players can leave reviews and ratings for games, creating personal profiles and trading items. Its wealth of data has made Steam a widely used resource for various research purposes, e.g., [25] [29]. The player reviews and profiles on Steam are a valuable source of information for researchers to understand players' perceptions, preferences, and experiences.

The Steam Web API, an official interface provided by the Steam platform, is used to collect the reviews of *Flower*. Next, using the user IDs of the players who wrote the reviews, a web crawler and a parser based on the R package `rvest` [43] is employed to gather data from the Steam player profiles associated with each collected user ID. This allows us to collect a rich dataset of player profile information, which we can then use to explore the characteristics of the players and establish the player typologies.

The data collection including fetching the game reviews and crawling the player profiles was conducted on the 19th of January 2023. After removing too short reviews and keeping only reviews where the player has a public player profile, there are 1094 reviews with corresponding public player profiles taken into the model training. For each player profile, after web parsing, 12 profile variables and 41 showcase variables across 15 showcase areas are collected.

3.2 Text Analytics

This paper employs a computational approach called topic modeling [6] to analyze the large amount of collected data. Topic models have been a widely used method for analyzing text data to identify the underlying themes or topics that are present in a document or collection of documents and have been employed in various research areas including games [30] and climate change [18].

In this study, we use a recently introduced text analysis technique called Cross-Structural Topic Model (CFTM, [31]) to jointly analyze the player profile data and review texts. The key advantage of such a model is that it cannot only identify underlying themes of the textual reviews but can also extract factorized player typologies that act as common characteristics across the player profiles. Moreover, the interactions between textual content and player types can be jointly modeled.

CFTM is a model that combines a topic model and a factor model. The topic model extracts the underlying themes of text, while the factor model is used to identify factorized player types. Each review text is then modeled as a mixture of topics, and each player profile as a mixture of underlying factors. CFTM also models the interactions between topics and factors, by modeling how factors can influence the topic proportions in each document and how factors can affect the wordings in a specific topic. This allows for a more detailed and nuanced understanding of the relationship between player behavior and the themes in the text.

In CFTM, each document is represented as a mixture of underlying topics and each topic has a distribution over words that symbolize an underlying theme of discussion. The probability of a word w occurring in a document d is modeled as a sum over K topics, so that

$$p(w|d) = \sum_{k=1}^K p(k|d)p(w|k).$$

where $p(k|d)$ are probabilities of each topic k in the document and $p(w|k)$ are probabilities of the words w in each topic.

Further, CFTM models the topic prevalence $p(k|d)$ of all K topics in a document d with a vector $\boldsymbol{\theta}_d = [p(1|d), \dots, p(K|d)]^\top$ which is drawn from a distribution that depends on the covariates, so that $\boldsymbol{\theta}_d = \text{softmax}(\boldsymbol{\eta}_d)$ and

$$\boldsymbol{\eta}_{d,1:(K-1)} \sim \mathcal{N}(\boldsymbol{\Gamma}^\top \boldsymbol{\Lambda}_d, \boldsymbol{\Sigma}_\eta)$$

where $\boldsymbol{\Lambda}_d$ is a vector of L document-level factor loadings, $\boldsymbol{\Sigma}_\eta$ is a covariance matrix, and $\boldsymbol{\Gamma}$ is a $L \times K$ coefficient matrix that governs the interaction between topic prevalence and document-level factor loading.

The same document-level factor loading $\boldsymbol{\Lambda}_d$ also governs the generation of the document-level covariates, with a factorization structure

$$x_d \sim \mathcal{N}(\boldsymbol{\Phi}^\top \boldsymbol{\Lambda}_d, \boldsymbol{\Sigma})$$

where x_d denotes a P -dimensional covariate vector of the document d , the coefficient matrix $\boldsymbol{\Phi}$ is a $L \times P$ matrix where each column $\boldsymbol{\Phi}_p$ is a vector of feature/ covariate weights on the L factors, and $\boldsymbol{\Sigma}$ is a covariance matrix. Here, we take two play time measurements (playtime when writing the review, and total playtime of the player) and player profile variables as the covariates.

We preprocess the text data by removing stop words (such as “is”, “this”, “etc.”) and rare words (words that only appear once in the corpus). We then apply lemmatization to the remaining words, (so that, e.g., “play” and “played” are lemmatized to their common lemma “play”). This preprocessing step helps to improve the performance of the model by reducing the dimensionality of the data and ensuring that the words are in a consistent form.

The final model was decided based on a criterion called Normalized Pointwise Mutual Information (NPMI, [4]), which measures how strongly the top words in each topic co-occur over documents, thus, it can be employed to evaluate the performance of topic models and to choose the best-performing model among several models. The model with the best average NPMI value over topics was selected as the final model. We searched among topic numbers $K = 5$ to 20 and factor numbers $L = 5$ to 20. For each setting, we trained 10 randomly initialized models. We found that a model with $K = 11$, and $L = 9$ yielded the maximum averaged NPMI value.

When analyzing the output from the final model, to outline the characteristics of each topic, we examine words of the topic. To address the problem of common, uninformative words appearing in multiple topics, we examine both the top words lists with highest probabilities and Frex values which emphasize exclusivity of words to a topic. The Frex value for each word v in topic k is computed as

$$\text{Frex}_{k,v} = \left(\frac{\omega}{\text{ECDF}(\boldsymbol{\beta}_{k,w} / \sum_{j=1}^K \boldsymbol{\beta}_{j,w})} + \frac{1 - \omega}{\text{ECDF}(\boldsymbol{\beta}_{k,v})} \right)^{-1}$$

where $\text{ECDF}(\cdot)$ denotes the empirical cumulative distribution function (proportion of items smaller than the value inside the parentheses). The weight factor, ω , is used to balance the word frequency and exclusivity, where we set $\omega = 0.5$ in this case.

4 Result

We first discuss the topics extracted by the method, then the player factors, and then the relationships between topics and player factors.

4.1 Extracted Topics

In Table 1, the extracted 11 topics with top 10 words are displayed with the top 10 words with highest probabilities and Frex values. Topic labels are given by the authors based on analysis of the top words and example texts (reviews with prominent proportion of the topic). This process is similar to “coding” in Thematic analysis [14] but without requiring analysts to read through all the collected review text. During the process, a playthrough video of Flower is also used to understand the overall flow and mechanics of the game.

Table 2. Extracted topics, probabilities (Prob%), and top frequent [P] / Frex [F] words.

Topic (Prob %)	Top Words
Relaxing Gaming (13.43 %)	[P] gaming soundtrack beautiful relax perfect stun grey highly absolutely sweet [F] beautiful soundtrack relax gaming perfect stun highly absolutely sweet fun
Concepts & Impressions (10.66 %)	[P] chapter mind scenery think concept enjoy chill restart love way [F] chapter mind think enjoy chill concept love way scenery keep
Game Release & Nostalgia (10.47 %)	[P] halo release now hope year today young happy future ago [F] release now halo hope year happy ago amaze today demo
Control & Porting Issues (10.47 %)	[P] controller analog gyro recognize port support original version sixaxis setting [F] controller port original version gyro setting run support fine frustrate
Achievement, Price & Length (8.97 %)	[P] achievement definitely grind buy price money bore mouse overall wall [F] achievement definitely buy grind price bore mouse money overall pretty
Message, Motion & Silence (8.78%)	[P] message silence sit sickness spend award however pull force amount [F] message sickness spend sit however unique force anyone certainly minute
Nature & ‘Pure’ Trophy (8.18%)	[P] nature pure glad big check come damage thing credit count [F] nature glad big come thing pure credit check part kind
Satisfaction & Plant Collecting (7.83%)	[P] plant title main depression open tell theme satisfy along location [F] plant title main open tell satisfy along theme depression dark
Level Design & Gameplay (7.53%)	[P] map stage room hit figure circle steer next character turn [F] map stage hit circle figure next turn steer happen room
Disagreeing With Praise (6.88%)	[P] player praise idea random suppose type straight animation flow probably [F] player idea random suppose praise type flow probably video animation
Immersion & Colorfulness (6.79%)	[P] world symphony colorful color current know enough list relaxation throughout [F] world colorful color symphony know current enough list fast light

Among the extracted topics, the most prevalent topic **Relaxing Gaming** (with top words such as “beautiful”, “relax”, and “soundtrack”) is primarily about the overall relaxing atmosphere, beautiful design and the soundtrack:

“A very simple and relaxing experience. Perfect for playing between more intense gaming sessions! Absolutely stunning casual game. Very relaxing, nice music, no stress at all ... recommend this beautiful game!”

“A unique and visually beautiful game ... overall it’s a relaxing and enjoyable experience, with a peaceful soundtrack.”

Another group of topics are about the game design and playful experiences such as **Concepts & Impressions, Satisfaction & Plant Collecting, Level Design & Gameplay, and Immersion & Colorfulness**:

“Flower is about the expansion of nature through our world... As you can already see, visually is a really colorful experience that fuses with the music in order to create a symphony that will get our hands and guide us through this wonderful journey of expansion...”

On the other hand, the collected game reviews also contain negative topics such as **Control and Porting Issues, Disagreeing with Praise**:

“Not necessarily for everyone. It definitely still looks gorgeous and the artstyle is such that it will probably never look dated. However, the ideas that appear to appeal to most people put me off...”

And the topic **Message, Motion & Silence**:

“... Its message can be made stronger if you spent a lot of time getting everything in the one area. However for me the time for the reward wouldn’t be worthwhile... If you can get over your motion sickness, I would recommend this game as it makes you feel like the petals ... I understood a lot of criticism about the sickness as some points your fighting with the camera...”

The topic **Achievement, Price & Length** also reveals various aspects:

“...For achievement hunters, this one is going to make you a little nuts...”

“...if you don’t like short experiences for that price then wait for a sale...”

Another gaming-related topic is **Game Release & Nostalgia**:

“...I felt about it 10 years ago. now that it’s been released for its 10th anniversary it’s not only still those things that I felt back then but much more than that. I am filled with a sense of nostalgia ...”

“I was shocked when I saw “Flower: available now” Steam promo. Thanks for releasing this on PC, I literally waited 10 years to play it. Can’t wait for Journey!”

Besides discussions related to playful experiences, players have also written about their reflections on nature in the **Nature & ‘Pure’ Trophy** topic:

“Flower celebrates nature but does not revile the artificial during the process. We always say that “nature will take revenge from us”, ... As we have damaged it over and over again, it fed us and it made us a mere part of its divine existence. We are all leaves in a one big flower.”

4.2 Extracted Player Factor

Tables 2 to 4 contain the extracted 9 player factors and their weights on each profile variable. We describe each factor and their average prevalence (percentage %) among players’ profiles below. Each player’s profile is a combination of many factors, the average prevalence of a factor is its average weight in the combinations across players.

Table 2. Feature weights of factors (1); [PT]: Play-time.

	Instructor	Creator	Photographer	Collector	Streamer	Achiever	Elite	Casual Player	Artist
[PT] At Review	0.52	-1.46	0.85	-1.39	1.58	4.10	-0.50	-13.38	12.26
[PT] Total	0.59	-0.40	0.15	-0.14	1.24	-0.66	-0.86	-11.71	13.55
Level	5.78	5.96	-2.90	1.41	-0.74	-6.19	9.21	-12.02	2.30
Profile Awards	-2.57	5.41	1.34	-2.61	-1.25	-5.38	9.22	-5.22	1.88
Badges	1.10	8.56	-6.37	-0.04	-2.04	-6.39	11.52	-8.50	3.29
Games	-5.84	-5.38	-5.65	10.82	-2.50	5.52	10.86	-6.35	-1.23
Screenshots	-6.95	-7.40	14.38	-7.90	1.78	-7.01	11.70	1.97	-0.42
Reviews	-7.28	-5.61	-4.19	5.31	2.63	1.53	11.28	-1.77	-2.44
Groups	-3.12	-3.35	-6.62	-5.19	1.76	-12.00	14.64	3.87	7.55
Friends	-4.79	9.76	-7.14	-5.10	-3.33	-4.78	13.03	-5.53	7.53
Guides	-10.13	-6.66	-9.66	-10.46	5.02	-4.42	18.39	9.40	4.66
Artwork	-10.64	-7.80	-7.88	-10.45	5.54	-3.12	17.67	11.36	1.40
Workshop Items	-8.35	6.77	-8.26	-7.80	2.96	-6.79	12.30	7.84	-1.70
Videos	-7.39	-8.38	-8.67	-1.46	5.40	-3.80	14.24	7.24	-0.18

Among the extracted factors, the factor **Creator** puts an emphasis on workshop items and featured artworks in the profile which is appreciated by other viewers through awards. This factor indicates the focus of a player on creativity. When it comes to artworks in general, the factor **Artist** has artworks that are appreciated (upvoted, commented and favorited) by other profile viewers. This player factor is also positively associated to play time on *Flower*.

The **Photographer** focuses on taking screenshots in the gameplay and the factor **Streamer** focuses on sharing video recordings. The factor **Collector** represents a dimension that emphasizes the ownership of games and DLCs, and being active in item trading. And the Favorite guides of an **Instructor** are usually appreciated by fellow players.

The **Achiever** has high weights on covariates related to achievements and game completions. The factor **Elite** has higher weights on variables such as level, profile awards, and badges that take relatively more time and effort to accumulate in a player's profile. And the factor **Casual Player** has negative weight on level, achievements and game completions and on *Flower* playtime, but in general, shows interest in non-gaming items (e.g., game wish list, workshop items) in the profile.

Table 3. Feature weights of factors (2): [GC]: Game Collector; [F]: Favorite Game; [A]: Award; [AC]: Achievement; [C]: Completionist; [B]: Badge; [S]: Screenshot [AR]: Artwork; [FA]: Featured Artwork

	Instructor	Creator	Photog- -rapher	Collector	Streamer	Achiever	Elite	Casual Player	Artist
[GC] Games Owned	-4.77	-5.07	-5.28	11.89	-1.69	6.32	10.19	-7.48	-3.29
[GC] DLC Owned	1.32	-0.40	-0.64	13.74	0.40	-1.32	4.52	-12.87	-2.12
[GC] Reviews	-6.99	-5.67	-4.57	5.94	2.66	1.54	11.36	-2.07	-2.67
[GC] Wishlisted	-12.40	-9.49	-11.22	-5.14	4.01	3.05	19.74	9.18	-1.38
[FG] Hours played	6.49	0.62	-1.47	-0.02	0.63	13.42	-2.56	-11.80	-1.22
[FG] Achievements	3.28	1.67	0.91	-0.10	0.25	13.87	-2.30	-12.87	-0.60
[A] Awards Received	-8.10	5.85	-8.27	-8.33	-2.70	4.53	14.54	3.22	-2.23
[A] Awards Given	-5.95	17.83	-1.87	-4.33	-2.08	-6.11	7.60	-4.24	-0.70
[AC] Achievements	-14.24	2.86	-11.67	-10.44	-2.88	21.73	18.10	0.33	-4.50
[AC] Perfect Games	-13.09	-3.80	-7.85	-10.65	0.09	22.45	19.04	-1.11	-4.85
[AC] Avg. Game Completion Rate	2.36	3.14	2.58	-4.35	-0.08	14.85	4.10	-14.09	-3.53
[C] Perfect Games	-11.30	-2.75	-6.43	-8.17	1.73	15.25	16.11	-0.80	-3.68
[C] Achievements in Perfect Games	-14.96	3.02	-12.55	-11.42	-2.75	20.95	18.49	2.14	-4.21
[B] Total Badges Earned	0.40	8.83	-8.15	-0.35	-2.44	-5.50	11.94	-7.35	3.31
[B] Game Cards	-10.37	-11.12	-10.94	3.36	-2.93	22.41	12.53	1.17	-5.16
[B] Foil Badges Earned	7.54	-2.01	-4.36	-2.18	1.75	-4.48	5.54	-2.19	1.34
[S] Up Votes	-15.05	-4.23	-11.42	-9.59	-3.75	22.73	17.13	2.49	-0.01
[S] Number	-7.76	-7.55	13.48	-9.97	2.08	-6.80	12.75	3.35	0.16
[S] Comments	-15.35	7.56	-12.59	-10.53	-4.14	14.75	17.35	0.32	0.93
[S] Favorites	-14.59	2.55	-12.16	-9.87	-4.31	17.54	17.36	1.83	-0.12
[AR] Up Votes	-2.93	9.52	-3.89	-3.47	-2.18	-12.66	5.47	-6.40	15.74
[AR] Number	-11.00	-7.96	-8.38	-10.60	5.68	-3.08	18.18	11.56	1.58
[AR] Comments	-2.53	12.48	-5.46	-5.98	-2.17	-18.42	6.56	-6.65	20.82
[AR] Favorites	-2.53	13.41	-5.04	-6.22	-2.50	-20.18	7.41	-7.06	21.39
[FA] Up Votes	-2.31	21.92	-2.49	-2.27	-1.92	-11.23	1.85	-3.94	0.39
[FA] Comments	-5.51	28.67	-5.31	-4.87	-2.92	-10.58	3.69	-5.68	2.31
[FA] Favorites	-5.13	30.35	-5.14	-4.33	-2.98	-12.75	3.93	-6.02	1.93
[FA] Number	3.85	7.24	-0.91	-4.29	-0.37	-17.85	7.82	4.03	-0.58
[W] Submissions	-4.42	25.55	-5.71	-3.14	-1.66	-9.74	3.24	-3.68	-0.77
[FA] Followers	-2.68	17.40	-3.71	-0.13	-0.67	-6.37	0.35	-2.46	-1.91

Table 4. Feature weights of factors (3): [W] Workshop; [V]: Video; [FI]: Favorite Items; [I]: Items; [IT]: Items for Trade; [G]: Guide; [FG]: Favorite Guide.

	Instructor	Creator	Photog- -rapher	Collector	Streamer	Achiever	Elite	Casual Player	Artist
[V] Up Votes	-1.14	-2.75	-1.59	-2.39	34.60	-13.58	2.14	-10.57	-1.74
[V] Number	-7.61	-8.30	-8.76	-1.67	5.57	-3.24	14.33	7.32	-0.62
[V] Comments	-3.41	-4.09	-3.04	-4.36	34.83	-13.57	5.56	-7.97	-1.81
[FI] Favorites	-0.93	-2.65	-1.69	-2.37	34.54	-13.52	1.94	-10.59	-1.73
[I] Items Owned	-7.98	-10.92	-11.26	0.42	-2.58	17.93	15.67	1.89	-4.23
[IT] Items Owned	-10.03	-12.00	-12.40	-1.72	-2.62	20.94	16.48	3.96	-4.23
[IT] Trades Made	0.37	-5.13	-5.23	9.94	-1.08	-0.72	3.18	-0.89	-1.02
[IT] Market Transactions	4.67	-2.63	-6.66	0.79	-0.59	-11.30	9.61	0.54	4.64
[G] Guides	-10.59	-6.50	-10.34	-10.61	5.37	-5.24	18.64	9.91	5.22
[G] Followers	-4.23	-0.37	-8.62	-8.47	1.54	-15.66	14.28	1.28	17.32
[FG] Stars	14.84	-6.06	-4.34	0.27	-0.74	-19.04	4.77	4.49	4.90
[FG] Ratings	10.71	-6.27	-2.59	-1.55	-0.90	-12.08	2.30	9.29	-0.49

4.3 Player Factor vs. Topics

The CFTM model enables the examination of the relationships between player factors and the topics present in game reviews. Figure 1-2 showcases the associations between the various player factors and topic prevalence, highlighting the effect each player factor has on the prevalence of certain topics in the reviews. This information is valuable in understanding the perspectives, preferences, and experiences of players, as well as the impact of these factors on their perception of the game. In detail, for each topic and factor we show the mean (dot) and confidence interval (line) for how much the factor affects topic prevalence according to a linear regression; an interval outside zero indicates notable positive/negative influence of the factor. Overall, most of the factors do not have a significant impact on the prevalence of topics.

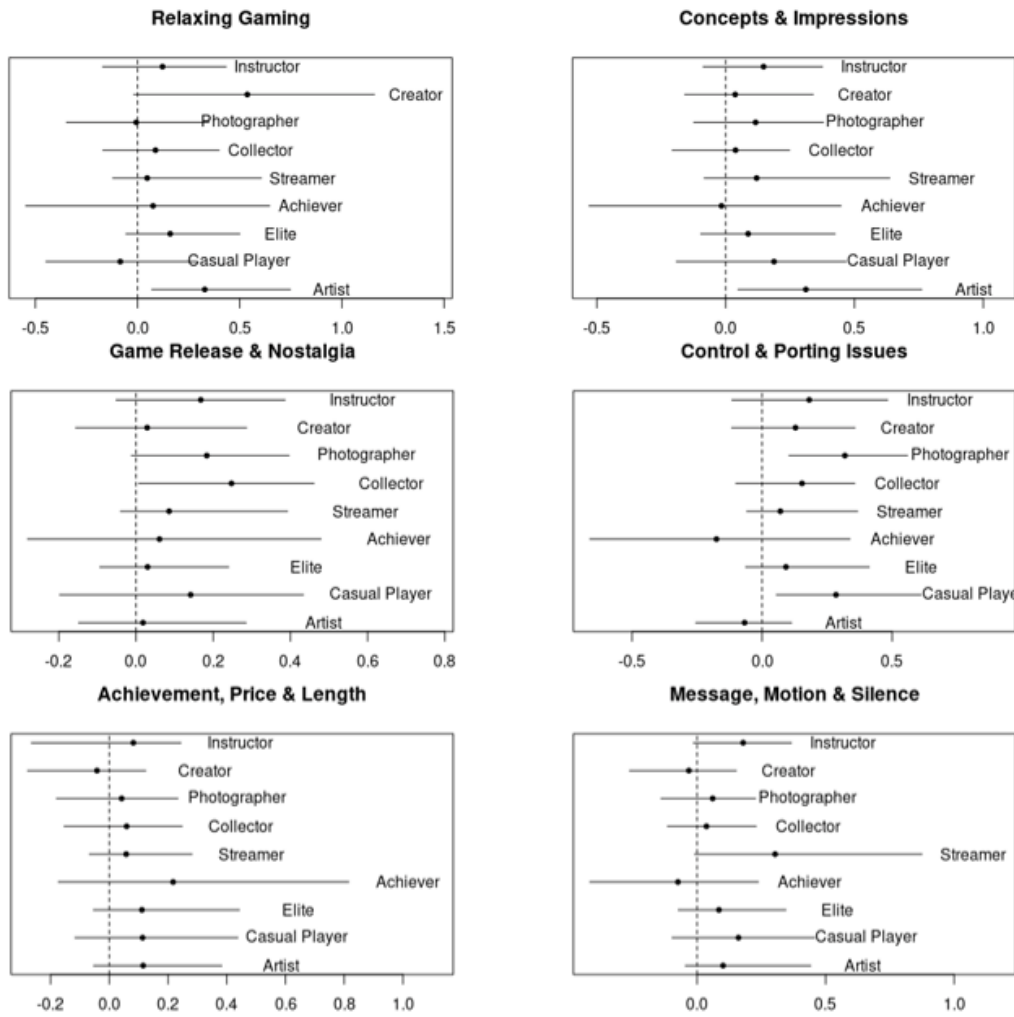


Fig. 1. Factor Impact on Topic Prevalence (1)

In particular, when it comes to the design and flow, the factor **Artist** shows significant positive associations to topics **Relaxing Gaming** and **Concepts & Impressions** and the factor **Elite** shows significant positive association to the topic **Satisfaction & Plant Collecting**. When it comes to gameplay, the factor **Photographer** shows significant positive association to the topic **Control & Porting Issues**. Besides, the factor **Collector** is positively associated to the topic **Game Release & Nostalgia** and the factor **Casual Player** shows a positive association to the topic **Disagreeing With Praise**.

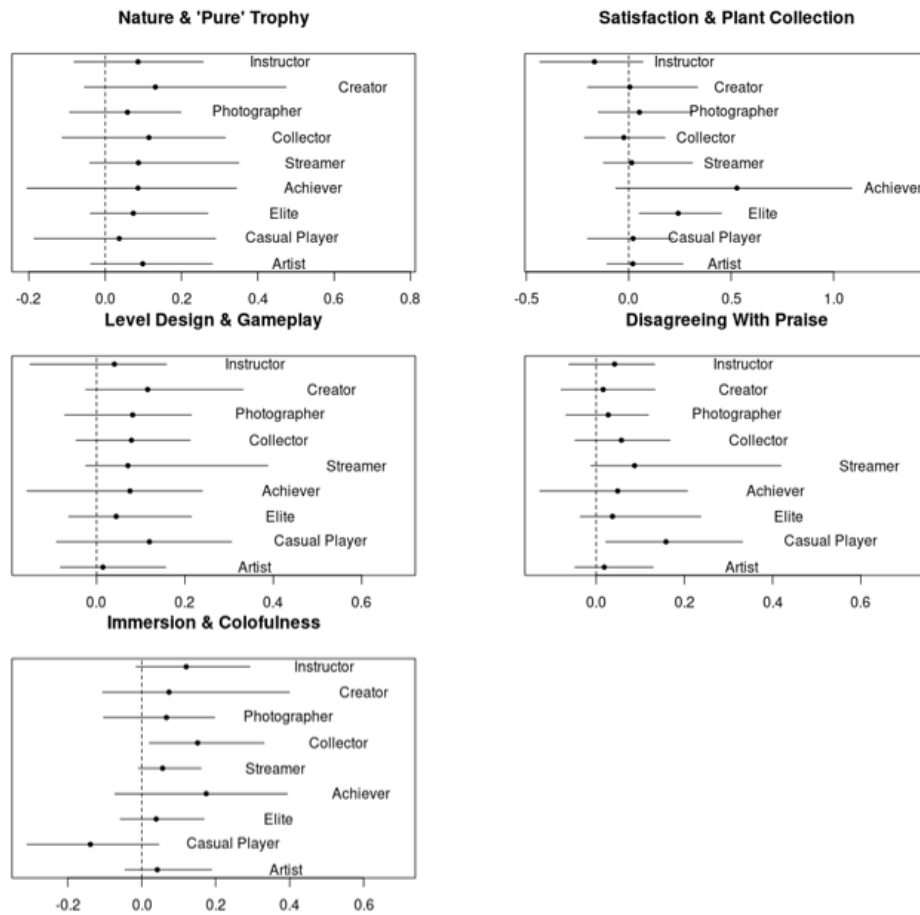


Fig. 2. Factor Impact on Topic Prevalence (2)

5 Discussion

5.1 Gameplay and Mechanics

The presence of the topics **Level Design & Gameplay** and **Satisfaction & Plant Collecting** in game reviews shows that these elements are commonly discussed and considered important in the evaluation of games. This demonstrates that despite its unique focus on environmental messages, *Flower* shares many similarities with other games in terms of the topics that are commonly reviewed and discussed.

The topics **Game Release & Nostalgia**, and **Disagreeing With Praise** show a dual effect of the game’s overall positive reception: for some players the game has earned a nostalgic place that they wish to return to and reflect on, whereas for some other players, especially those along the **Casual Player** factor, the overall positivity about the game had raised high expectations that the game did not meet well enough to overcome technical and gameplay issues.

A noteworthy discovery is the correlation between the topic **Game Release & Nostalgia** and the factor **Collector**. This demonstrates an example of the affinities between player typologies and experience. Moreover, it suggests that players who prioritize owning games may do so over multiple systems and may acquire games on Steam that they have appreciated elsewhere, suggesting nostalgia as one motivation for collecting. Hence, the factor **Collector** highlights the importance of these aspects in players’ considerations.

On the other hand, the frequent mention of the mechanic **Control & Porting Issues** in game reviews highlights its significance in the player's experience. The central role of control in *Flower* underscores the link between player expectations and game mechanics, as the virtual environment in the game reacts dynamically to player inputs [12]. Furthermore, the correlation with the factor **Photographer** highlights the significance of this mechanic for players who take screenshots, emphasizing the need to consider game mechanics in the overall design process regardless of the intended theme or message.

5.2 Graphics, Music, and Immersion

The topics **Relaxing Gaming** and **Immersion & Colorfulness** both highlight the importance of immersive experiences to positive gameplay experiences. In particular, the contribution of the interplay of design elements and the compound effect of visual and audio components to the enjoyment is underscored by the top words among those topics such as “soundtrack”, “symphony”, “beautiful” and “colorful”.

An important observation is the positive relationship between the factor **Artist** and **Relaxing Gaming** suggesting that players with artistic tendencies are more likely to recognize and appreciate design elements. On the other hand, the factor **Casual Player** does not seem to have a strong connection to this topic, though the association is not significant. This further implies the crucial role of individual motivations in capturing and retaining player engagement.

Our findings indicate that the musical score and visually stunning designs in *Flower* greatly contribute to the player's sense of presence and emotional connection. The player's level of immersion, or engagement in the game [8], is highly influenced by the coherent integration of various elements of the game [13]. The use of captivating music and graphics helps to transport the player into the game world, making them feel as if they are a part of the game and increasing their overall engagement and enjoyment. By creating a rich and immersive experience, *Flower* demonstrates the importance of music and visuals in engaging players. Note that using ambient immersive design to create a relaxing experience to engage players has also been adopted by other environment-theme games such as *Beyond Blue* [16], and *Alba: A Wild Life Adventure* [41].

5.3 Beyond Play: Environmental Awareness

It is clear that one key message that *Flower* tries to convey is to raise environmental awareness through the gameplay. The game takes players on a journey through various simulated landscapes, showcasing the beauty and fragility of nature, in a nonhuman perspective. At the same time, it highlights the impact of human actions on the environment and encourages players to take a more mindful approach to their surroundings. Through this, the game aims to promote environmental preservation and raise awareness about the importance of protecting nature.

The extracted topic **Nature & 'Pure' Trophy** further demonstrates empirical evidence of players' reflection on human-environmental relationships, although *Flower* takes the angle from nonhuman-environment perspective. This further implies that *Flower* has made an impact on enhancing the player's environmental awareness through playing the game. On the other hand, the topic **Message, Motion & Silence** indicates that although the game's strong message is appreciated, technical issues may hinder the environmental communication and players' adoption of the nonhuman perspective, and that players who miss the musical score due to technical issues find it harder to be comfortable and immersed in the environment.

Another notable issue is the achievements in the game. In *Flower*, the achievements are highly entangled with messages related to environmental awareness such as awakening the city and blooming flowers, and achievements have been mentioned in literature as a prominent design element when it comes to engaging players in climate change with games [19] [37]. However, the term “achievement” appears as one of the top words of the topic **Achievement, Price & Length** where achievements appear divisive, some players criticizing difficulty of some

achievements, others noting achievements for replay value, and some calling easy achievements either a positive or negative trait of the game.

We have also discovered that, although not statistically significant, the association between the factor **Creator** and the topic **Nature & ‘Pure’ Trophy** is the most prominent compared to all other factors. This sheds a light on the key role of imagination and the understanding of climate change [46]. It seems that the players aligned with the **Creator** factor are engaged with environmental awareness through playing. Players aligned to creative pursuits may notice and appreciate the underlying messages that *Flower* signals. However, the underlying motivation and implications of this particular connection still require further investigation.

6 Conclusion, Limitation, and Opportunities

This paper analyzes the player reviews of *Flower*, an environment-themed game that simulates flowers and the natural environment. We have identified 11 topics and 9 player factors. We have also investigated and analyzed the interactions between player factors and topics.

One potential limitation of this study is that we only consider player reviews on the Steam platform. *Flower* is also available on other platforms, such as PlayStation. A different platform can usually offer different player experiences, which is even amplified as controlling is a primary mechanic and can impact the overall gameplay of *Flower*. As a result, our analysis may be incomplete which affects the generalizability of our findings.

Another potential pitfall of this study is that the player profile data were collected at a single point in time whereas the player reviews have been written over a period of time (since February 2019). Player profiles can change over time, as players may alter their interests, preferences, or behaviors. The player factors extracted from the data may not accurately reflect the status of the moment when the review was written. This limitation should be considered when interpreting the results of this study, as the extracted player factors can only be considered as proxies that may not fully capture the complexity of underlying player characteristics.

Despite its limitations, our research provides valuable insights into how players can be engaged with environmental awareness through digital games. Our analysis underscores the significance of immersive design, particularly the influence of music and visual graphics. Our research also reveals a range of player experiences, both positive and negative, when it comes to embedding environmental messages in a game. Additionally, our study has identified a connection between player creativity and reflection on environmental awareness, indicating the potential for games to facilitate players’ engagement with environmental issues. These insights can serve as a foundation for future academic efforts in exploring the opportunities of engaging players and raising the environmental awareness through digital games. The results of our research provide a glimpse into the potential of games as a tool to engage players in environmental awareness and may lead to more innovative and impactful research and game designs in the future.

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Serendipity and role-playing game in the Bolivian Altiplano: the *Sumak Kawsay* game to support local development reflection

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Abstract. We propose a methodology for the co-design of role-playing games based on the analysis of surprises, which refers to the concept of serendipity. Our objective is to understand to what extent the analysis of surprises in a role-playing game workshop reveals key mechanisms sometimes difficult to tackle by researchers-designers. Based on bibliography references, expert interviews about the socio-ecological context and participatory observations, we pre-designed a first version of a game that we modified and co-designed in participatory workshops in two communities of the central Altiplano in Bolivia.

We distinguish 3 types of surprises and different facilitator's behaviors in response to these surprises. While the first two types of surprises help to improve the game in the co-design process, the third type is more related to the socio-economic context. It reveals the importance of the diversification of activities in addition to the sole agricultural income and the dynamics of the population decline of rural communities.

We discuss the conditions to facilitate the occurrence of surprises: 1) the design of the game must allow the players freedom to modify and encourage acceptance as a model of their socio-ecosystem, 2) the facilitator must adopt a posture prepared to welcome them, and 3) the development of a climate of trust to free up speech. Finally, the analysis of surprises during the appropriation of the game and its intention by the players highlighted the rural exodus experienced by the Andean countryside, as well as the attachment of the inhabitants and migrants to the community.

Keywords: role-playing game, co-design, surprises, social transition, Bolivian Altiplano

1 Introduction

Participatory modelling started with the rise of participatory approaches in the 1970s. It includes a diversity of approaches that use modelling with stakeholders to help in the decision-making process and the co-adaptative governance of socio-ecosystems [1]. Companion modelling or ComMod [2-4] is a participatory modelling approach developed in the 2000s, concerned by the recognition of multiple stakeholder viewpoints and the manipulative potential of models. Practitioners so define ethical principles written in a deontological charter [5]. These ethical principles are: 1) to challenge in the field the assumptions on which the modelling is based, 2) to explicit all the hypothesis for more transparency, 3) to consider the impact of the research process on the field and 4) to be careful about the validation process of the research approach.

ComMod uses co-constructed simulation tools as mediating objects to produce knowledge on socio-ecosystems, to discuss, to share views and to help decision-making [6,7]. The favored tools are mainly agent-based models, and role-playing games. An agent-based model, or ABM, is a generally computerized model that simulate the actions and interactions of autonomous agents with each other and with their environment, in order to understand system-level dynamics. A role-playing game, or RPG, is a simulation game made up of material elements associated with a system of rules, which allows players to embody a character in a fictional environment. While

RPGs have been present since the early days of companion modelling, the term 'serious game' is now also used [8].

The 21st century is "*an era of games*" [9]. For the past two decades, games, and more specifically serious games, have been experiencing a boom. Serious games are defined as "*games that do not have entertainment, enjoyment or fun as their primary purpose*" [10]. We use the term in the broader sense in which it was first used [11] and in the French literature [12] even if today "serious game" often means video games [13]. While they were first developed in education [11,14], serious games are now present in a variety of sectors, from health to art by way of advertising [15,16] and cover a diversity of intentions. In the last 10 years, this enthusiasm has spread to research [8].

When talking about co-design in companion modelling, it is often the conceptual model that is co-constructed [17,18]. It then serves as a basis for the researchers to build the RPG or the ABM. This study distinguished itself by its original set-up. Our approach was to propose an uncompleted game based on basic information about the context from the start instead of initiating the project by co-designing the conceptual model and then implementing it in an RPG or in an ABM. The game and the underlying conceptual model were then co-constructed during the participatory sessions.

Literature mainly discusses the importance of early co-design of the simulation model [19], but little works are detailing the process of co-designing a role-playing game [20].

Co-design and knowledge integration processes are complex. When participants have different knowledge, customs and experiences, they may have difficulty understanding each other. In research for development, the integration of knowledge between traditional and scientific knowledge raises issues of power asymmetries and knowledge hierarchies. A ComMod approach should facilitate the mutual recognition of stakeholders' representations and their integration (including the researcher) without prioritizing one particular point of view.

Here, we propose a methodology for the co-design of RPGs based on the analysis of surprises. **Our objective is to understand to what extent the analysis of surprises in a role-playing game workshop reveals key mechanisms of the system studied, sometimes difficult to tackle by researchers-designers.** To do so, we rely on specific examples of the surprises that occurred during the game sessions.

The notion of surprise is to be understood from facilitators viewpoint as an unexpected event in the course of the game, often linked to an appropriation or diversion of the rules by the players. However, surprises are an opportunity for us to better understand the socio-ecosystem studied. The place given to surprises in the process of game co-designing refers to the concept of serendipity dear to Merton, for whom it is the observation of a surprising fact followed by a correct induction [21]. Surprises arouse the curiosity of researchers who, in this case, have preconceived a game by formulating a series of hypotheses based on their knowledge of the social-ecological system, that these surprises lead to re-questioning. They are potentially revealing elements of reality that are poorly or not considered in the game [22]. Despite their heuristic potential [23], surprises that may appear in game sessions are rarely studied. We differentiate them from the surprises or events intentionally introduced by the facilitators of a game session to characterize certain player learning, which have been more studied [14,24,25].

2 Context of the study

The Bolivian Altiplano is a large arid plain located in the Andes at an average altitude of 3800m. For several decades, the Poopó Lake region on the central Altiplano has been undergoing major changes. Agriculture has intensified, notably with the quinoa boom in the south [26], but also with the development of livestock in the north [27].

Lake Poopó has dried up to the point of being declared a "disaster area" by the Bolivian government in 2016. Climate change plays a significant role in the desertification of the region. Indeed, it causes seasonal disruption, increased temperatures and evapotranspiration [28] in addition

to the impacts of agriculture and land use changes [29]. Finally, the El Niño and La Niña climate phenomena bring their respective consequences in terms of droughts or floods around Lake Poopó [30]. Although the level of the lake has experienced large inter- and intra-annual fluctuations and has dried up in the past [31], its current drying up is not only due to climate change, but mainly to anthropogenic actions: diversion of the Rio Mauri by Peru, increasing irrigation for agriculture, urban growth and mining [32] which modify the hydrology of the region.

This is compounded by the high salinity of the water due to the geological dynamics of this endoreic watershed [33]. In addition, the water is often contaminated by mining and urban centers activities [34]. Through irrigation, the mobilized water then contributes to soil contamination and salinization [35]. Faced with the accumulation of these difficulties, many families migrate, at least temporarily, to live or work in cities, abandoning rural communities [36].

3 Methodology: an inductive approach to co-designing serious games

The Wasaca project - founded by Agropolis International Fondation - aims to better specify the issues encountered in the area by seeking to imagine development paths with local actors. This work is based on a participatory, inductive and exploratory methodology of the Grounded Theory type (Reiter, 2013). Within the framework of a ComMod approach, we designed an RPG called *Sumak Kawsay* (Living Well in Quechua), in order to 1) support a participatory diagnosis of the Poopó Lake area and understand the main problems experienced by the farmers and breeders of the Altiplano, 2) refocus the research accordingly, validate its relevance and build its legitimacy with respect to local populations, and 3) imagine viable development scenarios with the Altiplano's farmers and breeders.

This work was carried out in two communities in the Altiplano, near Oruro and Lake Poopó (Fig. 1). A first version of the game was designed on the basis of knowledge gathered thanks to participant observations, report studies and expert advice. *Sumak Kawsay* is a board game representing a small community in which players decide on agricultural and livestock activities. It was tested with the NGO “Agua Sustentable” and the Technical University of Oruro. A martyrdom version was then proposed to both communities. We presented this version - already playable - to workshop participants as a game to be improved thanks to their feedbacks, during the play and the debriefing.

Fig. 1. Map of the location of the two communities (Source: Google Earth, adapted by the authors)



Two game workshops were conducted in each community between February and March 2022 gathering 24 players in total. These workshops brought together members of the committees of the irrigators' associations, local authorities and less notable members of the communities, mainly breeders and farmers. The participants were first selected by our local contact, the president of the water users' board of the *Desaguadero-Mauri* watershed. The second sessions were organised by the presidents of the committees of the irrigators' associations, at their initiative. They took place in the meeting rooms of both communities. A game session lasts about 3 hours, divided into 30 minutes of installation, presentation and explanation, 1 hour and half of game and 1 hour of debriefing.



Fig. 2. Photo of the first game workshop in Santa Maria on 19/02/2022

Afterwards, nine game evaluation interviews were conducted. All game sessions and interviews were recorded - using video when electricity was available - and transcribed.

4 Results

4.1 Description of the game *Sumak Kawsay*

Sumak Kawsay consists of a board on which are represented the land and farms of 6 farming families. One round represents one year and 4 rounds are planned for one game. The objective of the players is to feed their family at each round and to increase their level of satisfaction. Each family starts with 9 plots and an endowment. In each round, they must first build up or renew their herd and make investments: irrigation, barn, seeds... In a second step, the board is updated according to plant growth dynamics, which depend on rainfall and irrigation. In a third step, thanks to their plant production, families can feed their herd. In a fourth step, the animals reproduce and provide income. At the end of the round, each family checks whether it has been able to meet its needs of the year.

The UML class diagram of the game is shown in Fig. 3 and the organization of a round and the help sheet in Fig. 4.

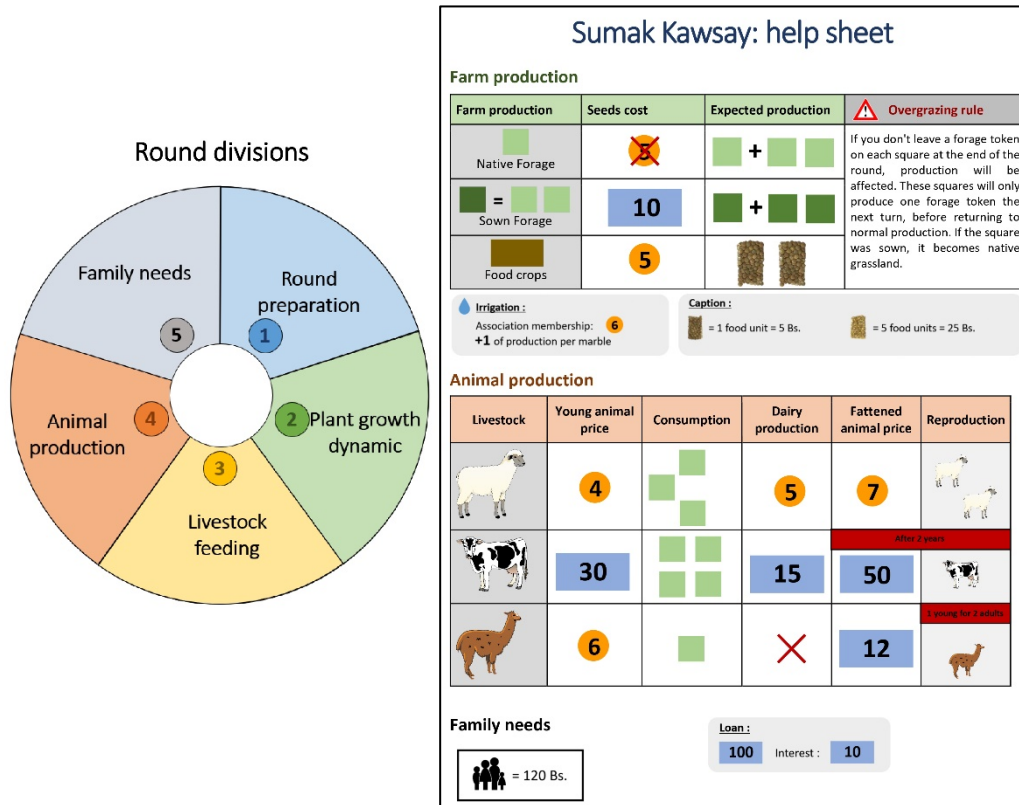


Fig. 4. (A) Organisation of a round and (B) *Sumak Kawsay* game help sheet

Events - planned by the facilitators - both individual and collective, social or natural, disrupt the game. The players can then reinvest the remaining money for the next round by buying animals for example, or by carrying out extra-agricultural activities such as studies for the children, the purchase of a house in town or a truck, according to the dynamics of pluri-activity and dual residence of these communities. To reflect the Bolivian context, exchanges between families are encouraged by events that require mutual aid or collective moments.

Besides a time on game improvement, the debriefing phase enables exchanges on the difficulties encountered, on the collective dynamics of the community and, at the family level, on strategies for subsistence and for improving livelihood conditions.

4.2 Surprises in the game

Not all the surprises are necessarily captured by the observation protocol. The role of the facilitator is therefore fundamental in allowing them to emerge during a game session. This means that the facilitation team members must be able to create an atmosphere of trust between themselves and the participants in the workshop. This is a prerequisite for the emergence of these surprises.

Surprises are discussed during the game if the opportunity and the need arise. If, however, the negotiation and rule change take too much time, we postpone it to the debriefing. During the workshops, the debriefings were a good moment for the players to say what was not realistic in the game and how to improve it. As much as possible, we tried to change rules during the game.

Changes that were too big or that were discussed in the debriefing were included in the game between two workshops.

We classified the surprises that appear in the course of the game into three types, supported by concrete examples and summarized in table 1.

Table 1. Classification of surprises and facilitator's reactions to their occurrence.

Types of surprise	Facilitator's reactions to the surprise	Examples
Misunderstanding or disagreement with a rule or a game mechanism	Helping the players	Feeding the animals
	Recalibration	Family consumption
	Removal of the responsible element	Removal of a pluriactivity card
	Changing the rules after discussion and negotiation	Reproduction dynamics of animals
Circumvention of the rules by one or more players	Letting it happen	Participation in kind in the maintenance of the canal
	Refusal and tightening of the rule	
	Modify the rule by completing it after discussion and negotiation	Purchase of a barn by several players: maximum 2 co-owners
Appropriation of the rules by a player and improvisation	Leave room for the player's expression	A player sells her animals at the end of the game to buy a truck, leave the rural community and become a businesswoman.
	Remind them of the framework of the rules	
	Discussion and negotiation of the decision and action on the game dynamics	A player buys a truck and asks for a work contract to diversify his activity.

1st Type: Misunderstanding or disagreement with a rule or a game mechanism

The target audience is not used to participating in role-playing games. The lack of understanding of the rules by the players often reveals that a game mechanism is too simplified or too far from reality. Disagreement can reveal a mis-simplification of the game. This type of surprise is therefore essential to consider for a better understanding of the system as it is designed by the stakeholders. However, there is a risk of being drawn into a game that is increasingly complex and close to reality. The more complex a game is, the more there is a risk of making it long and tedious, with a loss of the essential playfulness. This question of simplification or realism is recurrent in modelling [37]. It is particularly important to be addressed when the participation of stakeholders is sought.

For example, when the rules were explained during a session in Santa Maria, the players disagreed with the help sheet. It indicated that llamas eat 3 forage units of the game and sheep 2. We relied on various studies on sheep and cattle consumption [38,39]. Having found little work on the amount of forage consumed by llamas on the Altiplano, we assumed that the animal, being slightly larger than sheep, must consume more. One player, followed by the others, argued that the opposite was true. The llama eats little and has a very efficient metabolism. On the other hand, sheep are gluttons and eat three times as much as llamas. Together we changed the rules and the model of the game: now a sheep eats 3 and a llama 1.

2nd type: Circumvention of the rules by one or more players

Here, the rule is understood, but unlike the disagreement, the player does not oppose it head-on. He or she bypasses it. This circumvention in the game does not always reflect reality, but is more like taking advantage of a loophole in the rule system to gain an advantage in the game. If the

rule system really has a big flaw, players will not hesitate to use it in different game workshops. It is important to ask the participants about their actions in the game to find out if it is actually about taking advantage, or if their actions are realistic. It could be necessary then to complete the rule to run the game smoothly.

For example, in the game, building a barn is expensive, but it allows a player to store forage for several years. During a game session, two players start talking about buying a barn together and sharing its costs. The collective dynamic is interesting. There is no rule against buying together, nor is there a storage limit in the barn. The other players also want to participate in the purchase of the barn and share it. We asked if in reality barns are shared between several families and understood that they are not. We ended up negotiating and agreed on a new rule: a barn can only have a maximum of 2 co-owners.

3rd type: Appropriation of the rules by a player and improvisation

Beyond misunderstanding, disagreeing with or circumventing the rules, here the player disregards them. He or she no longer really plays within the rules of the game, but invents his or her own story and improvises. These surprises are the result of a certain eccentricity of some players. It only appeared twice, in two different workshops. Each time, the actions carried out were openly discussed by the other players, during the game and during the debriefing. As this was a case-by-case process, there were no rule changes.

Example 1: During the first session in Realenga, a player decided at the end of the game to sell all her animals except her llamas, to go and work in town and to become a businesswoman:

'Me, I want to sell all my cows, and I'm going to the city [...] I already have my house in the country, I want a truck to sell cattle, sheep and llamas. That's what I'm going to work with. Now I'm going to be a businesswoman.'

In the game, the city is not represented. There is a card for activities outside of farming and livestock, but these are more like side jobs that do not provide enough income to live on. Here, the action goes beyond pluriactivity as an additional income to remain living in the community. It expresses a desire to move to the city and leave the community to try one's luck elsewhere, to make a fortune and to experience social ascension. This action is illustrative of the rural exodus that communities of the Altiplano are experiencing. However, she chose to keep some llamas. This choice reveals the attachment to the community that the *residentes*, the people who work and live mainly in the city, maintain.

Example 2: In the first session in Santa Maria, a player bought a truck and asked for a contract to transport forage.

'Now I can have a contract, I have the truck [...] I want a transport contract.'

He refused to play the pluriactivity card and insisted on having this contract. After negotiating the salary so as not to distort the calibration of the game, the player drew up his work contract, which was signed by the facilitator (Fig. 5). This is the same pattern as before. Investing in a truck allows the player to go into business, earn more money, increase his standard of living and experience social ascension.



Fig. 5. Photo of the signed work contract and the lorry

In both sessions, these surprises made the other players laugh. However, during the round or later in the debriefing, these behaviors were criticized. In the first example, the leader explained that this was not the good strategy in his opinion and that it is necessary to invest in the country, in livestock, to create activity here. In the second example, several participants pointed out that there is very little transport here and the inhabitants live mainly from livestock.

4.3 The facilitator's postures to deal with surprises

Faced with these surprises, we, as facilitators, have had different reactions, also summarized in Table 1, that reveal different postures.

We have classified them into 4 categories according to the gradient of participation and consideration of the players' discourse.

1. Not allowing for or refusing surprise, for example by reminding the players of the rules. This is not a posture that was endorsed because we had an objective of co-construction and improvement of the game via trial and error cycles.
2. Providing help. Help is essential to accompany players through the game experience and to balance out differences in understanding between players. However, we do not really see it as a posture of openness to surprise. When we help a player, we encourage them to understand our model and our point of view, sometimes without trying to understand theirs, or the source of their misunderstanding. Conversely, when a player helps another player to understand the rules, it proves that the proposed model is at least understood by some players.
3. Removing the element that caused the surprise, often a misunderstanding or disagreement. There is no real discussion of the element in question, in order to make it understandable for all and to integrate it into the game in another way. This is done because of lack of time or because the element in question is too complex to change during the session.
4. Changing the rule after discussion and negotiation. These exchanges take place between facilitators and players, but especially between players, who discuss their different representations of the system. The validation of a new rule is therefore based on the

social control of the other players. This posture ensures a real co-construction of the game.

In addition to the surprises encountered in the game, which are related to the appropriation of the game by the players, we also encountered surprises in the appropriation of the game's intention by the players.

4.4 Surprises in the appropriation of the game's intention by the players

The initial intention of Sumak Kawsay

For the designers, the initial intention was to propose a game to revise and discuss a participatory territorial diagnosis and reorient the research according to the needs identified by the participants. The knowledge produced could then feed into a community project application to the municipality.

A game to learn how to make a living from agriculture and livestock?

However, participants from both communities saw the opportunity to use the game as a tool for "learning to invest", "managing a farm economically" and learning to "survive" in the Poopó Lake area.

A game to include youth?

Some leaders in both communities wanted to use the game with the youth of their community, with the objective of teaching them how to make a living from farming and livestock. This reveals their major concern: to prevent the exodus of young people. A version of the game desired by some could then be oriented to involve young people more in a transition of rural communities. The question then arises as to whether this demand should be met.

A bias in the game may have played a role here: in order to give participants as much choice as possible, they start the game with an endowment to build their herd and farm. In a way, each participant can be considered to be setting up at the beginning of the game. This initial configuration of the game may have inspired some leaders to use it with young people in order to convince them that a proper rural life was possible in the communities.

5 Perspectives and discussion

The surprise analysis approach presents several limitations. We will see the necessary conditions for the emergence of surprises and how to deal with the limitations. We will then see to what extent surprises can be indicative of transitions. Finally, we will consider the appropriation of the process by the stakeholders.

5.1 Limitations of a surprise analysis approach

This surprise analysis approach has several limitations. If initially we wanted to propose a very simple martyrdom version of the game so that the players would feel free to criticize it, improve it and make it their own, it is not easy to create a first uncomplex version.

The discussion of the rules and their modification in the game session can take time. There is a risk of breaking the game's atmosphere and making the participants bored. This is why some changes are made outside the session. When rules are changed during the session, there is always the risk of doing favors and creating injustice between players.

Finally, the analysis of surprises assumes that participants feel free to criticize and propose changes to the game, which is not always true, as we will discuss later. The following section suggests ways to address these limitations.

5.2 The necessary conditions for the emergence of surprises

In order to be interested in surprises and to study them, they must appear. Their appearance is encouraged by the design of the game and the posture of the facilitator, who must prepare for them and welcome them.

The design of the game

Our aim was to create a simple game so that players could understand it easily. The mechanics and rules should be transparent so that participants feel free to correct, improve and appropriate them.

Many games are built on actions and objectives to be accomplished, which leaves less room for playful behaviors and experiences motivated by curiosity and exploration [47]. We have tried to move away from this type of play by drawing on the Self Design modelling approach [48]. Dolinska [49] uses the self-design approach to support farmers' exploratory innovation. These role-playing games are designed to allow maximum freedom for the participants, with no predefined rules or objectives. Players can thus conduct a reflexive approach to their practices and objectives, make the game their own and add the elements and rules they deem necessary. However, games that fit this second design can be difficult to play and to facilitate. We therefore sought a balance between these two extremes.

In the end, although the game was less "simple" than we had hoped, the players had no trouble understanding its rules, which they found very close to their reality. More than the design, it is perhaps the acceptance of the game by the players as a model of their socio-ecosystem, and the resulting immersion, that encourages the emergence of surprises.

The facilitator's posture

The facilitator of a workshop must guarantee fairness between the players and the smooth running of the game. However, the facilitator's posture towards surprises is complex and requires a balance between openness and adaptation to the unexpected, time management and respect for the rules. In a co-design process, it is sometimes necessary to modify the rules during the game. Depending on the level of modification required, this can range from simple recalibration to a change in the mechanics of the rule system, which makes adaptation difficult or impossible.

Co-design and freedom of speech

The appearance of surprises depends on the design of the game and the facilitator's posture, but also on the participants' freedom of expression. This freedom of expression can be biased by 1) social inequalities between farmers and breeders with regard to local leaders and Western researchers, and 2) the interest of the inhabitants of rural communities in receiving international aid and therefore in being conciliatory with the initial objectives of the project. Creating a playful atmosphere and a climate of trust can then help to free up speech, to a certain extent.

5.3 Surprises revealing a social transition

While the first two types of surprise must be considered to enable the game to be co-designed and improved, the third type of surprise (improvisation) is more related to the socio-economic context and its transition. It reveals the importance of the diversification of activities in addition to the sole agricultural income and the dynamics of the population decline of rural communities.

A phenomenon of fragmentation of agricultural land has been at work since the agrarian reform of 1953 [40]. This leads to very small farms that are no longer sufficient to support a whole family. As the possibility of buying land remains very limited, rural Andean populations face a shortage of agricultural land [41]. In response, households are diversifying their sources of income.

Migration can be temporary or permanent. Many people are multi-active and have several residences, between town and country. Often, the money earned through mobility is not

reinvested in the countryside, but rather in the education of young people or in land in the city. *'Leaving the village is the ideal sought by the majority of the people who are experiencing upward mobility'* [42]. These migrations mainly concern young people, who leave to study and find job opportunities [43,44]. This change in lifestyle results in migrants often not returning to the communities, switching from temporary to permanent migrants [44]. Rural communities are thus experiencing a slow but certain decline.

However, it is essential to keep land in the countryside as security. Sometimes the family remaining in the community fulfils community duties and looks after the migrants' land and livestock. Zoomers [42] summarizes this contradiction very well: *'It is striking that the majority stress that they hope their children will be able to build a life outside the community, but also emphasize the importance of maintaining contact with the community'*.

The discussions that these surprises gave rise to during the debriefing and the criticism of such behavior revealed the attachment to the community and the desire to live there together.

5.4 Dairy farming project and risk of diversion of the results of the approach?

In Realenga, several people (often agricultural engineers) have a well-defined vision of the development direction that the community should take. One of them is a very active leader, currently head of the irrigators' association and organizer of our game sessions. His project is to build a village at the crossroads of the main roads, 500m from the current village center. The plan of the future village is already drawn and posted in the meeting room. It was approved at a community meeting. The aim is to make it a commercial and active village where mainly local products would be sold. This would counteract the depopulation of Realenga and create local employment. The project is ambitious. The village would have, among other things, a specialized university center and a milk processing plant. The actors, or rather the participants in the workshops, share a vision of the community as a center for milk production. Dairy farming seems to them to be more profitable and less risky than other agricultural and livestock activities.

There is thus a real risk that the game will be used to share and promote their vision of development, to facilitate communication of their project and to encourage participants to invest in dairy livestock.

According to Funder [45], the diversion of a participatory approach by stakeholders is a common occurrence. This reveals an appropriation of the approach by the beneficiaries. Giving participants in a modelling approach control over the use of the model is a central issue in order to achieve a level of participatory modelling that is said to be transformative, i.e. that aims at empowering participants [18,46].

However, there is a fine line between appropriation, diversion and manipulation. It will therefore be necessary to take a closer look at this project, to better identify its supporters and opponents and to understand who would be the losers and the winners.

6 Conclusion

We proposed a methodology for the co-design of role-playing games based on the analysis of surprises, which refers to the concept of serendipity. Our objective was to understand to what extent the analysis of surprises in a role-playing game workshop reveals key mechanisms of the studied system, sometimes difficult to see by researcher-designers. While the first two types of surprises must be considered in order to co-design the game and improve it, the improvisation-type surprises revealed 1) the importance of diversification of activities in relation to the sole agricultural income and 2) the dynamics of depopulation of rural communities. Faced with these surprises, the modification of the rules after discussion and negotiation with and between the players is necessary for a real co-construction of the game. The appearance of surprises is favored by 1) the design of the game 2) the facilitator's posture and 3) a climate of trust.

While being open to surprises is an opportunity to reorient the research project according to what seems important to the participants, the diversion and manipulation of the participatory

process raises ethical questions. In a context of great poverty where environmental conditions can seem hopeless, should we refuse to engage in a process in support of leaders who perceive this tool as an opportunity to communicate their development project and to slow down the exodus of young people? Or should we maintain a purely scientific approach to territorial diagnosis? A Critical Companion type posture [50] may be necessary.

This study raised the need for a game to think about the future of the territory and to consider the issues of rural exodus, in order to go beyond the future proposed by some and make it a vision shared by the whole community. The co-design method will therefore continue by mobilizing the game in order to use it to think about the future of the commons in the indigenous Andean peasant community. Indeed, the commons seemed to appear in watermark during our previous sessions and we wish to question them more to help local actors think about the future of their territory.

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UX/UI design for complex digital simulation games: the case of MSP Challenge

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Abstract. Within the simulation game research community, UX/UI design research publications often concern the effectiveness of the result, i.e., the actual game experience and interface design outcome, rather than the thinking and decisions leading up to it. This paper fills this gap in the literature by discussing the UX/UI redesign thinking and decision-making behind a particular digital simulation/serious game about marine or maritime spatial planning called MSP Challenge. The main foci for the UX/UI redesign of MSP Challenge result from observations of and questionnaire results following 48 game sessions with 1.028 participants, as well as a rigorous small-scale study (N = 10) with the existing latest version of the game. The foci are layout diversity, layout simplicity, and interface usability. The authors offer and argue for redesigns of data layer access, information, and spatial plan creation windows, with which layout simplicity and interface usability would be improved. They also offer and argue for redesigns of the login and loading screens, with which layout diversity and simplicity would be improved. Finally, the authors offer and argue for a design of a new tutorial mode and help overlay system, with which interface usability would be improved. The new design mockups provided throughout the paper depict a new graphical style, with which layout diversity would be improved. A future scaled-up quasi-experiment will hopefully prove the expected improvements.

Keywords: User Experience Design, User Interface Design, Digital Simulation Games, Maritime Spatial Planning.

1 Introduction

Over the past decades, user experience (UX) and interface (UI) design have become important aspects of creating successful software, including digital simulation/serious games. UX refers to the user's overall experience when interacting with a software product, while UI design specifically deals with the visual and functional components of the product's interface [1]. The goal of both UX and UI design is to create software products that are easy to use and provide a satisfying user experience. Although arguably the origins of UX and UI design can be traced back to when the first interactive computer systems were developed, the concept of "human-computer interaction" (HCI) emerged in the 1970s, with researchers beginning to study how people interacted with technology [2]. The term "user experience" was popularized in the 1990s by cognitive psychologist and designer Don Norman [3]. With the ubiquity of powerful computing devices and their usefulness to simulation games, the topic's relevance to digital simulation game design and research is self-evident [4,5].

Research into UX and UI design within simulation games has focused on a range of topics, including the impact of UX and UI design perspectives within a simulation game design context on player engagement and learning [6–8] and the importance of usability testing and related evaluation methods during simulation game design and development [9,10]. Methods involved include (quasi-) experiment-based user testing, interviews, and (digital) observations to gather data and insights into user behavior and preferences. Additional data analysis and user modeling techniques can aid in understanding how users interact with a software product such as a simulation game.

Within the simulation game research community, published UX/UI design research often concerns the effectiveness of the result, i.e., the actual game experience and interface design

outcome, rather than the thinking and decisions leading up to it. The lack of attention to these aspects of UX/UI design within the simulation game design process is problematic for at least three reasons:

- 1) It conceals that UX/UI design is partially subjective, i.e., dependent on the background (in the broadest sense of the word) of the designer(s) involved and their understanding and assessment of the target audiences involved.
- 2) It conceals the trials, tribulations, and often the innovation considerations involved in the UX/UI design process.
- 3) It limits opportunities to further an understanding of the specificity of UX/UI design for digital simulation or serious games as opposed to entertainment games or information systems.

This paper fills this gap in the literature by discussing the UX/UI redesign thinking and decision-making behind a particular digital simulation/serious game called *MSP Challenge*. We thus answer the question, ‘what is the rationale and are the propositions for the UX/UI redesign of the simulation/serious game *MSP Challenge*?’. In the remainder of this paper, we first provide a brief background and history of the design, development, and use of *MSP Challenge* to date and explain why there was a need for a UX/UI redesign. We subsequently discuss the thinking and decision-making process involved in *MSP Challenge*’s UX and UI redesign.

2 MSP Challenge UX/UI redesign rationale

2.1 About MSP Challenge

MSP Challenge is a simulation game about marine or maritime spatial planning (MSP), a highly complex endeavor of policy- and political decision-making for the long-term use and protection of sea space within the multidisciplinary context of (at least) marine sciences, varied engineering domains, and (inter)national law [11]. The game was first designed in 2011 for a HELCOM/VASAB/OSPAR/ICES Workshop on MSP, bringing together around 100 MSP professionals from mainly Europe [12,13]. It was a computer-supported multi-player role-playing game based on a challenging MSP storyline on using and protecting various ecosystem services. It featured a fictional but plausible sea basin and included datasets loosely based on those from providers ICES and HELCOM to fit the imaginary sea. Participants were challenged to make a national marine/maritime plan, considering cross-border coherence and shared interests. Assuming a role in the game-play allowed the participants to explore new and different approaches and points of view in planning to use the area. By doing so, they learned about the intricacies and overall complexity of MSP, which is the game’s main objective.

In 2015, the community around *MSP Challenge* was enlarged when the game became part of three EU co-funded projects: NorthSEE (EU Interreg NSR; European Regional Development Fund), Baltic LINES (EU Interreg BSR; European Regional Development Fund) and SIMCelt (EU DG MARE; European Maritime and Fisheries Fund). As a result, a new version was developed and became known as the *MSP Challenge Simulation Platform* (henceforth, we will continue to refer to this version as simply *MSP Challenge*). The overall game concept remained largely the same. However, with this platform version, we introduced several technological innovations, firstly by focusing on real sea basins and thus integrating actual geodata (marine and human activities) sourced from EMODnet, Copernicus Marine Services, and other (inter)national data providers [14]. We also integrated science-based simulation models for shipping [15], energy [16], and ecology (using Ecopath with Ecosim) [17]. By the time of writing, we support the North (Fig. 1), Baltic, Adriatic (Fig. 2), and Eastern Mediterranean Seas, as well as the Clyde marine region in North-West Scotland, thanks to the projects mentioned above as well as *MSP MED* (EU DG MARE; European Maritime and Fisheries Fund) and *EcoScope* (EU Horizon 2020).

In MSP Challenge, players are country planners and stakeholders, see the entire sea region, and review many different data layers to assess the current status. Then, they collaboratively (within their own country and across countries) develop plans for future uses and protection of sea space over several decades. Examples are new offshore wind farms, decommissioning of oil and gas installations, additional telecommunication cables, shipping lane changes, fishing priority areas, or marine protected areas. Finally, the consequences of the combined players' spatial plans for energy production capacity, common ship routes, and the marine ecosystem are simulated and visualized in indicators and heat maps. This means that players can see how and figure out why ships have changed their routes throughout the sea basin, the offshore energy capacity (in MW or GW) reaches the grid on land, and key species of fish and mammals are affected (e.g. they die or move). Time permitting, players can apply what they have learned in a new round of planning and simulation.



Fig. 1. Screenshot of the North Sea edition of the MSP Challenge Simulation Platform

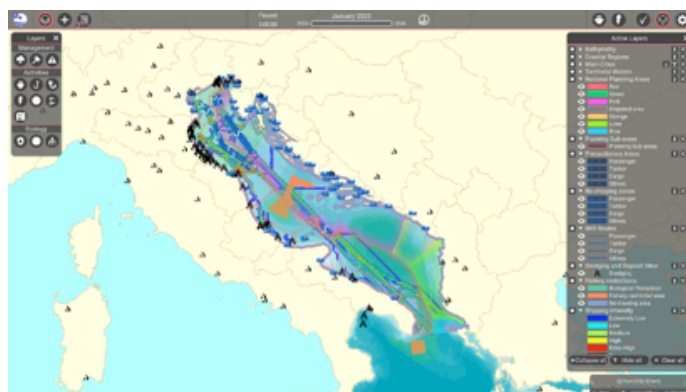


Fig. 2. Screenshot of the Adriatic Sea edition of the MSP Challenge Simulation Platform.

2.2 MSP Challenge game sessions

Since January 2018, we have applied the latest platform version of MSP Challenge in 48 game sessions with a total of 1.028 participants (students and professionals). Thus, on average, we have (co-)facilitated an online or face-to-face game session every five or six weeks with about 25 players. These game sessions (Fig. 3) typically lasted a full day and consisted of three phases: preparation, planning, and evaluation. We divided the participants into six or seven countries during the first preparation game-play phase. In each country team, we split the roles of planner and stakeholder representatives (e.g., energy, fishing, shipping, and environmental protection). Players subsequently started analyzing the status quo of their country and what they wanted or had to achieve in the long term with their MSPs. Afterward, each country

would briefly present these objectives (in whatever state they were) to the group before the teams started developing the MSPs in the game software. During the planning game-play phase, the teams made their plans more specific and fit in with all other existing activities and MSPs, both by themselves and by other country teams. Next, we ran the energy, shipping, and ecosystem simulations to transition to the final evaluation phase. We then helped the teams self-evaluate the consequences of their plans on these levels and, thus, whether they had reached their objectives.



Fig. 3. Photo of the first game session with an alpha version of MSP Challenge.

Over the years, we continued to improve the game software. The improvements mostly consisted of software bug fixes and feature additions. The earliest game sessions we co-facilitated in 2018 and 2019 were conducted with what we considered to be ‘alpha’ versions of the game software, i.e., still unfinished software. By the end of 2019, we transitioned to a ‘beta’ stage. Figure 4 provides an overview of which versions of the game software we applied in the different game sessions throughout the years and how many participants played with those versions.

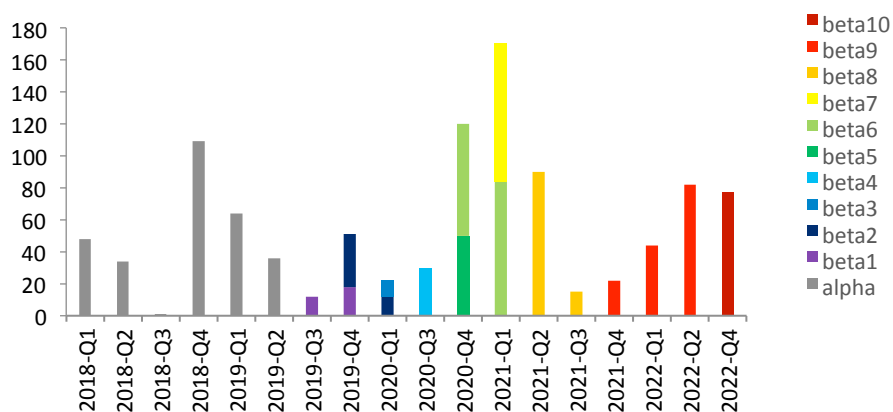


Fig. 4. Number of participants in MSP Challenge game sessions per quarter and per version.

2.3 The need for UX/UI redesign

As (co-)facilitator for all 48 game sessions, the second author of this paper was already long convinced that the UX/UI design of MSP Challenge could be improved. Observing participants with different backgrounds and skills during these sessions and listening to feedback obtained after a game session, it was clear that the game had become complete in terms of its features but a bit cumbersome in terms of its interface. Moreover, many participants did not seem particularly attracted to the game graphically. In version beta4, a minor improvement to the user interface's graphical style was introduced. However, the idea of a more radical UX/UI design overhaul lingered yet was not pursued.

There were more indicators of the need for a UX/UI design overhaul. Up to beta6, evaluations were carried out within specific projects' contexts and are subject to ongoing Ph.D. research. Starting with version beta6, following a sharp increase in game sessions (mostly online because of the pandemic lockdowns), we asked participants to fill in a very short post-game questionnaire. As shown in Figure 5, on a key statement ('The MSP Challenge software was easy to use'; N = 142), we have generally been scoring only reasonably well and not improving.

Correlations with other statements in the post-game questionnaire also indicated the need to improve the game's UX/UI design. These statements concern whether the participants generally found the game session enjoyable, sufficiently challenging, and useful regarding MSP learning outcomes. As Table 1 shows, with 142 respondents, we already see correlations at high confidence levels and with reasonable strength between perceived ease of use and all these other statements. Making the game easier to use would likely benefit these different factors and thus help us achieve our objectives more easily.

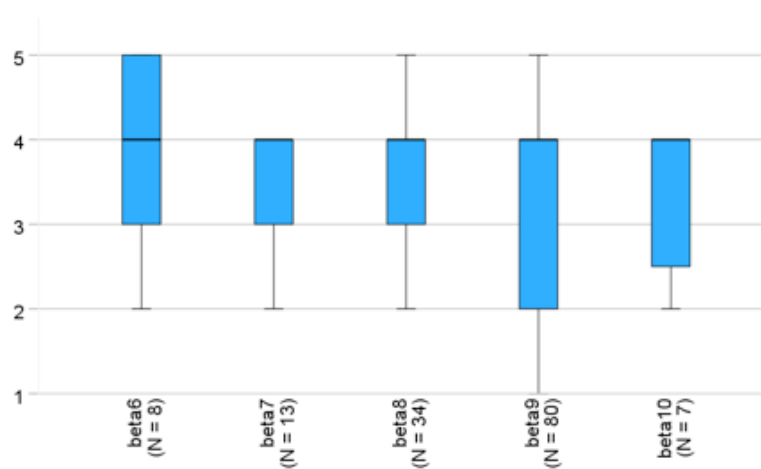


Fig. 5. Boxplot for responses to the statement 'The MSP Challenge software was easy to use' on a 5-point Likert scale per version.

For a more rigorous estimation of our UX/UI design problems, we set up a small-scale study with version beta10. We recruited 10 participants who had never played MSP Challenge - a random selection of colleagues and students, mostly 18-25 years old. With only a general explanation of what MSP is and no explanation of how MSP Challenge works, we asked them to conduct four tasks typical to real game-play. These tasks involved using the map and its data layers to discover a free area and creating and editing a plan for a wind farm and marine protected area. The participants took 10-20 minutes to finish these tasks. Afterward, they filled in a questionnaire with pre-validated items concerning usability, task-technology fit and misfit, and aesthetic appraisal.

Table 1. Correlations with the statement ‘The MSP Challenge software was easy to use.’ at 99% confidence level (N = 142)

Statement	Pearson correlation	Lower CI.	Upper CI.
I enjoyed the MSP Challenge session.	.474	.288	.625
The MSP Challenge session was challenging in a good way: not too easy, not too hard.	.520	.343	.661
I generally know better what MSP is.	.322	.114	.502
I gained more insight into the important factors of MSP and how they (can) influence each other.	.371	.169	.543
I gained more insight into how MSP decisions of different countries (can) influence each other.	.280	.069	.467

The means and standard deviations shown in Table 2 support our earlier conclusion. The participants generally agreed that, particularly in terms of the following three aspects, we had work to do:

- layout diversity, ‘reflecting visual richness, dynamics, variety, creativity, and novelty’ [18];
- layout simplicity, ‘reflecting ... clarity, orderliness, homogeneity, grouping, and balance’ [18];
- interface usability, or ease of use.

Interestingly, we seem to be doing rather well regarding task-technology fit (i.e., the effectiveness of the interface in performing the tasks).

Table 3. Results of the small-scale UX/UI study with version beta10.

* Only half of the original statements were used to shorten the questionnaire.

** We deemed the shortened version of VisAWI [19] too limiting.

Measurement	Scale	Items	N	Cron-bach’s α	Mean \pm SD
Usability [20–22]	5-p. Likert	10	9	.857	3.54 \pm 0.68
Task-Technology Fit [23]	7-p. Likert	6	10	.918	6.27 \pm 0.70
Task-Technology Misfit: Too little* [23]	7-p. Likert	3	10	.545	1.80 \pm 0.72
Task-Technology Misfit: Too much* [23]	7-p. Likert	3	10	.649	3.37 \pm 1.17
Aesthetics: simplicity** [18]	5-p. Likert	5	10	.712	3.52 \pm 0.77
Aesthetics: diversity** [18]	5-p. Likert	5	10	.734	3.26 \pm 0.77
Aesthetics: colorfulness** [18]	5-p. Likert	4	10	.690	3.88 \pm 0.73
Aesthetics: craftsmanship** [18]	5-p. Likert	4	10	.772	4.05 \pm 0.62

3 MSP Challenge UX/UI redesign specifics

This section discusses the thinking and decision-making process behind the chosen UX/UI redesign. Throughout this section, the reader will notice that part of the redesign was a complete redesign of the overall graphical style. The old graphical style involving mostly dark grey and dark blue was abandoned for one involving a more sea-like blue-green, earthy orange, and white. With this pallet, we try to do more justice to not just the focus area of MSP – the sea – but also the origins of humanity’s focus on that area – land. The style change is also strongly linked to the previously acknowledged design issue of diversity.

3.1 Simplicity and usability: Data layer access and information

MSP Challenge offers two main interfaces with which the player can access and further understand data layers shown on the map (Fig. 6). The data layers window serves as a catalog that players consult to explore the various data available for the sea area. Another window provides an overview of all the active data layers and defines the colors, gradients, icons, and patterns shown on the map. Although it is indeed basically a legend, it also offers controls for hiding and re-showing the layer or removing it from the list entirely.

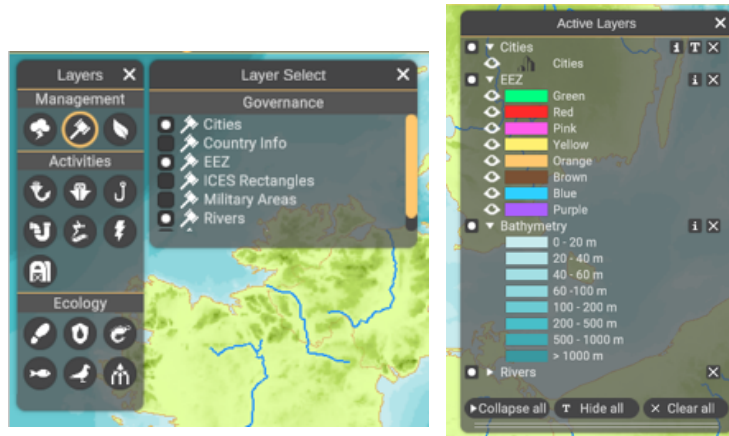


Fig. 4. Old beta10 version of the data layer select and active data layers windows.

The main problems with these map access and understanding windows concern simplicity and usability. The distinction and relationship between these two windows remained unclear for many players. The two windows seemed to overlap in meaning or purpose to the players, especially the more data layers a player would select for viewing.

We found it necessary to continue to provide two windows to aid the player's access to and understanding of data layers on the map, but propose a redesign of both (Fig. 7). The redesign of the first data layers window consists of the following:

- All icons have been redesigned to improve their consistency and understandability.
- The written-out sub-category name has accompanied its icon, so players no longer have to interpret it alone. This addition also improves the accessibility of the game software.
- A search bar at the bottom of the window enables the users to easily search for a specific layer instead of having first to guess to what sub-category it possibly belongs. In addition, entering text in the search bar filters the layer list immediately – no need to press the Enter key or an interface button.

The redesign of the second active data layers window consists of the following:

- The window's title has been changed to 'Legend' to convey better its main purpose, mainly befitting expectations of players with a (basic) geographic background, making up a fair percentage of our target audience.
- Players can no longer hide a data layer by default without removing it from the legend's list. Moreover, toggling off a data layer through the data layers window now removes the layer from the legend's list. Players wishing to keep a data layer in the legend can 'pin' it. The changed behavior reinforces the distinction between the data layers and legend windows – the former is for *accessing* layers, the latter for *understanding* them.

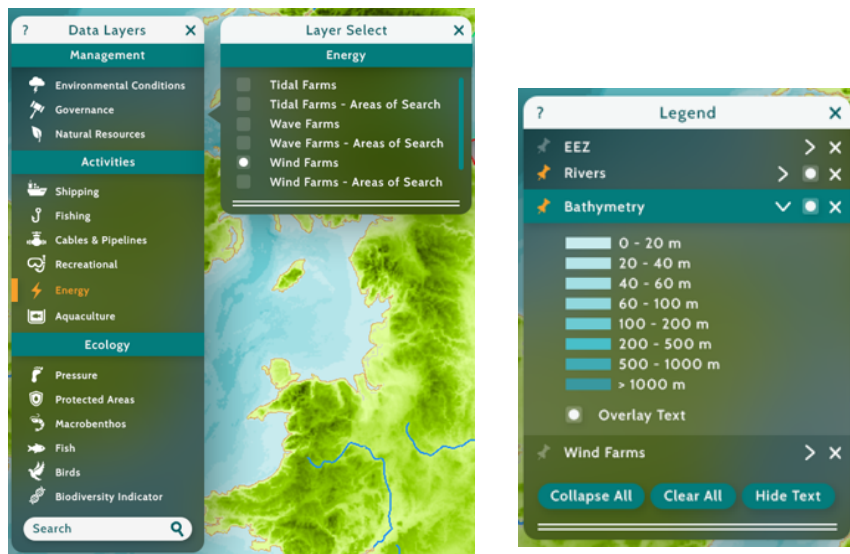


Fig. 5. Redesigned versions of the data layer select and (now) legend windows.

3.2 Simplicity and usability: Spatial plan creation

MSP Challenge offers three main interfaces with which the player can set up the plan and subsequently define specific areas and policies within this plan (Fig. 8 & 9). In a first plan wizard window, players set a name and realization date for the plan, as well as the data layers and policies which the plan should encompass (Fig. 8). After completion, this window disappears, and two new windows pop up. The active plan window indicates the player is actively viewing a plan. It contains a small pencil icon with which the player can enter geometry editing mode (Fig. 8). The second plans monitor window offers an overview of all plans and the opportunity to change other plan characteristics (e.g., setting policies; Fig. 9).

Again, the main problems with these plan creation and editing windows concern simplicity and usability. While the plan wizard was simple and easy enough, the subsequent windows appearing on different screen areas were easily missed, overwhelming, or confusing. Many players particularly struggled to get to geometry editing.

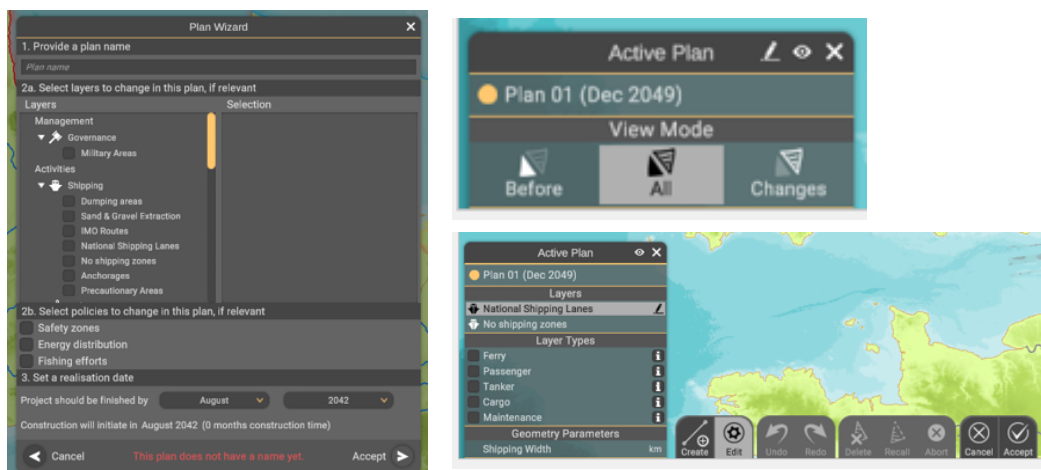


Fig. 8. Old beta10 version of the plan creation and editing windows, part one.

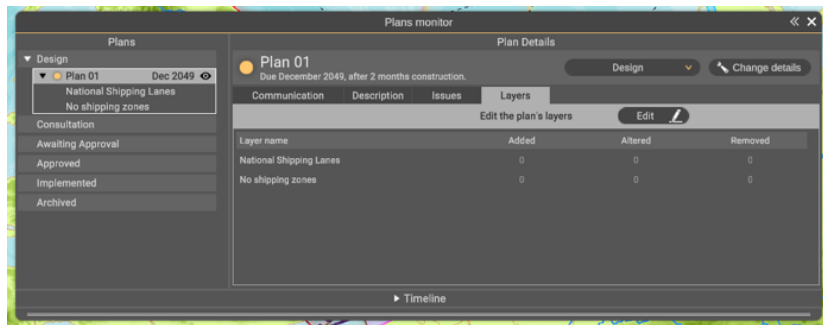


Fig. 9. Old beta10 version of the plan creation and editing windows, part two.

We found it worthwhile to attempt an integration of all these windows into one and thus propose a more radical redesign (Fig. 10). The redesign into this single new window consists of the following:

- The window still first requests some basic definitions, i.e., a plan name, a general description, and a realization date. Entering this information helps keep the player focused on what is important when setting up a new plan: what it will generally be about and when you want it.
- Upon confirmation of the above, the window expands progressively to enable the player to define other characteristics, notably which data layers and policies should be a part of the plan. Changing the plan name, description, and realization date is still possible. The additional features of the old plans monitor window concerning this plan's characteristics are also included. Only what is relevant to the plan being created is shown, and it is all shown together. This avoids confusion. Furthermore, no new windows pop up and there is no need to go back and forth between windows to find different options, which reduces cognitive load.
- The old plans monitor window's main function of providing an overview of all plans is kept separate from this singular plan creation workflow. Thus the plans monitor window has now been slimmed down and is, by default, no longer shown to the player at this stage (and therefore not shown in Figure 10). This again avoids confusion.
- It is now possible to add or remove data layers and add or edit a data layer's geometry from a single window. Thus, the distinction between the plan wizard and active plan windows is gone. This again avoids confusion.
- The geometry editing tools are now included in the selected layer settings rather than visually separated from them. This should make the player more aware that adding, editing, or removing geometry concerns a specific layer with specific type characteristics.

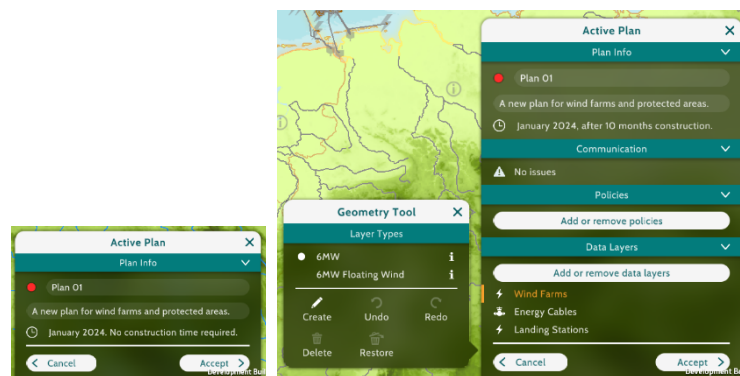


Fig. 10. Redesigned version of the (now progressive) plan creation and editing window.

3.3 Diversity and simplicity: Login and loading screens

Before the player can even do any data layers analysis or spatial planning, they need to log on to a particular game session hosted on a specific server, for which we have a login and a loading screen (Fig. 11 & 12). The login screen is the first screen a player sees when they start up MSP Challenge. In it, the player inputs the server address before selecting and connecting to one of the game sessions hosted on the server. Then, after choosing an appropriate country team and entering their name, the loading screen is displayed. The purpose of this screen is only to indicate the loading progress. Once finished, the map is shown.

The main problems with these screens concern diversity and simplicity. Many players struggled to understand what the login screen was about at all. Especially players completely new to MSP Challenge hardly had an idea of what MSP Challenge is, let alone what the login screen is. The interaction process of logging in to a session was also clearly a bit heavy on cognitive load with this design. The graphical design also already made the game appear very serious and technical, potentially eliciting a frame of expectation at odds with exploration, creativity and trial-and-error. Finally, like the login screen, the loading screen's visual design was somewhat unappealing, especially to first-time players on whom we would like to leave a lasting good first impression.

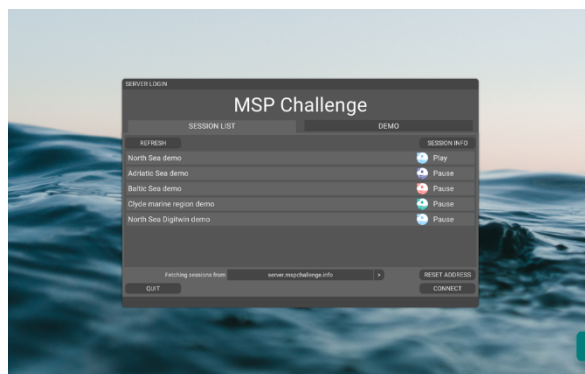


Fig. 11. Old beta10 version of the login screen

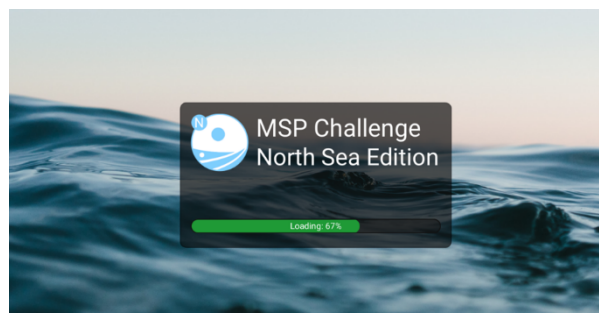


Fig. 12. Old beta10 version of the loading screen.

We found it worthwhile to reconceptualize both screens, though in different ways, and thus propose more radical redesigns (Fig. 13 & 14). The redesign consists of the following:

- Conceptually, we have turned the login screen away from the old basic 'launcher' / login design to a 'hub' / opening design, i.e., a good starting point for the entire MSP Challenge experience, thereby also better catering to first-time players. Furthermore, short texts and

movies offer a general introduction to MSP Challenge’s overall vision, possible use cases, main features, software update announcements, and other news.

- To limit the cognitive load of the additional information and features of the login screen, we have split it over multiple screens, accessible through buttons shown on the left. Dividing the information over a few screens with a clear category and more bite-size sections makes it easier and faster for users to find what they want. Having less information showing at the same time also enhances the overall clarity.
- In the loading screen, the background image is now the same as that of the opening/login screen. The loading bar was replaced by an abstract rendition of the background imagery, which slowly expands from a thin line in the middle of the screen to the sides until it reaches the full screen.
- The more vibrant colors and diverse imagery are meant to provide more of a ‘Wow!’ sensation after players start and load the game, especially for the first time.

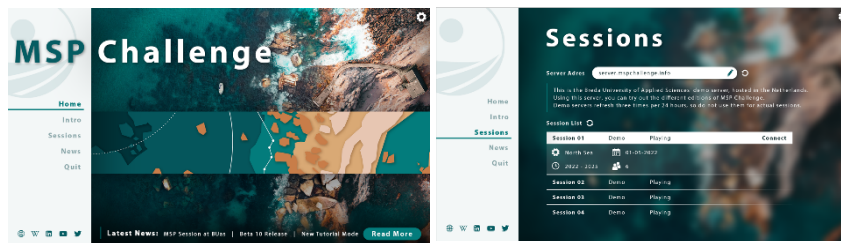


Fig. 13. Redesigned version of the (now) opening/login screens.

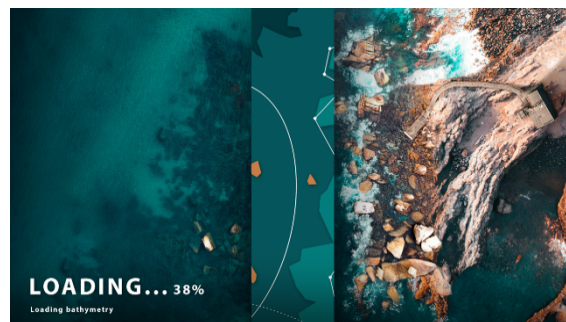


Fig. 14. Redesigned version of the loading screen.

3.4 Usability: Tutorial mode and help overlays

In the end, good UX/UI design facilitates exploration and building an understanding of what the game software enables through trial and error. However, we found that many players expected or required introductions to the experience and interfaces during game sessions. Thus, we provided a basic live tutorial on accessing and understanding data layers and setting up a spatial plan. This typically took about 30-45 minutes to complete.

There are several problems with providing such a live tutorial. First, it requires the facilitator to know all the ins and outs of the user interface. More importantly, having an actual game *facilitator* telling you what to do first in the game connotes, at least to some players, that exploration and experimentation are not central to the experience. This hinders the facilitator’s explicit framing of the experience as one of game-play, which we continue to find essential since key qualities of game-play (exploration, discovery, proactivity, creativity) are so important to MSP itself.

At the same time, at least for some players, a tutorial will likely always be required. Though we strive to make the user experience of MSP Challenge as clear and streamlined as possible, it will always remain a complex piece of software with extensive functionalities. The main purpose of a tutorial is to smoothen the initial learning curve of new players concerning the software's features and interface. Once completed, the users should have a general sense of what the game is about both thematically (i.e., the notion of multi-player MSP) and using the user interface to progress in the game accordingly.

We, therefore, decided to develop a new in-game tutorial mode. By setting it in-game rather than in-person, we could reach our objectives more consistently and efficiently. In addition, the facilitator would no longer be required to have extensive interface knowledge, and any negative connotation would be avoided.

The tutorial consists of informative pop-up overlays integrated into the actual game software instead of being a completely separate interface (Fig. 15 & 16). The tutorial occasionally requires the users to fulfill simple tasks before proceeding, such as consulting a specific window. However, this prevents users from accidentally or purposefully skipping past important information. The tutorial thus helps less adventurous players to learn what they need to know and more adventurous players to start exploring the rest of the interface on their own accord.

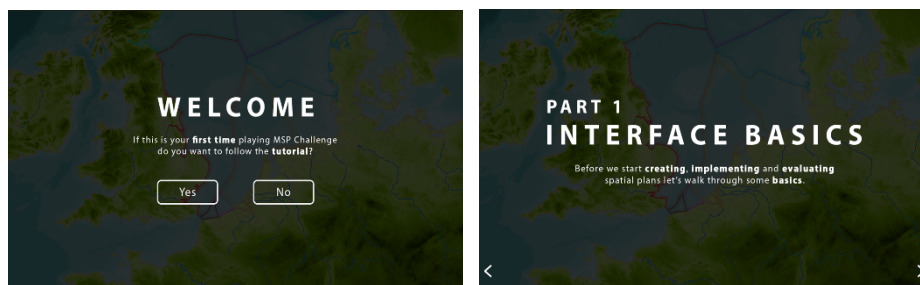


Fig. 15. Newly designed tutorial mode, part one.



Fig. 16. Newly designed tutorial mode, part two.

The tutorial is divided into four sections. As the name indicates, 'Part 1: Interface Basics' introduces players to basics, such as zooming in/out, panning over the map, and accessing important windows. 'Part 2: Accessing data & exploring the consequences' introduces players to the data layers catalog, the legend. This gives players a first impression of what is happening in the sea basin. 'Part 3: Creating & implementing plans' shows players how to turn their ideas into spatial plans, draw new or edit existing geometry, and get a plan approved and ready for

implementation. ‘Part 4: Evaluating consequences’ shows players how to assess their plans’ impact through appropriate windows once the simulations have run. This is why once players finish section three, they have the option to skip section four.

We also introduced a help overlay system for all windows in the game (Fig. 17). This system allowed us to keep the previous tutorial short and focused on providing the overview of the entire MSP game-play experience and key interfaces accordingly. It also allowed us to provide more specific information and guidance about a particular interface only to those who want or need it. The system is activated through a question mark button in the top-left corner of any window’s header. The overlay provides information about all available features in the window through infographic-like visuals.

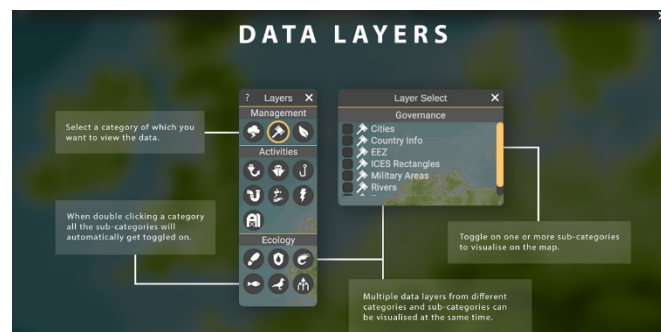


Fig. 17. Newly designed help overlay. The window concerned is still in the old beta10 style.

4 Conclusion

This paper discussed the main reasons for redesigning the UX/UI of MSP Challenge, a marine or maritime spatial planning simulation game. The latest installment of this game has been applied in 48 game sessions involving 1.028 participants since January 2018. However, over the past years and software releases, we have generally been scoring only reasonably well and not improving on a key statement in our short post-game questionnaire: ‘The MSP Challenge software was easy to use’ (N = 142). In a more rigorous small-scale study, our 10 participants provided the key insight that we had work to do concerning layout diversity, layout simplicity, and interface usability.

We discussed the thinking and decision-making involved in the UX/UI redesign. We offered and argued for redesigns to data layer access, information, and plan creation windows, with which we would improve layout simplicity and interface usability. We also offered and argued for redesigns to the login and loading screens, with which we would improve layout diversity and simplicity. Finally, we provided and argued for a design for a new tutorial mode and help overlay system, with which we would improve interface usability. The new design mockups shown throughout these sections demonstrated the new proposed graphical style, with which we would improve layout diversity.

We note several limitations to our analyses and discussions. First, we did not cover all the functionalities and accompanying interfaces MSP Challenge offers. We report the omission of interfaces for evaluating simulation results, for example. Second, at this stage, we only have expectations. We have yet to test or evaluate them. Moreover, we acknowledge that UX/UI design is only one perspective within or frame for simulation/serious game design. Finally, while we are confident our UX/UI design ideas have merit in themselves, we acknowledge the many other factors that influence the effectiveness of MSP Challenge in terms of MSP learning and support.

The next step is thus to implement further and evaluate our redesign. Ultimately, this means scaling up our small-scale study into a quasi-experiment. We will form a new experimental group

of respondents having never played MSP Challenge before. This group will perform the same tasks and fill in the same questionnaire as our previous group with version beta10. We expect the scores on all variables to be higher, or at least on layout diversity, simplicity, and interface usability.

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A serious game for the low-carbon transition: local energy community framework

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Abstract. As part of a research project (RECA) driven by recent European legislation on low carbon production systems, a participatory committee was set up to discuss the carbon footprint of photovoltaic (PV) panels and the creation of a serious game was proposed. The action research presented here is based on participant observations made during the first 7 meetings of the RECA Participatory Committee, as well as interviews conducted with the participants of the meetings. The article first presents the mobilisation potential of the game co-design as an anchor for the exchanges of the RECA Participatory Committee and then, in a second step, discusses the game experience itself. Three levels of objectives are intertwined in the research project: (i) for the researchers, the development of a methodology for calculating the carbon emissions of collective self-consumption; (ii) for the participatory committee, the discussion of the results of the RECA projects; (iii) for the serious game, the information of citizens on the design and operation of a self-consumption installation. Thus, through the co-design of the serious game, the technology is "experimented" and discussed among the players involved in the game. In the future, the participatory committee will be involved in the testing phase to get feedback and ensure that the game is playable. The public release of the game prototype is planned for 1 June 2023.

Keywords: Co-design, Participatory Committee, action research, photovoltaic carbon footprint

1 Introduction

Recent EU legislation [1], [2] has encouraged the development of low-carbon production systems and energy communities at the local level. As part of a research project, a participatory committee was set up to discuss the carbon footprint of photovoltaic (PV) panels and a serious game was developed to foster participation.

1.1 The development context of the serious game : Atlantech, a "low-carbon" district, incubator of a collective self-consumption operation

Atlantech is a low-carbon urban district located at the northern end of La Rochelle, France. It consists in an area of activity dedicated to the energy transition, making this district an incubator for innovation and a large-scale demonstrator. While some see it as a "beta" version of the city of the future, others see Atlantech as "closed in on itself". This sense of separation from the rest of urban life is encouraged by its modern design and architecture, which visually mark its distinction from the adjacent neighbourhoods, and is reinforced by its spatial configuration. Within the neighbourhood itself, groups are defined according to different activities: living, working or learning [3]. A research project is underway in the Atlantech district, the RECA project for "carbon reduction for collective self-consumption". This project started in July 2020 and will continue until July 2023.

One of the aims of this research project is to evaluate the carbon footprint of photovoltaic panels integrated within the Atlantech district, including both the environmental impact of the local production and storage (if any) systems and the interaction with the national grid. Production and consumption at a decentralised level is known as self-consumption and has

developed worldwide in recent years due to its economic attractiveness. Two configurations of self-consumption can be distinguished: individual vs. collective. In the case of individual self-consumption, the electricity generated from renewable energy sources is primarily consumed by the producer; the excess energy (if any) is then sold or given away to the main grid. In the case of collective self-consumption, the energy produced within the organisation is shared with nearby consumers according to commonly agreed rules, thus minimising excess energy. In this article and in the research project, we focus on collective self-consumption because of the societal challenges posed by energy sharing.

The environmental impact of PV panels was performed by researchers and quantified by evaluating the carbon emissions avoided by the PV panels (units in $t_{CO_2\ eq}/year$). Thermal and electrical simulations of the Atlantech district were performed for different time horizons (2019, 2035, 2050). Hourly simulations were required to better account for the variability of production, consumption, and emission over time. The first results of the research project indicated a positive impact of collective self-consumption even for future energy scenarios. Sensitivity studies were also carried out (Figure 1) and highlighted the strong influence of design choices on the environmental impact of the local production system [4].

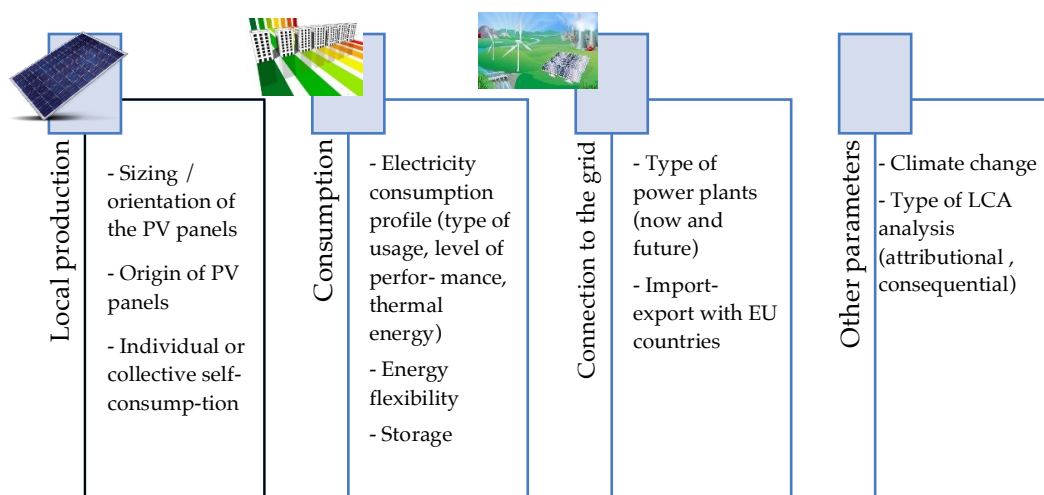


Fig. 1. Parameters tested in the sensitivity analysis.

1.2 The participatory committee of the research project

The other objective of the research project is to share and discuss the results outside the academic field. As shown in Figure 2, the participatory component of the RECA project, by bringing together energy experts, users, and local authorities, aims to integrate all the actors concretely involved in the development of a district through a participatory committee by acting on three points: (i) enabling citizens to reflect on their needs and energy consumption patterns, (ii) analyse the overall energy chain to identify carbon emissions, (iii) implementing and testing a common evaluation method between energy providers and citizens, in order to be able to objectively analyse the emissions of the collective self-consumption operations set up. In this respect, the Atlantech district is part of a collective self-consumption operation that questions the production and circulation of knowledge through participation. Participation, as a means of responding to specific issues, is relevant in the face of the incertitude caused by climate disruption, and indeed, it is also relevant in the projects inherent to the ecological transition [5].

ADEME, which is funding part of the project, is showing its willingness to integrate citizens more and more in research projects by funding "participatory research" projects. Several definitions of participatory research have been proposed. Thus, the Houllier report for the

Ministry of Higher Education, dating from 2016, defines participatory science and research as "forms of scientific knowledge production in which non-scientific-professional actors participate in an active and deliberate way" [6]. Another definition is proposed by the CNRS ethics committee, which refers to "sciences with citizen virtues, at the service of society in their organisation and functioning" [7] and reflects the idea that this mode of research aims to provoke social change and work for the transformation of science by providing concrete solutions, "for action" [8]. Several authors have highlighted the strengths and limitations of participatory serious game design [9][10]. They point out that it "increases public engagement with research and facilitates learning and change, ensuring that technologies are tailored to people's needs". However, despite its popularity, participatory design has remained limited in the design and development of serious games and is often restricted to critical feedback on games [41]. Therefore, the idea of creating a serious game (called Solaropolis) was discussed. Our approach is intended to serve as a concrete example of co-design of a serious game, on a minor theme addressed by serious games: collective self-consumption.

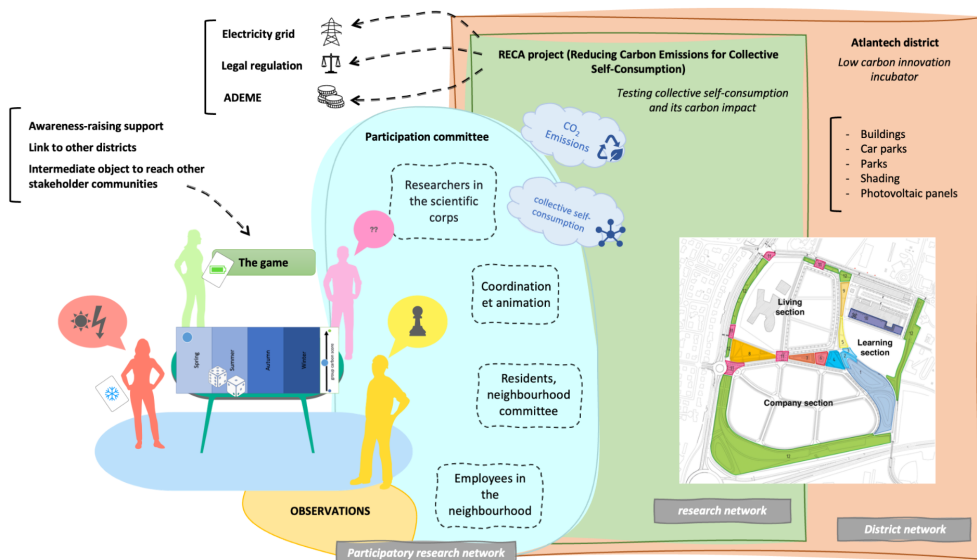


Fig. 2. Project and stakeholders ecosystem. Solaropolis game is represented as an "frontier object", mediating between the different components of the RECA project, the Atlantech district and beyond.

We have documented the entire participatory co-design process of the Solaropolis game. In fact, the action research [11] presented here is based on participant observations made during the 7 meetings of the RECA participatory committee over a period from January 2021 to April 2023 (Fig. 3), as well as on interviews conducted with meeting participants. This is action research as the researchers are directly involved in the search for strategies and methods of action, the main objective being to prepare the group for change through the participatory process and by creating a form of individual and collective liberation, empowerment. Participatory observations are carried out by the project coordination and facilitation team and result in reports for the participatory committee. At the same time, a logbook is used to record the various key moments of the project, which will form the basis of a broader analysis as part of a thesis in progress¹. The comprehensive interviews [42] carried out at the beginning and during the project (between September 2021 and December 2022) are 19 in number and constitute the first phase of a more

¹ Nina Colin - Participation as a mode of research: between plurality of practices and potential for replication. Through the study of a territorial case: the energy and low carbon transition in La Rochelle.

global study around the RECA project and its participatory committee, they will be coupled with a second phase of interviews in June and July 2023, at the end of the project.

The article will first present the potential of mobilising the co-design of the game as an anchor for the exchanges of the RECA participatory committee and then, in a second step, we will discuss the co-construction of the game experience itself.

2 Mobilizing the game framework as an anchor for the RECA participatory committee's discussions

The purpose of this section is to illustrate the intent and the contribution of game co-design to (i) the RECA research project; (ii) the researchers; and (iii) the users. By analysing the evolution of the objectives of the participatory committee, let us begin to study the genesis of the serious game.

2.1 Evolution of the objectives

During the set-up phase of the RECA project, there was a real desire to integrate the future users – residents, workers, students – of the self-consumption loop into the research carried out, with the initial objective of building a simplified and robust methodology to assess the carbon impact of self-consumption at the scale of the Atlantech district. This involvement of users in the project does not stem from an initial need on their part, but rather from the framing of the project coupled with the will of the funder. The participants are either individual volunteers or from neighbourhood organisations who are obliged to attend Atlantech events. It should be noted that this obligation concerns the organisations, but the participants as individuals are all volunteers. The committee is also made up of researchers who have little experience of participatory research but who are convinced of its importance.

Extracts from the interviews conducted at the beginning of the project (phase 1)

Employee 1 in the Atlantech district	Resident 1 of the Atlantech district
<p><i>"Maybe I wouldn't have provoked it, but it was an opportunity. Afterwards, as we said earlier, it was obvious ... and it was part of the job."</i></p>	<p><i>"I think that it is quite representative of the general population, in a general way, we speak about the environment, we speak about energy saving, we speak about ... here we are, about ... managing energy [...] but and ... what do we do? And what can I do, at my level? That's the big question."</i></p>

This initial configuration is not necessarily conducive to the implementation of participation. The users were initially quite critical about the project, lamenting the technocratic choices made in the district. After the first meeting, they only expressed the wish to build "something that stays", they were willing but waiting to know "what to do together".

Extracts from the interviews conducted at the beginning of the project (phase 1)

Resident 1 of the Atlantech district	Resident 2 of the Atlantech district	Employee 1 in the Atlantech district	Resident 3 of the Atlantech district
<p>"[...] for concrete action, yes, and something we can touch."</p>	<p>"So what now ... the next step? Where do we go, what do we work on? With whom? And our projects? Is the project feasible? Will we be able to see the evolution of the neighbourhood? because the neighbourhood is evolving ..."</p>	<p>"[...] But in any case to build something, yes, that will allow us to easily talk again even when there is no longer this system of animation like that. And then to make collective choices on energies, well, on things to put in place."</p>	<p>"I don't know yet, in relation to the meetings, because we haven't done much [...] where we want to go and where we are going? And I think now, in the next few meetings, we're going to have to settle down and start doing ..."</p>

As meetings are held, the involvement of the committee led to a shift in the participants objectives towards the followings: the appropriation of a new technology, involving the entire neighbourhood (2 km) by a small group and the accompaniment of the energy and environmental transition through energy sobriety. So the idea of creating a serious game was proposed by the animation section and discussed and agreed by the committee.

At this stage of the article, it seems important to specify that three levels of objectives are intertwined in the RECA project: (i) the objective of the RECA project itself corresponds to the development of a methodology for calculating carbon emissions for collective self-consumption; (ii) the objective of the participatory committee is to provide reflective feedback on the work of the RECA project researchers. This objective requires an improvement of the group's knowledge and skills in the field of energy. For this purpose, the collective creation of the serious game seems relevant, as it is able to set the framework and channel the exchanges. It also responds to the group's desire to create something that will last beyond the project. Finally, (iii) the objective of the serious game — which is in the design phase — is to inform citizens about the design and operation of an energy community and the environmental impact of self-consumption. It also makes it possible to disseminate the results of the RECA research by presenting the principle of collective self-consumption to future users or communities, and/or to encourage future investors to join an energy community. Finally, it is also intended to teach the right gestures for the optimal use of collective self-consumption in order to guarantee a reduction in carbon emissions. In fact, through this energy management game, the committee will have to make decisions, react, give its opinion on several indicators and/or co-construct these indicators.

2.2 The game as a framework

Djaouti et al. [12] date the official birth of the term 'serious game' to the early 2000s. These are experiential environments [13], playful objects, diverted — at least in part — from their initial use: to entertain us to focus on reflection, information or stimulation. They are tools for simulation and even co-construction [14]. A recent review from Morganti *et al.* [20] highlighted the positive influence of serious games on energy-saving behaviours. The development of the game presented here is based in particular on (i) collective creation times, (ii) an "ultra-simplified" carbon calculation model. The game itself is based on the allocation of roles and the organisation of debriefing by the facilitator at the end of the game session.

The serious game developed during the research project is related to energy, which level of knowledge within the population is known to be relatively low [15]. This level of knowledge is sometimes defined as energy literacy: it encompasses not only the understanding of the nature

and role of energy in the world and in everyday life, but also the ability to apply this understanding to answer questions and solve problems [16]. Several reasons can explain this energy-illiteracy: complexity to visualise energy flow, distance from the centralised production systems or energy sources, and difficulties to identify the capacity of actions [17]. Moreover, in the case of the development of collective self-consumption, understanding energy is not sufficient, but citizen's active participation is the foundation for the acceptance and development of new technologies [18]. The game co-design is therefore used here as a basis for the group to appropriate and understand the technique.

In a certain way, the game serves also as a framework for the exchanges of the participatory committee by its capacity to give rhythm to the passing of time: it guarantees that the participants, whose wish it was, have an objective. Indeed, as we have seen previously, participation is conditional on the investment of time and energy being used for something, and the research process does not guarantee an outcome, let alone a usefulness [19]. This is particularly apparent during the preparation phase of the group sessions, where certain elements of the game framework (e.g. preparing a workshop to create "random event" cards or to reflect on the different roles in the game) structure the issue to be addressed in connection with the research project (such as the origin of the photovoltaic panels, the indicators to be taken into account, the governance, etc.). These numerous possible connections are as many "entry points" to apprehend the complexity of the research objects that are self-consumption and the calculation of carbon emissions. During the collective high points, the discussions and debates are then channelled around the objective of creating the game. The game framework sets the conceptual model that allows for exchanges. Beyond the general direction given by the project, this space of exchange between experts (researchers and engineers) and users is also a space to raise awareness of energy sufficiency, presented as an essential aspect of the energy transition.

The "game" object is a mediator for the appropriation of this technology to be used in "common". The common construction of the intermediate object allows the participants to build a common representation of their system allowing in a sense to lead the group towards a new form of decisional autonomy concerning the consumption of electricity, stronger than if they had only participated in a game session. Thanks to the facilitator training that will be organised in the near future, participants in the game design will be able to become "game ambassadors" if they wish, by facilitating and broadcasting game sessions, along the lines of LittoSim-Gen and the "LittoTeam", for example [21]. These are overflows that we cannot foresee or anticipate at the moment, which will be the subject of a second phase of analysis (from July 2023).

2.3 The facilitator, a necessary game master?

As Ghelli [39] reminds us, "The question of accompaniment is fundamental in the design of an educational game: the game does not have the same constraints if it is designed to be played independently or if, on the contrary, it requires the presence of a facilitator." [39]. The participatory committee imagined a game that requires the presence of a facilitator, whose role is to facilitate during and after the game, during the debriefing phase. For the committee, this is not a "Saturday night game", but a learning and awareness tool dedicated to specific moments and organised by a third party.

During the game, the facilitator acts as a narrator, but is also responsible for ensuring that the participants understand the mechanics of the game. He is at the same time a "game master" who explains the rules at the beginning of the game, a companion who guides the players during the game, and also a "knowledge broker" [40] who is able to provide information and approach theoretical concepts when necessary. In short, he is the guarantor of the pedagogical objectives and therefore of the "serious" dimension of the game [14].

At the end of the game, he or she will also be responsible for conducting the final debriefing. Based on the model of the "2-ton" workshop, the aim of this debriefing is to allow the group to discover how it could have improved "even more" the carbon footprint of the self-consumption

operation designed by the team. It also serves to ensure the "double process of translation and interpretation" inherent in the use of a boundary object, allowing the interpretation of what happens in the virtual world of the game for the real world. It makes it possible to understand and analyse the results of the game in terms of action in the real world [33].

3 Co-constructing a game experience, from intention to action

The purpose of this section is to present the existing serious-games related to energy communities and then describe the co-design phases and the gameplay. We will focus on the development of the game within the RECA project and the role given to the participatory committee and the researchers. It was decided to create a new game, rather than hack an existing one, for several reasons: (i) after a survey of existing serious games on the subject, we found few board games linking the themes of energy and carbon on an annual scale. (ii) The original creation of a game made it possible to capture all aspects of the design and therefore of the project, implying a stronger bond of the collective creating something unique. Nevertheless, it should be noted that the group was inspired by the mechanics of several games, including: (i) *Galerapagos* (Gigamic, 2017) for its resource management aspect and its extension in terms of roles and character cards, (ii) *Carbon Lean* (Themelsle, 2020) for its game mechanics around carbon calculation.

3.1 State-of-the art of existing games

Serious games on energy-related topics are seen as one of the solutions to overcome the knowledge gap on energy. In this article, we will focus on games related to the development of renewable energy systems. Regarding the level of study, some games target the country- or city-scale with the objective to develop a complete energy system made up of different sources (e.g. *CityOne* [22], *Power Matrix* [23], *EcoVille* [24]). Other games focus on a smaller scale and deal with the local production of energy connected to an electrical grid (e.g. energy communities). A recent review proposed by Nykyri et al. [25] lists the serious games developed in the context of energy communities. Table 1 provides an overview of the characteristics of these serious games. The objectives are quite similar for all board games, i.e. to provide a better understanding of local production systems and to initiate cooperation/ negotiation. From this table, it can also be observed that the games focus on different stages of development: the design/investment phase (*Changing the game*, *Energy Game*), the operation phase (*Social Mpower*, *Sous Tension*) or both phases (*Electric City*, *DLT Energy Game*). The games developed were either digital (2D or 3D) or board games. For some authors, board games were seen as advantageous as it allowed keeping an overview on the whole system [18]. Regarding the timescale represented in the game, a large variety can be observed, from one day (*Social Mpower*) up to 30 years (*Changing the game*, *Energy Game*). Finally, it should be highlighted that some games proposed a physical representation of energy in the form of brick to overcome the problem of materialising energy use (*Changing the game*, *Sous Tension*).

Table 1: List of serious games related to local production and consumption of energy and local energy communities.

Name of the game	Learning objective	Format	Role	Unit	Duration	Cooperation
<i>Social Mpower</i> [13]	Understanding RES, Energy sharing	3D simulator	Inhabitants	Energy	Typically a day, until a player run out of energy	Yes (negotiation among players)
<i>Changing the game – Neighbourhood</i> [18]	Create a district and its energy system (electricity, heat, transport), CO2 reduction	Board game	District designers	Energy and CO2	30 years	Yes (for global targets and for unpopular actions)
<i>Electric City</i> [26]	Secure and manage electricity, food and water	2D island simulator	Inhabitants	3 dimensionless resource scales	6 turns	Yes (negotiation)
<i>DLT Energy Game</i> [27]	Understanding of peer-to-peer energy trading and DLT	?	Inhabitants (with PV or without PV)	Energy and Cost	2 rounds (with and without exchange)	Limited (sharing only)
<i>Energy Game</i> [28]	Design a neighbourhood energy supply and earn as much money as possible	3D environment	Developer	Energy and Cost	30 years	No
<i>Sous Tension</i> [29]	Share energy among apartments	Board game	Inhabitants of the building	Energy	1 week (divided in 3 hrs)	Yes

3.2 The game context

Game synopsis:

Welcome to the Solaropolis district! Today, you will play the role of citizen-builder by participating (or not!) in a local renewable energy production project. Together, you will have to develop your district in two stages: you will start by initiating a self-consumption project, and then you will have to develop it throughout the year by limiting its carbon footprint, despite the dangers and interests of your characters! Don't forget: sobriety and resilience will be essential to finish the game with the lowest possible carbon footprint, while saving your wallet...

The synopsis of the game (see text above) aims to allow the player to enter the game universe through 'setting in narrative' [14]. This storytelling, coupled with the different possible scenarios, serves as mediation by allowing players to immerse themselves in the message conveyed by the designers. In this case, it is the participatory committee that produced the synopsis, through a collective intelligence workshop proposed during a group highlight. We note the emphasis on the collective and cooperative dimension in the synopsis of the game produced by the committee.

3.3 Design Phase

One of the main challenges of designing a serious game consists in simplifying the complex mechanisms of the real world by a few clear rules, which will provide the framework for the execution of the game [18]. Moreover, to achieve the learning goals, the game should include the

following features: pleasure, reward and progression over time [30], [31]. The initial design of the game started in June 2022 and the test phase is still ongoing to date (Fig. 3). We will thus describe the first outcomes of the design process.

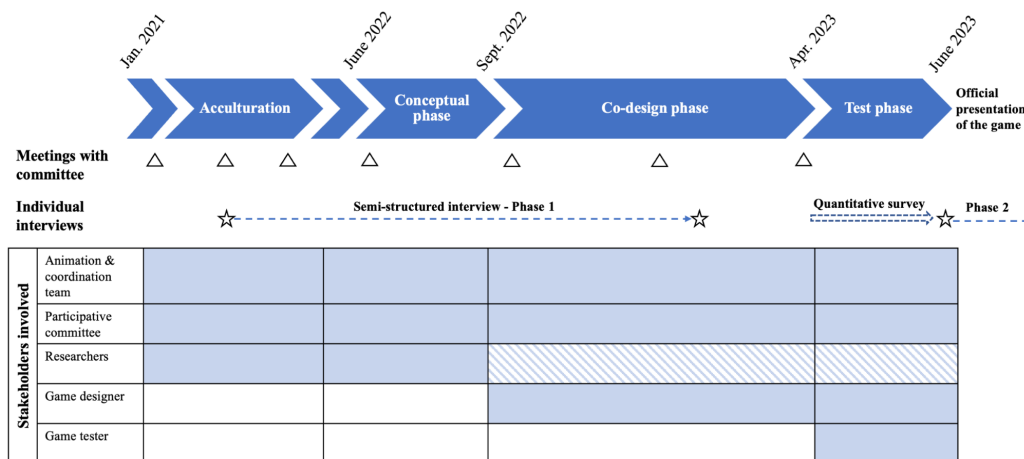


Fig. 3. Game development timeline.

The overall design phase was twofold: first three meetings were set-up to acculturate the committee to the topic of energy and self-consumption and four meetings were then organised over a one-year period to design the serious game in cooperation with the participatory committee. In addition to these regular meetings, two persons were more closely involved in animating and coordinating the participatory committee and ensuring that the results of the meetings (sometimes with conflicting opinions) were incorporated into the game design.

Different topics were discussed in groups to develop the game: format, cooperative vs. competitive, gameplay, roles, rules, indicators, storytelling, etc. Various game formats were proposed: mobile application, escape game or board game. During the discussions, the board game was favoured due to its ease of deployment and to support the exchanges between players. The participants also agreed that the game should be deployed during collective times (neighbourhood committee, events, etc.), which makes the board game more suitable. A debate was also opened on the interaction between players, and more specifically if the game should be cooperative or competitive. Due to the collective nature of (collective) self-consumption, it was quite natural to propose a cooperative game and a large part of the committee agreed on this choice. However, some proposals later in the design phase tended to be more competitive as this format was seen as a way to spice up the game and foster participation. This will be checked during the test phase.

Another important part of the co-design phase included the definition of rewards and penalties in coherence with the scientific project. As highlighted by Prilenska [28], the development of the gameplay should avoid the bias from oversimplified models. The order of magnitudes should be in line with the scientific results to avoid misleading the players. In order for the participatory committee to get a better understanding of the carbon footprint of self-consumption, a simplified model (see Fig. 4) was proposed by the scientists to observe the variation of the carbon emissions depending on the design and operation of self-consumption (see parameters in Fig. 1). The committee could explore a spreadsheet on their own, to estimate the gains or losses from various design choices. However, the committee did not really make use of this spreadsheet and relied more on scientists to provide them with accurate figures. This role of external and trusted advisor was also identified by Voinov [32]. Among the different factors that can influence the carbon footprint of collective self-consumption, it was decided to focus on a few of them, namely: the

origin of the PV panels (China vs. EU), the size of the powerplant, the influence of seasons, the behaviour of participants (energy conservation, flexibility) and the energy efficiency of buildings. Moreover, the committee decided to have both monetary and carbon units in the game, as these two indicators could lead to conflicting choices for the players.

It should be highlighted that the lessons learned from the game are not specific to the district evaluated (i.e. the Atlantech district). In fact, the results and conclusions will be alike for other sites in France (similar annual PV production), other district sizes (effect of scale only) and other years (sensitivity study over four different years). However, the conclusions will not be valid if there is a drastic change in electricity use (e.g. industrial district, or a district with a limited use of electricity for space heating or domestic hot water).

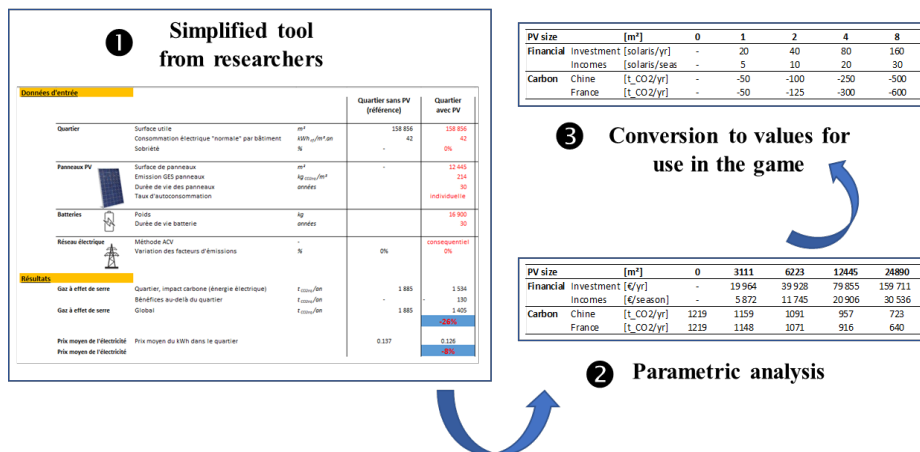


Fig. 4. Presentation of the workflow for defining the data to be used for the design of the cards.

3.4 Gameplay and game material

The game involves the design and operation of an energy community in the Atlantech district. Residents, investors and workers must work together to design and operate a PV system that both improves the district's carbon footprint and generates savings.

The game material consists of a wooden board with chips manufactured locally (see Fig. 5). Before starting the game, each player chooses a card with a role assigned to it (family living in the neighbourhood, young adult renting an apartment, landlord, CEO of a company, etc.). These roles will define individual objectives to reach (either more focussed on the money, or on the carbon emissions) and different interest in the installation of PV systems (depending on their electricity consumption). The game is organised in five rounds: the design of the PV system is performed during the first round, and the four last rounds are related to the operation of the system during four seasons (autumn, winter, summer, spring). The objective of the first round is for the player to understand the interest (financial or carbon) to group their investment in a shared local production plant. The last four rounds focus on the challenges related to a variable production system and the need to adapt the consumption of the district. The group wins if they manage to get electricity all year long and if they reach their collective target to decrease the greenhouse gas emissions.

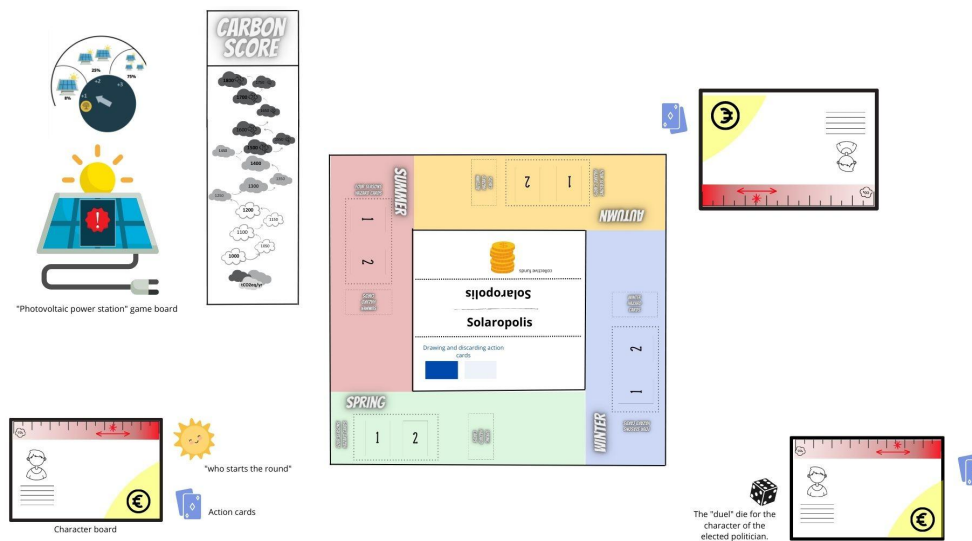


Fig. 5. Provisional gameplay. The photovoltaic power plant is built during the first phase of the game. The game board comes into play during the second phase of the game and represents the four seasons, each season consists of risk cards (weather, circumstances, ...) the change of season takes place when each player has drawn a risk card and possibly performed an action during the season, the end of the game is called when all four seasons have been played. Each player has in front of him: a character card and action cards. The carbon scoreboard makes it possible to follow the evolution of the carbon impact of the collective self-consumption operation over the course of the game. (Illustration : Mégane Haenn).

4 Discussion

4.1 Matching the game's intent (part 2) to the game's mechanics (part 3)

E.Ostrom [37] pointed out that the conditions for cooperation within the commons are not reduced to access to the resource. They depend largely on the degree of commitment to the collective and the trust that its members maintain [38]. Factors that facilitate cooperation include the ability of participants to communicate with each other, their ease of entering and leaving the collective, and their ability to project themselves over the long term [37]. Through the organisation of shared sessions between several social worlds, the game aims to enable mutual knowledge between the users of the self-consumption community and the different actors involved (producer, organising legal entity, distributor, etc.), thus ensuring long-term involvement within the energy community. Bourazeri et al [13] also use Ostrom's notion of the commons to design a social serious game that aims to enable collective awareness of energy consumption, while showing that the serious game is an effective way to change users' behaviour and habits around energy consumption.

4.2 Beyond the participatory approach, the appropriation of a technique

This section aims to highlight the impact of the game design on the participatory committee and in the appropriation process of the collective self-consumption technique. As Barreteau et al. [33] note, *"knowledge sharing is a privileged means of changing the relationships between individuals, as well as the relationships between individuals and the resource"*. Thus, the serious game presented here - which is still in its design phase - can be described as an intermediate object (IO), in the sense that it allows for collective reflection between several types of actors: "laymen", "researchers", "technicians" and "facilitators" (Figure 2).

The game is an artefact [43] that helps to structure the committee by giving it consistency, a clear and tangible objective and stability over time. It also fulfils the three characteristics of IOs as defined by Dominique Vinck [34][35].

Thus, the game is an intermediary object for the participatory committee, but also subsequently for all future players. By becoming the mediator of change, it allows the exploration of different transformation options and their consequences, of different possible transition paths. More precisely, it is a frontier object because it can be used by multiple actors from different social worlds. This frontier object induces a situation of mediation in which the actors seize the object differently while sharing a common goal: testing different scenarios of self-consumption, possibilities of development of the operation and can interpret roles without direct impact on reality [21].

4.3 Playful transmission of technique use

One of the objectives of the RECA participatory research project is to analyse the potential for replicating collective self-consumption operations, such as the one carried out in Atlantech, in other districts. The game, which is not specific to Atlantech but aims to represent a typical neighbourhood, seems to be the ideal intermediate object to allow future users of these neighbourhoods to understand the technique that will be used there. In fact, the data used in the project are applicable to other cases of study because the indicators taken into account are: the French climate and the "residential area" aspect.

We have therefore decided to involve them in the participatory process during the test phase of the game (Fig. 3). We will therefore organise three test sessions of the game with the future users of two districts of La Rochelle, before the day of the return of the project and the official presentation of the Solaropolis game on 1 June 2023. The test phases of the game will take place between 6 and 20 May 2023. To document this phase of the project, we have planned (i) a quantitative study analysing the dynamics and mechanics of the game, the pedagogy of the game and the initial knowledge of the respondents on the energy field. This quantitative study will be coupled with a focus group to explore in detail the testers' experience of the game. This is part of the ongoing RECA research.

5 Conclusion

In this article, the potential of mobilising the co-design of a serious-game as an anchor for the exchanges of a participatory committee was presented and the game design and experience were described. Three levels of objectives were intertwined in the research project: (i) for researchers, the development of a methodology for calculating carbon emissions for collective self-consumption; (ii) for the participatory committee, the discussion of the outcomes of the RECA projects; (iii) for the serious game, the information of citizens on the design and operation of a self-consumption installation.

Thus, through the co-design of the serious game, the technology is "experimented" and discussed among the players involved in the game. Existing literature also supports this finding, it has been confirmed that a game is beneficial for learning knowledge considered outside the normal expertise of a player [27]. However, we recall here that at this stage of the study, the game has not yet been tested, so we are waiting to find out whether the game is really pleasant, what impact the facilitator has on making the game pleasant and instructive, and whether the educational objective of the game is achieved. The aim is to involve the participatory committee in the testing phase to get feedback and ensure that the game is playable. The public release of the game prototype is planned for 1 June 2023.

The limits of the participatory process will be discussed and analysed at a later stage of the study, when the second phase of interviews has been conducted. For the moment, the game seems to have reduced the asymmetries between "researchers" and "users", but we note a form of asymmetry inherent in the seniority of the participants in the participatory committee. In fact, we

decided at the beginning of the process to leave the participatory committee open to the renewal of participants. This proved to be necessary because not all participants were available for every meeting, although a 'core' group formed over time. Nevertheless, the last people to join the committee showed more difficulty in integrating into the process, as evidenced by their difficulty in speaking up, the number of suggestions they made, and their degree of socialisation. We will try to explore this aspect of the study in more depth in the near future.

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Harnessing the complexity of socio-ecosystems to design games as “viable metaphors”: lessons from a case study in the lower Amazon floodplain fisheries

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Abstract. In the Amazonian floodplains, artisanal fishing is a historic activity of high socioeconomic and cultural importance. In the last decades, fishing and fishermen have been suffering from numerous socio-environmental threats, compromising the ecosystem and its biodiversity, and local population livelihoods. Since the end of the last century, fishing communities have pressured the government, civil society, and other social actors to assume and support a sustainable co-management of fisheries in the region based on fishing agreements. It is in this context that we have been developing the construction of a role-playing game called 'PescaViva'. Based on a companion modeling approach, the game has been built collaboratively, involving local fishermen/farmers leaders and environmental agencies representatives. Our aim is to develop a game that would meet not only the wishes of the research team but mainly the fishermen and people from the government. This paper describes how researchers, together with local actors, have worked on the challenges of the 'PescaViva' co-construction, considering the complexity of artisanal fishing in the Amazon and the scarcity of scientific knowledge about the activity. In some test sessions in the fishing communities, the game was understood, well-received, and associated with the local reality. It remains to be seen whether gaming sessions could be organized at the initiative of the local stakeholders themselves with the support of local facilitators in order to revitalize the dialogue and stimulate the construction and review of local fishing agreements.

Keywords: Fishing Agreements, Companion Modelling, Floodplains.

1 Introduction

Fisheries co-management is a difficult process worldwide [1] and artisanal fisheries in the Amazon floodplain are no exception. Floodplains are the periodically inundated margins of the rivers of the Amazon watershed. Because of the river's level variations along the year, the landscape is drastically transformed, between the low- and high-water periods, impacting both ecological and socio-economic dimensions. Floodplains have been occupied by the human population before the colonial period, relying on rich soils for agriculture and highly productive waters for fishing [2]. Fishing remains the main source of animal protein and income for Amazonian populations living in floodplain regions, [3-4]. Until the 1960s, fishing was a seasonal activity. From the 1960s onwards, technological innovation and the increase of urban population transformed fishing practices and favored large-scale fishing whose production is exported to cities and other regions of Brazil. Large-scale fisheries in the last decades have been exerting tremendous pressure on fisheries stocks [3,5] associated with freshwater ecosystem degradation leading to signals of overexploitation of some fish species and fisheries stock depletion [6-7]. The perception of fish stocks declining and the entrance of large-scale fishing boats in floodplain

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environments, considered communal properties, motivated populations living along the rivers to organize themselves to limit, or even prohibit, access to the flooded lakes, leading to significant conflicts in the region. This mobilization formed the basis for fisheries co-management on the Lower Amazon floodplain at the beginning of the 2000s [8]. However, only in 2021, *Pará* state issued a decree setting out the criteria for the formalization of community agreements and tasked representatives of artisanal fishermen (unions, fisheries council) and the municipal and state environment secretariats of *Pará* to accompany the process. From this, the communities felt motivated by the perspective of fisheries co-management evolution in the region.

It is in this context that we conducted our research in the region of the Great Lake of *Curuai* (*Lago Grande do Curuai*). A companion modeling (ComMod) approach was used to engage local fishermen in tackling the issues of sustainable fishing in the context of socio-economic pressures and hydroclimatic changes. Supporting decision-making processes is not the core objective of the co-design and implementation of a model, but there are demonstrated cases in which the ComMod methodology was able to foster agreements to common-pool resources sustainable management [9]. The ComMod approach [10] encompasses a large panel from computer-free games to autonomous agent-based models to explore solutions to a sustainable future. This paper presents a current experience with ComMod for fisheries co-management in the Lower Amazon floodplain and, in particular, the challenges we faced in developing a version of the game that would prove useful and be easily adopted by the local stakeholders involved in its co-design. Indeed, in some experiments, the game is only useful for researchers. Once the game has been designed, local actors and decision-makers cannot deal with it on their own. To address this, [11] argues that a game 'must function as a viable metaphor'. In other words, it must be recognizable, playable, and appropriate, making the game relevant to its target audience. Therefore, our aim in this paper is not to present the process that led the participants (including the researchers) to better understand the functioning of the system, but rather to relate the different steps with the actors involved that made it possible to represent the complexity of the system while keeping the game useful to users and managers as a tool to address issues about fisheries management.

2 The Lago Grande do Curuai floodplain

The floodplain of the *Lago Grande do Curuai* (Fig. 1) extends for one hundred kilometers (bounded rectangle -01°50'16"N - 02°15'12"S and -55°00'51"E - 56°05'00"W) along the right bank of the Amazon River in front of the city of *Óbidos* in *Pará* state. It consists of numerous lakes connected by channels. The flooded area varies roughly between 2200 and 600 km², depending on high and low water levels. Most of the municipalities in the region are administratively attached to the district of *Santarém*, but to the west, they are attached to the district of *Juruti* and to the north to the district of *Óbidos*. Under the auspices of the National Institute for Colonisation and Agrarian Reform (INCRA), most of the communities in the region have been consolidated through agro-extractivist settlement plans (PAE). *Lago Grande* PAE covers about 250,000 hectares and includes more than 128 communities. In this area, the land is shared collectively, and the use of renewable resources and the development of economic activities are regulated by a plan of use drawn up by representatives of the Federation of community associations, FEAGLE [12]. According to local fishermen, fish production in the *Lago Grande do Curuai* floodplain, which was historically very high, is now much lower. Fishing is regulated locally by community or inter-community agreements. However, invasions by large-scale fishing boats from other communities or regions are common. Agreements are not necessarily systematically respected within the communities themselves.

The game board

It depicts a floodplain with five fishing sites around which four communities are located. Two boards are used to represent the seasonal changes in the landscape throughout the year: 1) the *inverno* (winter) board represents high water, and 2) the *verão* (summer) board represents low water. On the *inverno* board, all the fishing spots are larger and connected. On the *verão* board, they are smaller and one of them is isolated (see Fig. 2). The fishing spots are materialized by jars placed under the board. Holes of the same size as the jars allow the players to "fish" with different fishing equipment. Each jar contains a certain number of small seeds, corresponding to a volume of water for each season, in order to reflect the variation in water levels between winter and summer.

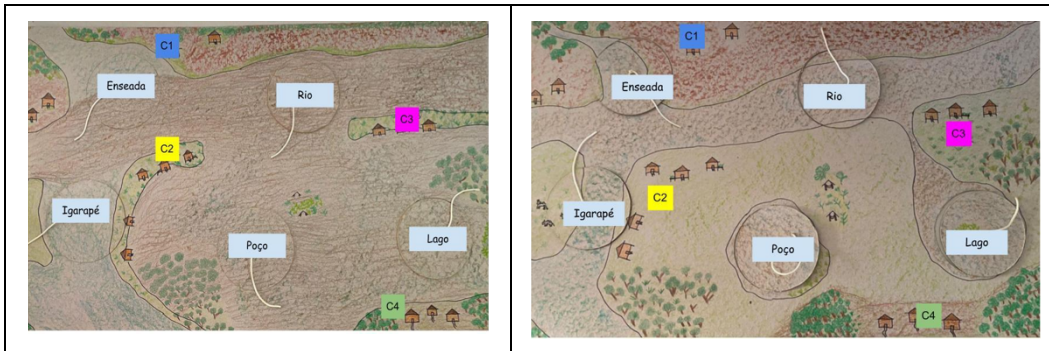


Fig. 2. On the left: *inverno* game board; on the right: *verão* game board. C1 to C4 indicate communities 1 to 4. Here the holes under which the jars are located are covered by round cardboard pieces.

The players can see the game board, the location of the communities, and the five fishing spots. However, they cannot see the fish stocks located in these spots. They can only estimate the stocks based on their catches when fishing.

The fish stocks

There are two types of fish in the game: Scaly fish and Flatfish, each represented by a sought-after species (e.g. *tambaqui* for Scaly fish, *surubim* for Flatfish), which is subject to a fishing ban (*defeso* period) during its breeding season, and a base species of lesser value. The four types of fish are identified by different colored pearls. The varying density of fish in each site and in both seasons is represented by the "amount of water" (weight of seeds) contained in each jar. The pearl fishes are thus "diluted" in the jars, which leads to different catch probabilities due to the dilution, but also due to the fishing gear used by the players.

The initial number of fish is chosen in such a way that the stocks are partially depleted quickly. Fish reproduction and migration are represented by a simple law. The resulting updates are made at the beginning of the summer season. Some predators are also introduced in the jars: the '*boto*' (pink dolphin), the *jacaré* (cayman), or the *piranha* (a carnivorous fish). While fishing, players may accidentally catch predators. These predators will not only eat the fish (thus reducing some of the fish catch) but will also damage the fishing gear.

The fishermen

Each player (or team) takes on the role of a fisherman in a floodplain region. If the game is played as a team, one of the team members will also take on the role of president of the community association and will be involved later in the game in the process of negotiating a fishing agreement. Each player belongs to one of the four communities (C1 to C4, see Figure 2) and is given a profile card containing information about the size of their family, two fishing gears: *miqueira* and *malhadeira*, two types of gill nets that differ in mesh size, fishing capacity, and material; and an initial amount of money (\$15).

Other roles in the game

- These roles can be played by the research team or by participants who already know the game.
- The "salesman" buys the fish. The price varies according to the type of fish and the fishing gear used. He also sells food (to feed the family) and two types of gill nets, and a cast net (*tarrafa*), which is usually used in the summer. It allows the fisherman to throw back any unwanted catches. The seller pays the *seguro defeso*, a subsidy set by the State as compensation for the prohibition on selling certain sought-after species during their breeding season.
 - The Environmental Agency Patrol (SEMAS) can inspect the fish to be sold during the fishing ban and, in the event of non-compliance, confiscate the fishing equipment and/or impose a fine.
 - The *geleiro* is a fisherman. His boat has a large cooling capacity. He arrives before the banned period ends. He has access to all the fishing spots. He uses his hands to catch fish to "simulate" his large fishing capacity.

The formal description of the model

The following UML class diagram (Figure 3) gives an overview of the game elements, their attributes, and their relationships. The colored boxes refer to the tangible elements of the game that can be manipulated by the players. Their names were kept in Portuguese because the game was co-designed during participatory workshops with Brazilian colleagues. The four types of fish are Scaly Fish (*Escama*) and Flat Fish (*Liso*), which in turn are divided into desirable (*Valioso*) or basic (*Básico*) species. The five fishing spots have names: *Enseada* = Creek, *Poço* = Well, *Igarapé* = Stream, *Lago* = Lake, and *Rio* = River.

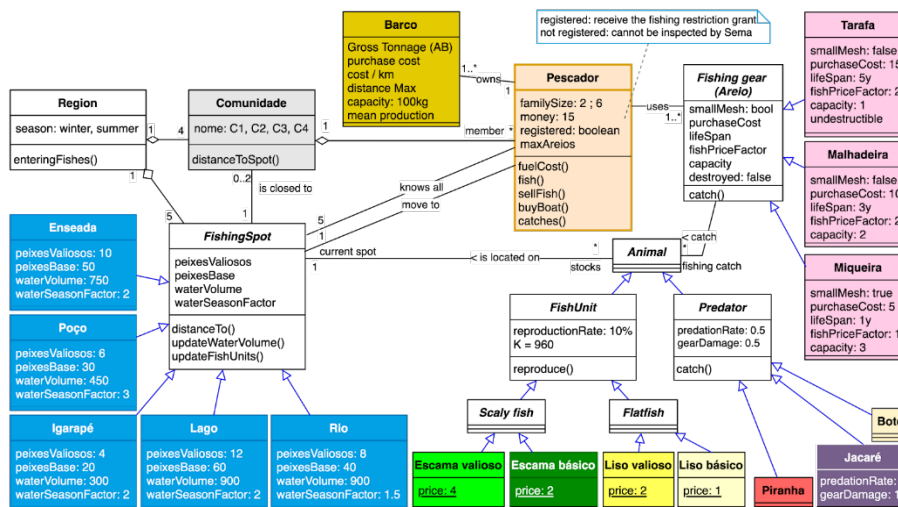


Fig. 3. UML class diagram representing the structure of the model behind the game.

4.2 Game sequence

A round of the game (1 year) is divided into three stages. The first is played on the *inverno* board (March to June), the second (July to October), and the third (November to February) on the *verão* board. The last step is called *defeso*. During this period, the sale of sought-after species is forbidden. The Environmental Agency (SEMAS) can carry out some controls.

Each player is invited to fish in turn at each stage. Each gear can be used once in each location. After the selection of the fishing spots, the selection of the fishing gear, and the payment of the fuel (the further the fishing spot is from the location of the community, the higher the fuel costs), the player can fish. To do this, the facilitator gives the player a small cup (the size

of which varies according to the fishing gear). The player puts the cup in the chosen fishing spot and tries to catch fish (Fig. 4).



Fig. 4. The action of fishing in the PescaViva game board.

Before and in between fishing actions, players can visit the Fishing Market, where they can buy new equipment, sell fish and buy food and consumer goods. During the third stage, if the player is not fined by the SEMAS, he will receive the *seguro defeso* from the salesman.

4.3 Organization of a session

In its current version, a session of *PescaViva* covers 10 years of fishing. We combine pure role-playing with agent-based simulation. After the first year (three steps), which is played on the game board, the next four years of fishing are simulated using the agent-based model (ABM) of *PescaViva*, implemented on the Gama platform [13]. For this purpose, the recorded decisions of the players are read by the simulator, which generates the results by copying the behavior (fishing location and gear used) of the players. The results are shared and discussed with the participants after 5 simulated years. At this point, the four presidents of the associations are invited to set up - in 15 minutes - a fishing agreement within and/or between the communities. Then, in the sixth year of the game, the players return to the game board to fish. No instructions are given as to whether the fishing agreement is to be respected or not. Based on the fishing decisions in year 6, the ABM simulates the next 4 years as in the first cycle. Finally, the results of the 10 simulated years are shared and discussed with the participants.

The debriefing starts by asking for feedback from the players on the game itself. Then we question the choices made by the players during the game and the reasons for their decisions. Finally, there is a discussion on the realism of the game: relevance and suggestions for improvement or modification.

4.4 Examples of two sessions of the PescaViva game

In July 2022, two sessions were organized in *Lago Grande do Curuai*, the first one in *Agua Fria* and the second one in *Curuai* (see the locations in Figure 1 and the audience in Figure 5).



Fig. 5. Left: Game session in *Agua Fria*, 25/07/22: players selling their fish at the market. Right: Game session in *Curuai*, 26/07/22: players fishing on the board game.

Observing the socioeconomic conditions, *Agua Fria* is representative of a community lifestyle whereas in *Curuai*, the fishermen, more numerous and more diversified than in *Agua Fria*, follow more individualized trajectories. We wanted to assess to what extent the participants would jump into the game and found it somehow related to their reality. Table 1 displays the results in terms of variations in total fishing effort.

Table 1. Total numbers of fishing gears (Mi = *Miqueira*; Ma=*Malhadeira*; Ta=*Tarrafa*) used by players in *Agua Fria* (left) and *Curuai* (right) in each step of years 1 and 6.

Session	Agua Fria								Curuai							
	1				6				1				6			
Fishing gear	Mi	Ma	Ta	Tot	Mi	Ma	Ta	Tot	Mi	Ma	Ta	Tot	Mi	Ma	Ta	Tot
Inverno	6	3		9	5			5	6	6	1	13	4	7	3	14
Verão	3	4	3	10	5	3		8	8	8	1	17	5	6	3	14
Defeso	4	5	2	11			4	4	9	13	3	25	1	5	3	9
Ano	30				17				55				37			

In *Curuai*, the participants increased their fishing capacity during the first 3 steps of the first year, while in *Agua Fria* the total number of gears remained almost the same. Faced with the results of the computer simulation in terms of poor catches at the end of year 5, it was decided in both sessions to reduce the intensity of fishing effort during the *defeso* period substantially (by 64%). In addition, the *Agua Fria* participants took the radical decision to ban the most destructive fishing gear (*miqueira*). The differences and similarities in the participants' basic attitudes and responses to the onset of the crisis seemed to us to be consistent with the way the fishery operated in the two places where we tested the game. More importantly, we received positive feedback from the majority of participants about the game's ability to allow them to project themselves into real-life situations.

5 Challenges in designing a game as a “viable metaphor”

Cleland (2017) suggests that games are “viable metaphors” when they are playable, recognizable, and suitable for the targeted stakeholders. The game is recognizable if the intended stakeholders can identify elements of their reality in the game. It has to correspond to the intended audience representation. By suitability, she means that the issues and scales (time, space) of the game must be in line with those that participants may have leverage over in their real lives. Finally, the playable principle refers to the balance between the freedom and structure of a game/model. A highly structured game/model can make the game very mechanical without much freedom and creativity for decision-making by the players. On the other hand, a highly open game can result in very random decisions, making analysis and discussions based on the game/model results

unfeasible. Finding the right balance between the different elements of the game to make it both attractive and interesting for the target stakeholders is therefore quite complex. We present here some lessons learned from the development of *PescaViva* and try to draw some guidelines.

The game’s design is recurrently confronted with the complexity of the studied system. Too much complexity in a game often leads to too many rules, which are sometimes difficult to remember and can limit interaction between participants and their creativity. Complexity is therefore very much related to the playability of the game. However, a balance has to be found. Too much simplicity can make a game unrecognizable and participants will find it difficult to embody their role.

The way *PescaViva* presents fisheries in the Amazon is the first example of the balance between complexity and simplicity. Literature suggests that the catch composition varies between 29 and 45 fish species, which represents a large diversity of exploited fish compared to other fisheries [14-16]. Each species has its own biological and ecological characteristics, which influence its population and stock dynamics. The fishermen of the region use a great diversity of fishing gear, fishing is usually done with more than one fishing gear and the use of each depends on the variation of the river level [16-18]. What is the minimal structure of the game adopted in these conditions to keep a credible representation while keeping the game playable? Keeping in mind the central objective of the game “to discuss fishing agreements”, discussions with the focus group led to the adoption of a description based on local categories of fish, each represented by two species, one called “basic” and the other called “valuable”. This last distinction was important to be able to introduce the *defeso* period into the game and to bring into the debates, elements on the regulation of fishing and the role of the environmental agency. A similar approach was adopted in the Fish Banks model [19] for example, in which only two fish stocks are considered to mimic the deep ocean and coastal fisheries. The two fish “stocks” only differ by the parameters used in the law used to describe the fish population dynamics. Fish Banks game has been applied with students, researchers, and fishermen and was judged sufficient to bring discussion upon renewable resources management.

When designing *PescaViva* an important feature to be considered was the dynamics of the river in the floodplain. In the prototype, the hydrological fluctuation was defined according to the scientists' categories of rising, flooding, receding, and low water. This resulted in four game boards. In addition to the fact that in this version four rounds of the game had to be played per year, with the amount of water being updated in each round, which slowed down the game considerably and reduced its playability, the players did not recognize this division of time. They explained that there were two seasons that they considered when deciding how to fish: 1) summer, a time of low water with few rainy days; and 2) winter, a time of high water with many rainy days. Although the four periods were not unfamiliar, we decided to have two game boards instead of four: one for winter and one for summer. By including the *defeso* period, a year unfolds in three rounds.

On the other hand, too much simplicity may limit the recognizable features of a game. Literature suggests that lakes are the main places to fish in the region [16-17]. The prototype game board exclusively represented lakes, the river was represented but it was not considered as a fishing location. In the first few sessions of the game, however, participants had difficulty understanding why they could not fish in the river. We also noticed that some players had difficulty recognizing water or land, with water in the prototype being represented in blue, and land in brown. Specific drawing activities with the stakeholders (Fig. 6) allowed us to list the different important fishing sites in the region. From the many fishing locations drawn during these activities, we selected five that seemed most important to the focus group and adopted their color code (the water is brown and the land is a mixture of brown and green) to completely revise the game board. Using participatory mapping to collectively design the game board is therefore important, and is often used by game developers [9].



Fig. 6. - On the left: initial gameboard drawn by the research team. On the right: a drawing of the fishing spots made by some participants of the workshops

Another important aspect of game design concerns the elements that influence the time needed to play the game. In the area of common pool resource use, it is necessary to play several rounds of the game in order to identify trends, as system responses are generally not immediate (e.g. declining fish stocks, gradual water degradation, etc.). Even if an attempt is made to simplify as much as possible the various actions to be taken during a game round, it is sometimes difficult to reduce the length of the game round. In the current version of *PescaViva*, for example, one year is represented by three rounds. With 4 players, this means about 30 to 40 minutes. However, it is difficult to mobilize participants for long game sessions, especially since the game is only one part of the organized workshops. A debate is systematically organized after the game. In *PescaViva* we chose a computer-based game to overcome this problem. The ABM reproduces the behavior of the players (fishing grounds, fishing gear used) for the next 4 years. This period is close to the duration of the fishing agreements in the communities where we work. Of course, the identical reproduction of the players' behavior over several consecutive years does not allow the game to be faithful to reality. However, it does provide sufficient elements for the debates that follow the actual game session. This computer-based support was also used in the *VárzeaViva* game [21]. The player fills in a decision sheet every 4 years. Again, this duration was chosen to match the growing cycle of the fields in the area being studied. However, speeding up the time with the help of a computer can lead to other difficulties: For example, it may not be acceptable for players to be able to change their decisions despite the conditions (e.g., continuing to use a type of net when fish stocks are already very low). The choice of the duration of the "projection" must be discussed with the participants. It must make sense in relation to their reality.

It is difficult to find the right balance between the "serious" aspects of the game and the elements that make the game fun. In some cases, these elements are intentionally detached from reality (e.g. drawing a lucky card: you have won the lottery) and, although fun, may not fit very well into the dynamics of the game. In *PescaViva*, fishing itself is an element of fun. Although the equipment for each type of net is the same for all, the players have more or less luck. Some fish a lot, while others catch little or nothing at all, and a "competition" quickly develops between the players. The game also includes predators. This was suggested by the focus group. When fishing, players are worried about encountering one of these predators. These playful elements in the game (predation, inequalities in catches) are often commented on in discussions because they correspond to real situations and cause sadness and anger among fishermen when they happen. Fun is considered a non-explicit goal of participatory game design [20]. In our experience with local actors facing serious socio-environmental problems and conflicting interests, the tensions generated by these problems can create a negative atmosphere during the game. Therefore, fun is

an important dimension to consider in order to reduce some of these tensions. In addition, the recognition principle of the game is also related to the elements of surprise mentioned above. Because it happened in their reality, the players accepted the loss of their catch and equipment when encountering predators.

Ensuring the suitability of the game has implications for the scales of space and time considered in the game. In *PescaViva*, this principle is evidenced when participants are invited to establish fishing agreements within the community and between communities which is a form of regulating fishing in the region. These scales (community and region) are the ones users deal with in reality to propose their agreements. Moreover, the game board incorporates “generic” fishing spots in the region. During the game sessions with the focus group, the participants tended to project themselves at the “regional” scale of the *Curuai* floodplain and stressed the importance of having agreements between the fishing unions of the municipalities of *Juruti*, *Óbidos*, and *Santarém*. During the community play sessions, players had no difficulty establishing “community” agreements to preserve fishing spots near their communities represented on the board. The time scales considered (5-10 years) correspond to those used to define the validity of these agreements. During the game sessions and discussions, however, participants stressed the importance of involving the environmental agency to enforce agreements and tax violators. The environmental agency is responsible for enforcing the *defeso* period, and given the evolution of legislation in the *Pará* state will also have to enforce the fisheries agreements. Introducing this role in the game and inviting representatives of these institutions to participate in the workshops of the focus group was important to make the game “suitable”. By inviting the environmental institutions of the region to participate in the workshops, we allowed the fishermen to discuss and articulate their claims. Thus, the suitability of the game involves not only the scales of time and space represented in the game but also the composition of the group of participants engaged in its design.

6 Conclusion

Playability, recognisability, and adaptability are important principles to take into account when designing a game/model if it is to be useful and easily adopted by users and managers of socio-ecological systems. An indicator that we have achieved this with *PescaViva* was the report of the agents of the Environmental Agency of *Óbidos* who participated in the focus group. They used *PescaViva* in one of their activities in a fishing community in *Óbidos*. They did this without the help of the research team and made some adaptations to better suit their activity. They indicated that the results obtained with *PescaViva* were very positive in relation to their awareness-raising activities with the community.

The collaborative process with the actors of *Lago Grande do Curuai* and also being open to changes while designing the game was significant to develop *PescaViva* as a ‘viable metaphor’. However, some challenges still remain. We intend that *PescaViva* can be a generic game for the lower Amazon floodplain. To validate it on a regional scale, which means to know if the game is representative of any fisheries on the Lower Amazon, sessions in different fishing communities are necessary. That is the current stage of the collaborative process. Some sessions have already been held and participants pointed out *PescaViva* as a game really related to their reality.

Another ongoing challenge that emerged in the last *PescaViva* sessions with the focus group was how to represent the social system of fisheries. The game barely explores this dimension. Indeed, the community is not used except for the initial distribution of players. Yet the social dimension obviously plays an extremely important role in fisheries management and by doing that, the game would be more recognizable. One way to address this dimension is to consider various Fishermen's profiles, which should significantly change the playability of the game. Thus, these changes could further strengthen the mediating role

of the game around fisheries agreements and, therefore, be more attractive to fishermen, organizations, and government leaders.

From this experience and to make the game useful for local actors and decision-makers, we conclude the need to engage in a longer participatory process. If, as initially planned, 10 workshops were carried out, we recognize that additional sessions with the focal group and other fishing communities will be necessary.

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lessons from a case study in the lower Amazon floodplain fisheries**

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Design of Roles in Simulation Games

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Abstract. New ways of teaching, societal challenges, and growing student numbers are just some of the challenges that universities will face in the coming decades. Universities are a complex system in themselves, with many stakeholders involved along with their demands and wishes. All of these must be taken into account in campus visions of the future and therefore, a participatory approach is necessary. For the development of a campus vision for Delft University of Technology in the Netherlands, the simulation game Campus2040 was developed. This game has two main objectives: Firstly, to inform the involved stakeholders about the new campus vision for 2040 and to illustrate the associated complexity. Secondly, to explore and discuss the development of the campus and collect insights about the necessities of the involved stakeholders. In order to allow the different perspectives to be perceived, players take different roles and play the game from the perspective of their role, however, the design of the roles was challenging. Different perspectives from numerous players in their function as stakeholders needed to be collected, while the expectation was that a homogeneous group will play the game together. In addition, different players take on different roles, some of which the role or the objectives associated with the role may be contradictory to their own backgrounds. To test the balance between the different perspectives on role design and personal perspectives of the players, we tested different role-based implementations and observed the differences in the contribution to the worlds of Meaning, Reality, and Play (Triadic Game Design by Hartevelde, 2011). Based on this, challenges are discussed and best practices derived.

Keywords. Complexity, Vision, Simulation game, Role design, Role-play, Role-taking.

1 Introduction

Universities are continuously in development caused by changing societal challenges, growing student numbers or new ways of teaching. Boards of universities develop visions and long-term ideas for the role of a university in society. The ideas about the future of research, education and valorization influence the development of a campus. As many different stakeholders work and live on campus and the campus and its activities affects the city, it is necessary to take these different stakeholders into account when developing a campus vision. In the Netherlands, Delft University of Technology (TU Delft) is also defining its vision on the campus for 2040. TU Delft sets several ambitions to become a sustainable campus and expects a large growth of students and more hybrid working of both students and employees. Also, TU Delft has many different users that also have expectations about the development of the campus. Students would like to have good student facilities and a place for leisure and living, while researchers would like to have research laboratories and citizens of Delft would like to avoid an overcrowded city with students, while at the same time they see the (economic) advantages of the university. A participatory process to include different perspectives in the design was a desire.

The answer was found in a simulation game. With simulation gaming, players can explore and discuss the development of a campus and share their insights about the necessities for the campus area. These insights can be collected and used by the project team developing the vision. At the

same time, the project team would like to show to the stakeholders that choices have to be made and that not everything is possible, taken into account the limited space and financial constraints. In this sense, it should be tried to get support for the vision. The simulation game to be developed should focus on two main objectives: Firstly, to inform the involved stakeholders about the new campus vision 2040 and to illustrate the associated complexity and secondly, to collect the interests of the involved stakeholders.

One of the challenges in the design of the simulation game Campus2040 was that different perspectives from numerous stakeholders should be collected, while the expectation was that a homogeneous group will play the game together, e.g., a research department is playing together, a group of students, a management team etc. In order to still allow the different perspectives to be perceived, these people take different roles and play the game from the perspective of the role. In this publication, the authors explore the challenges in designing these roles. Therefore, the structure is as follows: In a first step, the authors summarize existing studies on the topic of role design in simulation games and highlight the functions and design criteria of this game mechanic. Secondly, the serious Campus2040 game is described. Thirdly, observations from different set-ups regarding the design of roles are discussed. Lastly, the findings are discussed and final conclusions are drawn.

2 Role-play and design of roles

Role-playing games include a large subset of games and comes in many formats, from *Life Action Role Playing* to *Massive Multi Online Role Playing Games*. In these games, players take the role of a character in a (fictional) setting and act according to the rules associated with the role and the game [1, 2]. Defining characters to players is not exclusively for role-playing games. In many other games, such as simulation games, players are assigned to certain roles¹. Peng, Lee and Heeter [3] make a difference between role-taking and role-playing. Role-taking relates primarily to the activation of cognitive processes in individuals who imagine themselves to be a different person over a period of time versus the active performance of behavior in role-playing. Through role-taking, it is possible to gain insight into the attributes associated with the role and thereby better understand a perspective other than one's own.

When it comes to the *reasons for implementing roles*, according to the authors, they are manifold. One of the motivations may be rooted in the game itself (*game perspective*), because roles have the advantage that they make first-person experiences possible and also increase immersion through narrative elements. Gordon and Schirra [4] did research about digital games and the influence of experiencing different roles on people's understanding and their engagement within communities. They stated that the use of an immerse role-play can engage players, because that should make it possible for the players, while playing the game, not only to understand the needs and desires of the corresponding role, but also to act accordingly. Peng, Lee and Heeter [3] have found in their research that role-taking influences empathy and helping behavior and van Ments [5] concluded that one of the added values of experiencing different roles is that it motivates the players. In addition to the game perspective, the *learning perspective* needs to be considered. For example, taking on roles enables the training of soft skills [6]. Inspired by Bowman [7], Agusdinata and Lukosch [8] defined three functions of role-playing games, namely 1) strengthening the cohesion of a group, 2) promoting complex problem-solving and providing an opportunity to learn, and 3) guaranteeing a safe space to experience different roles. Here, too, the learning perspective becomes visible. In order to gain insights into other roles (learning perspective), these must of course first be implemented accordingly (*simulation perspective*). By experiencing a role, players learn the (unique) abilities associated with this role - both consciously and unconsciously - and adapt this accordingly to the game situation [9].

¹ With roles the authors mean the characters that are assigned in the game world. In game sessions, you can also take different roles like facilitator, teachers, observer etc. Although designers and facilitators need to think about these roles, these are not the roles the authors are referring to in this publication.

The design of roles in simulation games comes with different target functions. Based on the *Triadic Game Design* (TGD) philosophy developed by Harteveld [10], which assumes a balance of the three worlds of *Reality*, *Meaning*, and *Play*, the authors would like to explore the *functions of role design* in more detail per each of the previously mentioned worlds. In relation to the world of *Reality*, the ‘right’ roles that are recognizable to the target group must be selected and the information used in the role descriptions that lead to the actions associated with the role must be realistically represented in such a way that a valid simulation game can be demonstrated. One of the aims of the game to be developed is to experience the perspective of different stakeholders. In relation to the world of *Meaning*, it is therefore important to realize that the players who take on roles are still given enough freedom to bring their own perspective into the game. In addition, the third world of *Play* must be taken into account. If one refers to the design of roles, one has to consider to what extent roles are part of a narrative element and whether the functions associated with the roles also lead to the desired goals, such as in-game discussions of all roles involved.

To conclude, the use of roles in simulation games comes with several advantages. Not only is it possible to learn more about the perspective of a corresponding role by experiencing it in a playful manner, but also to act in a safe way that is not always possible in the real world due to restrictions. In the following, the simulation game Campus2040 is first described in more detail, and then the developed and tested roles are zoomed in accordingly.

3 Simulation game Campus2040

The main target group of players of the simulation game Campus2040 are stakeholders on the campus (e.g., employees, students, companies) and stakeholders affected by the campus (e.g., municipality, citizens, public transport operators). Players will in groups of around eight people play the game during a workshop of two to four hours hosted by (ideally) two facilitators (one being responsible for the process, and one being responsible for the content). A workshop consists of a brief introduction of the project and the Campus2040 game to provide background information and tell the players they are safe to experiment. The facilitator sets a narrative to bring the players from the real world into the game world and explains the rules. Next, the roles are divided over the players whereby each player is assigned to a different role.

The players have the task to develop the TU Delft campus, which is represented on a large map with its buildings that are made of Lego bricks (see Figure 1). At the start, the players receive four targets (number of students, number of employees, research laboratories and companies) and four ambitions (sustainability, livability, accessibility and housing). Their tasks are to make enough capacity to reach the targets and based on the role to score as high as possible on the ambitions. The game is round-based. In each round, the players receive several basic buildings with a specific function (such as education, housing, offices, or leisure). All players also receive ‘personalization cards’, which they can use to adapt the basic building. This could mean that other functions are added or that the building becomes a sustainable one. As only two personalization cards can be added to a building, players need to communicate and collaborate on what they want. As these basic buildings are also from Lego, they can add the personalization by adding Lego bricks. After the buildings are ‘designed’, the players have to place the buildings on the campus map and they have to describe how they envision the buildings. The new buildings affect the targets and ambitions. After updating the score, a new round starts. Players lose the game when they are not able to meet the targets, but can measure their grade of success based on how well they represented their role. Depending on the available time, the players play two to four structured rounds.



Fig. 1. Parts of the set-up of the simulation game Campus2040 (TUD Gamelab, 2022).

After the game play and during the debriefing, the players look back at their decisions and final design of the simulated campus. In this stage, the players can give their opinion about their design and how they relate this to their role, their own perspective, and the design of the real campus. The motivations, argumentation, agreements and disagreements between the players are written down to provide input for the project team as variables to take into account. The session will be closed with some concluding observations and how these are used in the further process.

During the development of the game, one of the main challenges was the design of roles, as 1) different perspectives from numerous players in their function as stakeholders should be collected, while the expectation was that a homogeneous group will play the game together, 2) and the authors want different players to take on different roles, some of which the role or the objectives associated with the role may be contradictory to their own backgrounds.

4 Designing roles: Observations from different set-ups

From the world of *Reality*, it was necessary to simulate the different interests and related dilemmas. Therefore, a stakeholder analysis was done to define the different stakeholders and their values and objectives. Based on this analysis, the authors defined nine roles: 1) the Municipality of Delft, 2) Society of Delft, 3) Dutch students, 4) International students, 5) Deans, 6) Scientific staff, 7) Support staff, 8) Independent Research Organizations, and 9) Start-up companies. As the purpose of the game is to gather preferences of stakeholders and collect their visions and ideas for the campus for 2040, the players should be able to freely design their own vision while experiencing other visions at the same time (world of *Meaning*). Finally, from the world of *Play*, communication and discussion is a main game mechanic and to start a discussion, roles need to have different objectives.

The authors decided to divide the perspectives of the stakeholders through the different ambitions of the roles. Because different players were given different interests by (role) design, players need to discuss and compromise during the game which could make certain real-world dilemmas clearer or even give rise to new ones depending on the interpretation of the different roles' ambitions.

To test the balance between the different perspectives on role design and personal perspectives of the players, the authors tested different role-based implementations and observed the differences in the contribution to the worlds of *Meaning*, *Reality* and *Play*. It should be noted that other parameters of the Campus2040 game were also iterated and consequently tested. As mentioned in the previous section, certain indicators are linked to the roles, such as demands and wishes, which were implemented in various ways during the design phase. The sessions described in this publication took place between September and December 2022 and per session, five to eight different players (not part of the design team) and two to four facilitators and observers (design team) took part. In order to validate the game and individual game mechanics,

the different versions of the game were tested with players outside of the design team, who deal with strategy and vision planning in their work lives and are therefore familiar with the aspects implemented in the game.

4.1 First test session (September 2022)

Role design

Each role had a role card. On this card, the name of the role was visible. To display the current status of the need(s) of this role, a so-called satisfaction score was added (see Figure 2). On the card, each player had the chance to see how he/she scored.

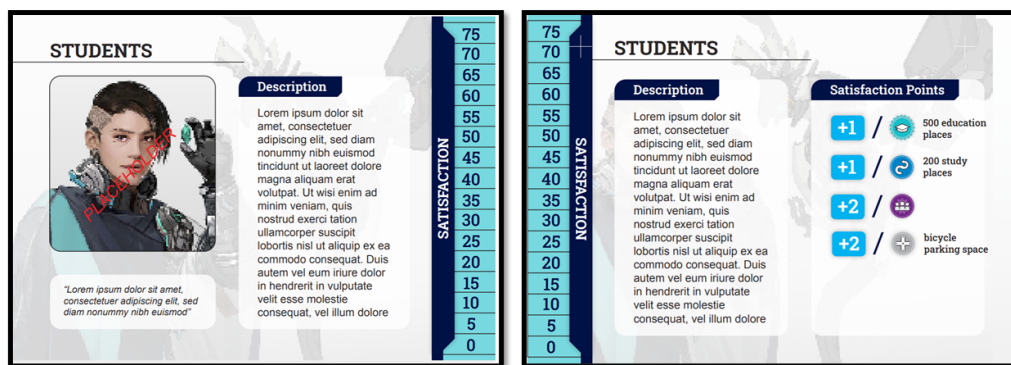


Fig. 2. Example of a role card (students) with satisfaction score (front and back).

Observations

World of Reality: The roles were currently too stereotypically described by the satisfaction score. This is not corresponding with the differences within the group of represented stakeholders.

World of Meaning: One player communicated that he/she did not feel triggered to look differently at the campus vision - from a different perspective in terms of planning. It may be that the role the player had was too close to his/her real (stakeholder) perspective. It could also be that those perspectives are not yet coming out strongly enough in the information written down on the role cards. So far, the role cards contain only information about the satisfaction score.

World of Play: It was too easy for the players to get the requested level of satisfaction points. The satisfaction score of the role cards did not contribute to the discussion during the game. Players were only focused on their own satisfaction score and once they reached their maximum, the role cards were of no further interest or use during the game. In addition, the players would like to have more competition between the roles.

4.2 Second test session (November 2022)

Role design

The first test showed that the relation between the satisfaction score and the buildings as well as the satisfaction score and the game goal were not clear (Reality). Players also mentioned they wanted to have more conflict in the game (Play). For the second test, the authors removed the satisfaction element from the role card, but added three demands and a wish for each role (see Figure 3). These demands were more extreme to represent the complexity and to create conflicts. The authors also added a description of the role and asked the players to introduce themselves (from the perspective of the role) to the others. Last but not least, it was decided that players should ideally not play a role that is his/her own to allow for a real 'Aha'-moment during play.



Fig. 3. Example of a role description (students) with demands and wishes (front and back).

Observations

World of Reality: The players commented that the roles felt too generic and not well represented. The addition of a description to the role cards and introducing the roles to each other were not sufficient to overcome this obstacle.

World of Meaning: As the role descriptions felt too generic, the players could not really identify themselves with the role. Because of this, the complexity of bringing the different perspectives of the represented stakeholders together wasn't really visible (except for the personal perspectives of the players).

World of Play: The players had difficulties acting based on their roles. The role description had no real influence on the players' actions in the game. There was too much text on the cards, whereby it was realized immediately after the game play that the players were given too little time to read and thus understand their roles.

4.3 Third test session (December 2022)

Role design

It is important to give players more time to understand and be able to take on their role. Furthermore, the facilitator of the game should explain that the players represent someone that is part of a certain stakeholder group rather than representing the group as a whole, since there is of course great variance and diversity within a group. Therefore, the authors changed the names of the roles to better represent that the players are an individual of a certain group and have emphasized this more clearly on the role card. Based on the players' feedback, the authors shortened the role descriptions, changed them to a first-person perspective and added personal items on the cards (e.g., a mug for the dean or a notebook for the Dutch students; see Figure 4), as well as a physical item to the corresponding role for which the players were asked to tell a personal story with reference to their role. The idea was to work with an open-ended question where the players could make notes directly on the role card and inform the others about their role and the items. Three demands and one wish for each role stayed the same, however, the description of those was specified.

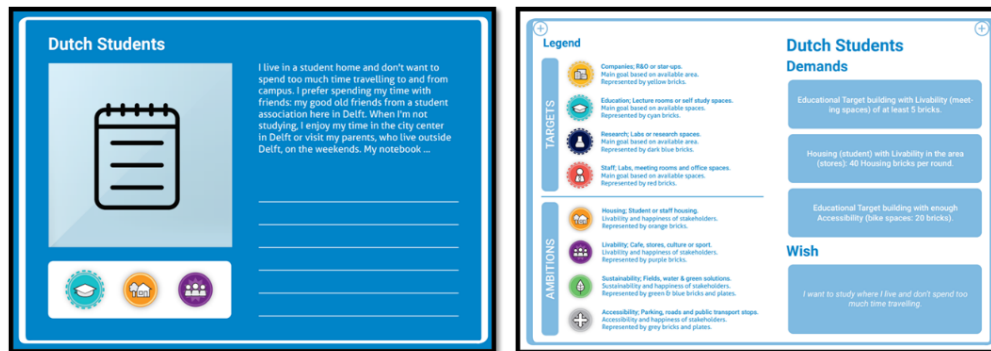


Fig. 4. Example of a role description (Dutch students) with shorter description, first-person perspective, and personal item (front and back).

Observations

World of Reality: The roles conformed better with reality when emphasizing that a player is just one person in a certain stakeholder group.

World of Meaning: Because of the more personal take on the roles there was room for not only the perspective of the roles as on the cards (including the demands and wishes), but as well as the player’s interpretation of it. This gives even a deeper layer to the complexity of various stakeholders’ perspectives.

World of Play: The players had difficulties working with the items, but the presentation of the roles to the other players (some of their colleagues) based on the texts formulated from the first-person perspective worked well according to the observers' perception.

4.4 Fourth test session (December 2022)

Role design

Due to the challenges the players had with using the items, the authors have decided not to use this any further and thus, removed the item association from the stakeholder cards and still emphasized the open ending to the description for the players to complete. The description of each role was made more general explaining that the player would represent an individual of a certain group. Each player was asked to introduce their role with a sentence that started with “*I am a ... and I want a campus where...*” The idea being that they could explain even better who they were and how they interpreted the stakeholders (see Figure 5).

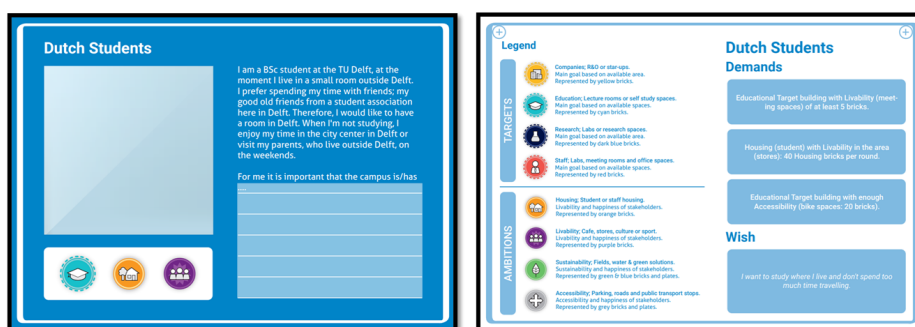


Fig. 5. Example of a role description (Dutch students) with open-ended questions (front and back).

Observations

World of Reality: Players that portrayed stakeholders that were similar, such as a Dutch or an international student, tried to work together and tried to find support during discussions by

mentioning arguments that would suit other players' roles. However, during discussions, the roles were rarely mentioned or their demands used as arguments. Players that included their role demands in their decisions did so quietly.

World of Meaning: Players knew the demands and wishes they had in their role, but not why it was relevant. No attention was given to the narrative given by the facilitator, as such the players found it hard to connect with their roles and this impeded presentation of the players' roles perspectives.

World of Play: The players were all able to understand what stakeholder they were representing. They found it more difficult to know what to do with this information. When they introduced their role to the rest of the group, the players mostly introduced themselves to the facilitator rather than to the other players. It was also clear that some of the players repeated what was stated on the cards itself rather than gave their own spin on it. The players still referred to the facilitator for guidance. During play, it became clear that players were still not sure how to hit the demands of their role. They were not sure how often they should achieve the demands. Some players tried to achieve their role demands each turn, while others tried to achieve them towards the end.

4.5 Fifth test session (December 2022)

Role design

For the last test, the authors planned to let the players present each other's role to each other rather than the facilitator. The descriptions would also be written more clearly to give players more guidance in which role they represented. The role cards included a short description of the individual that is part of the represented stakeholder group. These introductions are written in a first-person perspective and gave less room for the player's own interpretation than earlier iterations. The demands of the roles were set more clearly by giving quantitative demands (amount of bricks) with a time goal (each round).

Observations

World of Reality: Similar to the last iteration, the players found the role description realistic enough, because of the change in demands and the inclusion of the description which makes it clear that the roles are individuals rather than a whole group. However, the fact that players need to represent a role, rather than themselves, means that the reality of the game will not be the reality of the players. Sometimes the role demands might align with a player's demand, but this is not always the case. During this session, one of the players found it difficult to incorporate his/her role in the game because he/she did not agree with the corresponding demands. His/her own reality was thus too far from the reality of the game, even though the role was realistic.

World of Meaning: Players asked each other what the demands were and how they could make sure that all the ambitions were met. This meant that the players were more focused on the ambitions of the campus rather than the demands. The players were still able to meet the demands of the game, but they were more involved in the game and the contents of the buildings. This allowed to show the arguments of the players and their own ambitions and needs as well as how they interpreted those of the roles. Therefore, the game was able to reach its intended purpose of showing the complexity of creating a vision and gathering information about the wishes and demands of the various players.

World of Play: The players were asked to introduce themselves before the start of the game. Thereafter, the facilitator introduced them to the game with a short story explaining why the players would play the game and how it will work. As part of this story, the players were given their roles. They were given some time to read them and then asked to once again introduce themselves to the group, but this time as their roles. To allow the group to interact with each other, the facilitator stepped away from the group. This method of introduction proved to work better than previous iterations. Still, some players found it difficult to introduce themselves by their own words without reading out loud what was stated on their cards. During the game,

players referred back to their demands to see what they wanted to build. At the end of the game, players were allowed to reorganize the whole campus without any rules. The players no longer needed to represent the stakeholders. This allowed them to represent themselves. Players commented that they were glad that they had this time to express their own desires and ideas as well as learning about the complexity of all the stakeholders. This was the last test session. The final version of the role description card can be seen in Figure 6.



Fig. 6. Final version of an example of a role description (Dutch students) (front and back).

5 Discussion

In the following, the authors would like to highlight the most important observations based on the TGD.

5.1 World of Reality

The authors encountered certain situations where players in their real function as a stakeholder were too closely connected to the roles. Although this was not a problem for the game and its purpose, the players expressed that they found this less engaging in the game. They did not feel like they gained any new insights themselves. The other way around happened as well, where the players' (stakeholder) demands was too far off their roles' demands. This resulted in the player limiting the incorporation of their role. It can therefore be preferable to let players choose roles based on their personal experience, both for when they are too disconnected or too similar. The players would experience the game as either not realistic enough or too realistic which can hold them back from experiencing the game world designers tempt to create with a game, however, this also depends on the players. Some players can differentiate themselves from roles in games more easily than others.

5.2 World of Meaning

The purpose of the game is to gather information from the players, their wishes and demands, as well as allowing the players to experience the complexity of the situation with all the stakeholders involved. The balance between those purposes of the game was challenging. By including roles with wishes and demands that are purposefully contradictory to other role cards, the game increases its complexity. Players experience the different needs that the campus will need to fulfill. Because players assume a role in the game, they are limited in the expression of their own ideas. The game includes debriefing moments after players have learned about the complexity of the situation, which allows players to express their own ideas, wishes and demands.

5.3 World of Play

Because the reality of the situation is complex and abstract, the players could get overwhelmed by all the possibilities, which was experienced in early prototypes of the game, especially when players would need to keep all the demands of their roles (representing a whole group of stakeholders) in mind. Therefore, the addition of more specific roles to the game (Dutch student in comparison to student) helped to keep the information manageable. Players would only need to keep track of their own role demands and express this to the group. To create suitable roles, the description needed to be open enough for some interpretation for the players, but clear enough to be easily understandable. The role description needs to have a balance between clear and understandable rules and open-ended space for interpretation.

5.4 Dilemma between Reality and Play

At first, the roles were very generalized and represented as one homogeneous group with demands that were presented as facts. During early test sessions, it became clear that this evoked the wrong discussions. The discussion surrounding the roles were focused on whether or not the role indeed had the stated demands rather than how to best represent the role during the game. The reality aspect of the role was too low and negatively impacted the play aspect. Later on, the roles were presented as an individual that was part of the corresponding group of represented stakeholders. The roles also left room for interpretation so that players could form their role. This offered more information on how roles were seen and in certain situations what their actual demands are.

5.5 Dilemma between Reality and Meaning

Initially, the players were asked to increase the satisfaction score of their roles. The satisfaction score was in turn influenced by various demands and wishes of the roles. This was done to increase the play portion of the game. However, it was not very realistic, since it could result in a player only focusing on one demand rather than a balance between various parts. It also proved to negatively influence the discussion of the game. Players were only looking at the numbers and reaching a score. Once the score was reached, the player was deemed 'finished'. The satisfaction score was therefore removed and replaced by demands that needed to be ticked off on certain times throughout the whole game.

5.6 Dilemma between Reality, Meaning and Play

One reason the roles were included with certain demands, was to stimulate discussions and conflicts by design, such as the question to build on campus in Delft or outside of Delft in new campus areas. These conflicts in the role descriptions had to be carefully balanced. The stimulated conflicts contained realistic and also partly playful elements. It was especially important to guarantee that it would not become a '7 against 1' on certain topics. What also became apparent was that players who had different preferences themselves, found it difficult to act accordingly to the role. This further showed the importance of the demands not being connected to a singular role. One way to circumvent this problem is to introduce more concrete consequences of not meeting the goals per role, however, as discussed in the satisfaction paragraph, this could, and did, negatively affect the discussions.

6 Conclusions

The present publication discussed the role design in simulation games based on the development of the simulation game Campus2040. An interesting challenge from the design perspective is to look at the implementation of pre-defined roles to show complexity and the experience of the visions of numerous stakeholders taking on these roles by providing the right degree of freedom

between giving and receiving role-specific input. In a review of publications that addressed this topic, many advantages of role design for different forms of games have been identified. The simulation game Campus2040 made also use of this game mechanic. Different versions of role design were tested during several test sessions. It was noticeable that at the beginning, changes had to be made mainly in the *Reality* world of the TGD, whereas towards the end, i.e., in the later test sessions, the focus was mainly on changes related to the *Play* world. Based on the authors' observations and players' feedback, the authors derive the following recommendations for the design of roles in simulation games:

- 1) Players must be given enough time to familiarize themselves with their role. It is necessary for the facilitator to provide the necessary space to let players take on their role.
- 2) In order to be able to identify stakeholder interests while at the same time defining role descriptions, a good balance between very detailed and very open role descriptions must be striven for. When game aspects were left open for interpretation and players were not given clear rules, consequences or handholds, they let go of their roles more easily. It was decided to define demands and wishes per role to give the players a direction for their actions. Although the authors wanted to make sure that each stakeholder is represented well by the players, the goal of the games is also to collect the vision of players. They should therefore not be limited in their ability to do so. Without clear demands and rules for players to meet their stakeholder demands, however, it is easy for players to interpret them more freely or disregard them completely.
- 3) The description of the roles must be written clearly and especially not in the sense that it is purely stereotypically presented.
- 4) Even with complementary roles, there must be synergies between the roles to guarantee a basis (common ground) within cooperative serious games [11].
- 5) A balance must be sought between the role, the actions of each role and the objectives of each role. For example, there are roles that have more of a control function. If there are substantive reasons for integrating such roles, then specific actions must also be associated with this role, so that each role has the same contribution in the game.
- 6) The design of roles goes hand in hand with narrative storytelling elements. The more the role is seen as part of the game, the better the role is accepted by the players. This can be realized through exciting elements as part of the role description.
- 7) Players should ideally not play a role that is his/her own, whereas this might be dependent on the specific research objective.
- 8) The players should have the space of making the role their own by developing this role more specifically. To enable players to expand the role, categories of roles to be implemented were identified and these categories were then chosen as role descriptions. Thus, the transition between the real and the game world in the briefing and thus the transition from stakeholder to player to role-holder is crucial.
- 9) A structured discussion phase during the game made it possible to change perspectives; the perspective of the player and the perspective of the role experienced by the player. Here it can help to plan a game session in a very structured way and to give more freedom to the players after a certain number of rounds. In our case, there was an automatic transition from role-holder to stakeholder.

At the beginning of this publication, the difference between role-taking and role-playing was explained. In the authors' observations it has been noticed that the transition is sometimes very subtle and that it is mainly up to the personality of the players how the experience of the role is lived out. It should also be noted that in the game developed, there are no consequences associated with not playing the role or not achieving the personal goals associated with the role,

however, this can be addressed in the debriefing. This shows that the focus is primarily on the players' intrinsic motivation to perform their role and is not driven by external in-game stimuli. In future research, the authors want to evaluate the simulation game Campus2040.

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Social Awareness about Energy Transition and Sustainability: The Role of Video Games

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Abstract. Energy security and climate change concerns have emerged due to the world population growth and increasing energy demand. This requires taking measures to address these concerns, especially social awareness, as household energy consumers (HECs) can contribute to enhancing energy transition and sustainability. Besides, Video games play a key role as a tool for education, changing human behavior, and enjoyment. This study aims to investigate the influence of playing video games on household energy consumers' awareness of energy transition and sustainability. A questionnaire was designed to evaluate the players' awareness of energy security, the environmental effect of using energy, the development of the renewable energy sector, and the economic benefit of managing energy consumption before playing a game. Moreover, another questionnaire to evaluate how their awareness was affected by playing a game was designed. To do so, The Power the Grid game was taken as a case study, and then ten experts in playing video games were invited to play the game. The players' awareness was compared before and after playing the game; the results showed that the players' awareness increased about energy issues, the role of HECs in the importance of managing energy because of its contribution to enhancing energy security, supporting the renewable energy sector, reducing the environmental impact of energy usage, and understanding the working principle of the smart meter. Based on the results, a set of proposals to expand the game's options and boost the players' awareness have been presented, especially about demand response (DR) programs.

Keywords: video games, social awareness, energy transition, sustainability

1 Introduction

Sustainability refers to the responsible use of resources without compromising the ability of future generations to meet their own needs. This includes promoting renewable energy, economic development, and maintaining the environment. The world witnessed progress in the energy transition from dependence on fossil fuel to renewable energy sources (RES), as the share of renewable energy in total final energy consumption in Europe increased from 10% to 22% between 2005 and 2021 [1], which helped in reducing the annual CO₂ emissions by 19% [2]. However, with the increase in population and the technological development that leads to an increase in energy consumption, measures need to take to contribute more to increasing the penetration of RES into the electrical grid [3]. As it is known, RES is primarily dependent on weather conditions. For that, the problem of balance between generation and energy demand emerged and led to calls for regulatory measures to solve this problem in case we want to increase renewable energy generation plants and enhance their penetration into the electrical grid. Among these measures is the involvement of energy consumers play a role in the process of enhancing energy transition and sustainability. As a result, the smart grid (SG) and the concept of demand response (DR) have appeared, as decision-makers established an electric tariff system that would contribute to managing energy consumption in line with the state of the electrical grid (supply and demand), here data exchange between and supply and demand side is enabled [4]. In addition, the residential sector is one of the largest energy-consuming sectors, and hence managing energy consumption in the residential sector would contribute to improving energy

security and the penetration of more RES into the electrical grid, thus reducing the environmental impacts of energy use.

Several studies have indicated the factors that affect consumers to make them manage energy consumption, participate in DR programs, and enhance the sustainability of the renewable energy sector. It was found that the economic factor in terms of financial income by reducing the cost of the electricity bill contributes significantly to making the consumer participate in DR programs [5, 6, 7]. It was also found that reducing carbon emissions would encourage them to participate in DR programs [5-8]. Contributing to energy security is also an essential factor that plays a key role in participating in DR programs [4, 5, 8]. In addition, consumers' awareness of the importance of the sustainability and development of the renewable energy sector plays a positive role in participating in DR programs [5, 8, 10, 11]. Moreover, installing devices that provide consumers with information about their consumption and electricity prices, such as smart meters increases participation in DR [5, 7-9]. Therefore, participating energy consumers in DR programs requires efforts to increase social awareness.

Nowadays, video games have become widespread worldwide and they have become a wide part of the lives of almost all children and adolescents, and a vibrant medium of human self-expression [12]. In addition to entertainment, video games can be used for educational and developing skills, especially in decision-making [13-15]. On the other hand, video games contribute to the social aspect through friendships, and therefore it is likely that people who play beneficial games have a favorable impact on others [16]. Besides, in game designing and development, the developers must have feedback from the players to know their interests and the quality of video games, especially at the beginning. Developing games in line with advancements in real life is essential, and paying attention to game content is a priority. However, some of them are still in the stage of growth and development. Alongside this, the DR part in energy games is uncommon, and the utilization of energy-smart tools in video games is still limited [17].

As a result, it is necessary to study the role of DR in video games by developing a viable pathway. Then, we may anticipate that incorporating this concept into games will help to clarify the importance of participation in DR and managing energy consumption in addition to their enjoyment of playing video games. Therefore, the purpose of this study is to investigate the influence of playing video games on household energy consumers' awareness (HECs) of their essential role in managing energy consumption to enhance energy transition and sustainability.

2 Materials and Method

To discuss how playing a game affects people's awareness of energy transition and sustainability together and the growth of the renewable energy sector, this study implements the following methodology: exploring the factors that might affect HECs to manage their energy consumption, searching for a video game whose content includes energy production and consumption options as a case study for this work, creating questionnaires to investigate the influence of playing a video game on awareness of energy issues, suggesting tools based on the results to be added to the selected game regards increasing social awareness.

2.1 The Game Selection

To choose a game as a case study for this work, it has been searching for a video game that provides access and control in the energy management process and illustrates the importance of energy consumers' role in energy transition and sustainability. Google was used to find the best-fitted game (by searching in digital platforms that serve as PC game distributors and gaming forums). To understand better how a video game works, YouTube was used to watch videos posted by designers. This study uses a game as an example to understand better, how video games contribute to society's changing energy consumption behavior. Power the Grid Game is a real-time-strategy tycoon game that simulates the power grid. This game offers multiple power plants to cover the energy demand during the day. The players' role is to keep balancing between

supply and demand, so the players have to observe the state of the production and demand at each time and for the coming hours too, to predict the optimal amount of energy that needs to produce. Moreover, it offers to buy and establish renewable energy plants. As long as the players keep the grid stable, they earn money, where the money needs to spend wisely on establishing the power plants and buying fuel and coal to operate the plants. Besides, in the case of a power shortage, the players have a specific time to recover the grid stability by operating more power plants. With time, the city is developing and expanding, and thus the energy demand increase. In the end, the players seek to establish a 100% renewable energy system that covers the energy demand during the day.

2.2 Questionnaires

The investigation procedure of this work (Fig. 1) is as follows: two questionnaires were created; the first questionnaire is conducted before the participants played the game, aiming to measure their awareness about energy issues. The questions were simple to have an impression of the participating players' knowledge.

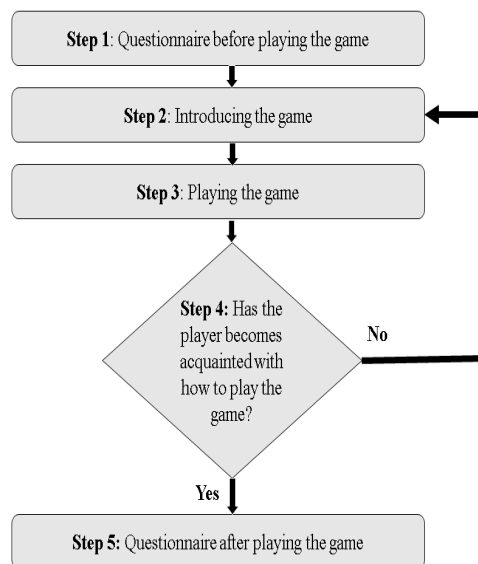


Fig. 1. The flow chart for the procedure of the questionnaires

Before playing the game, a detailed explanation of the game rules through a lecture in a computer lab where the players play the game is given. Then, the players play the game several times until they become familiar with the game's options and thus leads them to complete the mission. Meanwhile, the players can communicate with the supervisor to clarify any doubts about the game's rules. Where the duration of the game and rounds depends on the performance of the players, the players who become familiar with the game's rules complete the mission in a shorter time than the players who are not familiar with the game's rules. This reflects in the results, where more players' familiarity with the game provides more realistic results. After that, the second questionnaire is conducted after completing playing the game to measure the effect of playing this game on increasing their awareness about energy issues and compare it with the results of the first questionnaire as shown in Table 1. In the second questionnaire, the questions were asked in more detail to obtain more accurate results, assuming that the participating players' knowledge of the electrical system operations increased after playing the game.

Table 1. Questionnaire form

Stage	N ^o	Question
Before playing the game	Q1	My knowledge level about energy issues (availability, affordability, and efficiency) is extensive
	Q2	I think that HECs can contribute to energy security
	Q3	I think that HECs can contribute to developing the renewable energy sector
	Q4	I think that HECs can contribute to improving the environment
	Q5	I think that HECs can contribute to reducing electricity prices
	Q6	I think I am knowledgeable about the function of the smart meter and that it can contribute to managing energy consumption effectively
After playing the game	Q7	I have gained a better understanding of energy issues (availability, affordability, and efficiency) after playing the game
	Q8	I think that HECs can contribute to energy security (such as grid stability, and uninterrupted availability of energy sources) in the short and long term
	Q9	I think that HECs can contribute to increasing the penetration of renewable energy plants into the main grid and reducing fossil fuel plants
	Q10	I think that HECs can contribute to reducing the environmental impact of using energy, such as by reducing the CO ₂ emissions
	Q11	I think that HECs can contribute to reducing electricity prices (demand side and supply side)
	Q12	I think that smart meters can provide valuable information about the demand and supply state, which contributes to managing energy consumption effectively
	Q13	I think that HECs' awareness of the importance of managing their energy consumption will improve after playing this game

After that, a discussion to gain a deeper understanding of the players' point of view about adding some features to the game is conducted that would contribute to players' awareness of energy issues. In addition to bringing more enjoyment to the game. The survey of 13 questions divided into two questionnaires with a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) was answered by the participants.

2.3 Participants

This work is a primary study; the participating players were ten Ph.D. students from the Faculty of Science at La Universidad de Santiago de Compostela. They have selected based on their tendency to play video games regularly, not sporadically. 30% of the participants' players have experience playing energy video games, and their average age was 29.

3 Results and Discussion

3.1 The Depth of Players' Knowledge of Energy Issues Before Playing the Game

This section describes how knowledgeable the participating players are about energy issues, the environment, and the renewable energy sector before playing the Power the Grid game. Figure 2 shows the percentage of answers to questions 1 to 6. In the first question, which measures the knowledge of the participating players about energy issues, it is clear that only 10% of the players have sufficient knowledge and 10% have little knowledge, while the rest show a low

level of knowledge. Similarly, the answers to the second question indicate that the players' knowledge of HECs' role in enhancing energy security is limited. Regarding the role of HECs in contributing to the development of the renewable energy sector, the answers to the third question indicate that the players show a better understanding compared to the answers to the previous questions. However, their knowledge is still somewhat low.

Concerning contributing to improving the environment, the results from the answers to the fourth question indicate that there is a lack of awareness of the role of HECs in enhancing the environment, as 60% of the participants do not have knowledge (10% strongly disagreed and 30% disagreed and 20% are undecided). As discussed earlier, HECs play a crucial role in reducing electricity prices. However, the answers to the fifth question indicate that only 40% somewhat agreed and 10% strongly agreed. Moreover, the results show a lack of awareness of the participating players involved in the working principle of the smart meter and its role in energy management at home; 10% showed that they agreed somewhat with the importance of the smart meter, and 10% agreed strongly.

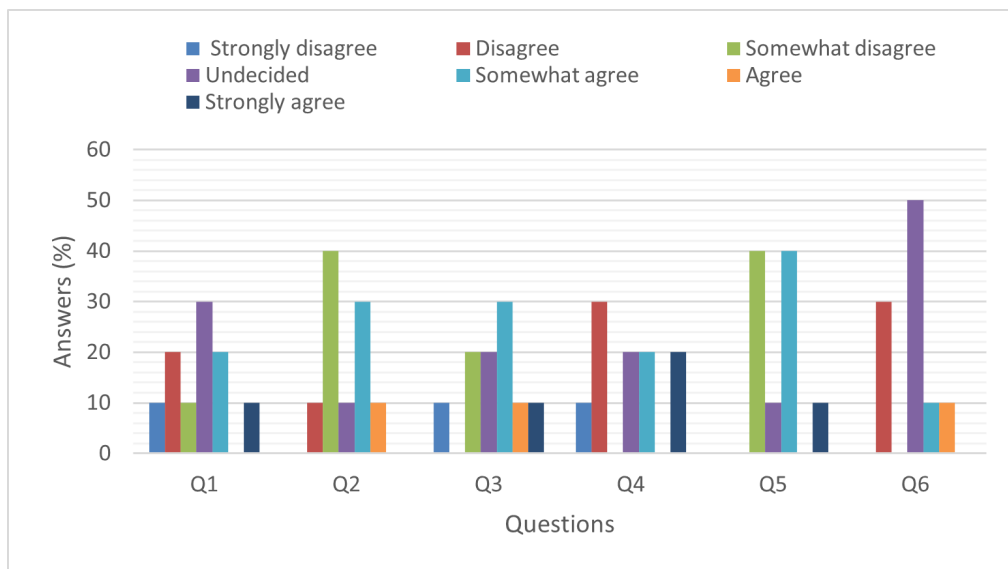


Fig. 2. Distribution of the participating players' answers to the first questionnaire

3.2 The Effect of Playing the Power the Grid Game on Players' Awareness of Energy Issues

Before the participating players started playing the Power the Grid game, the game rules, constraints, and tools have explained in detail. The second questionnaire was conducted, which contains seven questions from 7 to 12 to measure players' awareness after playing the game. The results of the level of players' awareness after playing the game were compared to the results of the last section to understand the impact of playing the game on the players' awareness.

It is clear from Figure 3 that the awareness of the players has increased after playing the game. As their awareness about energy issues increased, 30% indicated that they have little knowledge, 30% have good knowledge, and 10% have sufficient knowledge. Whereas before playing the game, only 10% had comprehensive knowledge, and 10% had low knowledge of energy issues. Likewise, the answers to the Q8 indicated an increase in participating players' awareness of the essential role of HECs in promoting energy security; 20% strongly agreed with this, 30% agreed, and 10% agreed somewhat, while before playing the game only 10% agreed, and 30% somewhat agreed. The results also indicated an increase in awareness about the essential role of HECs in

promoting the renewable energy sector, where all players agreed on their crucial role in enhancing the renewable energy sector and reducing fossil fuel power plants. Whereas some of them did not agree with that before playing the game. Before playing the game, the participating players showed some awareness about the role of HECs in enhancing the environment. However, after playing the game, 90% of the participating players (50% agreed, 40% strongly agreed) agreed that HECs contribute to reducing the environmental impact of using energy.

As known, HECs contribute to reducing electricity prices by managing their energy consumption based on the grid status and the amount of energy generated from renewable energy plants and thus contribute to reducing the electricity bill and reducing fossil fuels used by the supplier. Before playing the game, 50% of the participating players showed a lack of awareness of this aspect (disagreeing and undecided). However, after playing the game, it was found that only 10% are unaware of this aspect, which indicates that the game has a significant effect in increasing awareness. The smart meter is crucial in energy management, as it displays the electricity consumption and prices, moment by moment so that the consumer can manage energy easily. In Power the Grid game, the electricity consumption is shown, which contributes to helping the consumer to understand the working principle of the smart meter in reality. Before starting the game, the participating players showed an insufficient understanding of the working principle of the smart meter and the importance of its role. However, after the game, they all indicated that they agreed with the importance of the smart meter in energy management and that they got aware of its working principle (70% strongly agreed, 20% agreed, and 10% somewhat agreed). Concerning the role of playing the Power the Grid game in improving the players' awareness of energy issues, question 13 was asked. The participating players showed their complete conviction that the game had an influential role in raising their awareness about the importance of energy management due to its contribution to enhancing energy security, the environment, and the renewable energy sector; 70% strongly agreed, 20% agreed, and 10% somewhat agreed.

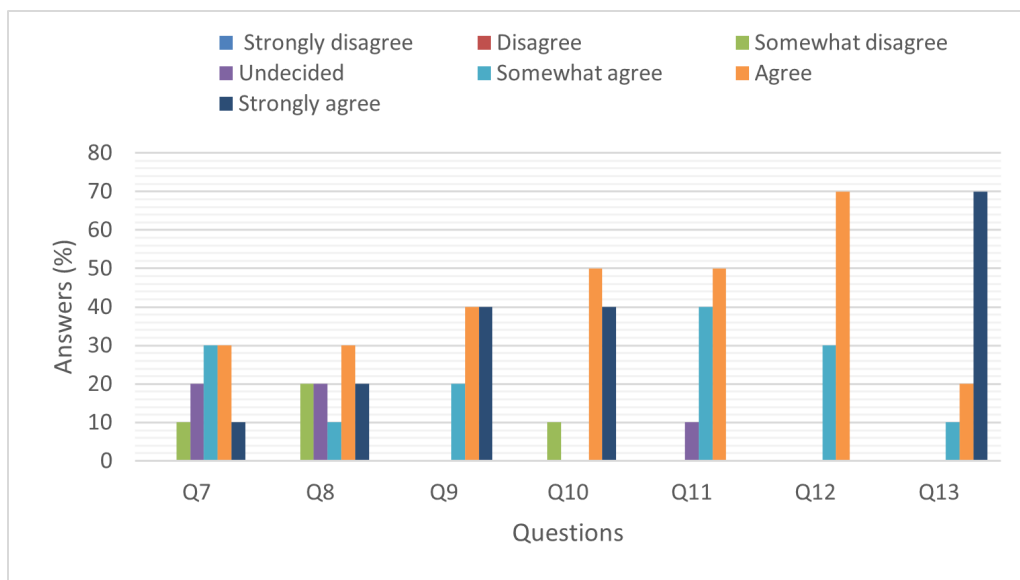


Fig. 3. Distribution of the participating players' answers to the second questionnaire

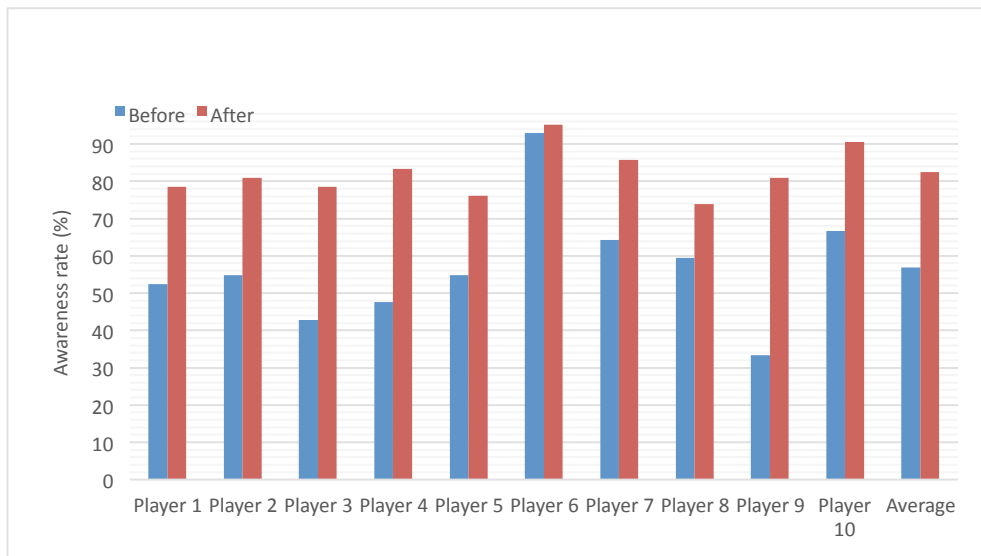


Fig. 4. The awareness rate of the participating players before and after playing the game

Moreover, Figure 4 shows the level of awareness of the participating players about the importance of the role of HECs in energy management before and after playing the game. The effect of the game on increasing awareness is clearly shown. Before playing the game, the awareness rate of 30% of the players was less than 50%, the awareness rate of 60% of the players was between 50% and 70%, and the awareness rate of 10% of the players was more than 90%. However, after playing the game, it was noticed that the awareness increased clearly, as the lowest awareness rate was 73.8% for player number eight. Whereas the percentage of players whose awareness percentage was less than 80% was only 40% and 40% whose awareness percentage was between 80-90%. In addition, the awareness rate of 20% of the players was higher than 90%.

3.3 Recommendation for Improving the Power the Grid Game Effects

The Power the Grid game contains various features that simulate reality, bring fun and suspense and encourage players to think deeply. Figure 4(a) shows the daytime mode; the city's infrastructure, the amount of energy produced, and the expected electricity consumption are displayed. In addition to the power plants (the hydroelectric power plant) and the gross of available fuel. It is noted that energy consumption increases with time during the daytime hours, and the player manages the energy for this city accordingly. Figure 4(b) shows the nighttime mode, a coal power plant has been purchased and established. With the increase in the demand for energy due to the city expansion, the lack of fuel stocks, and the slow establishment of power plants, a power balance problem occurs, thus leading to a power outage in the city, as shown in Figure 4(c), as the energy was poorly managed.

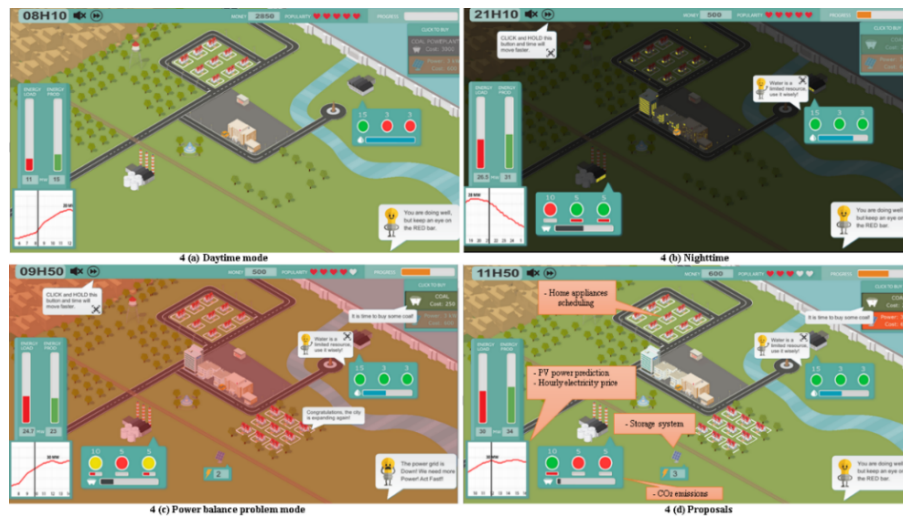


Fig. 5. Power the Grid game, source ref [18]

Based on the results of the last sections, which showed the impact of the game in raising players' awareness, this work suggests expanding the game's options and covering the options that do not exist in the game. The suggestions would significantly boost the awareness of players in keeping with the technological development in real life, in addition to increasing the fun of playing the game. (see Fig. 4(d)). First, the amount of energy expected to be generated from renewable energy systems such as the solar system, which depends on solar radiation. Secondly, adding an option to install an energy storage system, so the player can store energy in cases of excess energy generated from renewable energy systems and use it later instead of using fossil fuel plants, thus reducing the energy usage cost and reducing the environmental impact. Third, adding a DR strategy; allows the players to schedule the operating times of some appliances in homes, machines in factories, and city lighting depending on the available produced energy. In addition, express the cost of energy usage from the power plants hourly; by adding a smart meter that displays the electricity prices besides the hourly energy consumption. Thus, the player can manage energy by scheduling consumption at different intervals based on the amount of energy generated by renewable energy plants, the amount of energy stored in the storage system, and the electricity prices of other fuel plants. Forth, adding a CO₂ emissions measurement device that counted the amount of CO₂ emissions caused by the use of fossil fuels in power generation. Adding this tool would raise players' awareness of the environmental impact of using this fuel and thus guide them to manage energy usage environmentally.

4 Conclusion

This study presents an investigation of the role of video games focusing on social awareness, taking into account energy transition and sustainability. In line with the technological development in the energy sector and the increase in concerns about energy security and climate change, this study was carried out to investigate how video games might affect HECs' awareness of their role in contributing to energy security, reducing the environmental impact of using energy, and reducing electricity prices. First, a questionnaire was conducted to measure the awareness, and then the game rules were explained, and the players started playing. After that, another questionnaire was carried out after playing the game to measure the effect of playing the game on increasing awareness. The Power the Grid game was chosen as a case study with the participation of ten players.

The results showed a significant and remarkable role of playing this game in raising social awareness and educating HECs about energy issues compared with their awareness before playing the game.

Accordingly, several options were proposed to be added to the game, which would enhance social awareness of their essential role in ensuring a secure energy future and a better environment, in addition to the accessibility of electrical power at reasonable prices. The content of these proposals revolves around the execution of the DR strategy, which has begun to be applied in several countries. This study recommends increasing the interest in supporting game designers and facilitating the marketing of such games to increase the number of their goers because of their positive impact.

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Designing and Evaluating a SG for Learning: a Subtle Balance Between Designers and Learners

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Abstract. In a learning context marked by the disengagement of learners causing difficulty in developing skills, profound changes to diversify approaches have been initiated through pedagogical strategies and training systems to create commitment, generate motivation and thus promote learning. Through the literature and eXperience Feedback, the design and use of Serious Games (SG) appears to be an effective and efficient approach to creating an engaging and motivating context.

Through this communication, we define a theoretical framework around the design of SGs and we propose elements of response with an iterative design method of the design-based research type at the service of pedagogical engineering and skills development. We will show that the design phases of an SG articulated around the “10 commandments of the Serious Game Padawan” and combined with the exploitation of traces (learners, designers) lead to an approach having measurable impacts on the development of skills and the appropriation of the SG in a professional context. Thus, we highlight the subtle balance that is exercised between research, design, development, feedback from the SG through a comparative approach between traditional pedagogy versus active pedagogy based on the use of a SG.

Keywords: serious games, gamification, design, play and learn, design by learning

1 Introduction

Much research on games, education and psychology show that its use allows to “construct the experiential existence of man” [1] bringing a symbolic function conceding in particular the construction of identity, the development of relationships social, skills and motor coordination. Indeed, Kergomard P. promotes games and toys in the official texts of Education: “play is the work of the child, it is his job, it is his life” [2]. This pedagogical approach, very present during the first years of the educational course, is gradually being abandoned. The ambition, through the edutainment modality, is to mobilize game mechanics by repositioning learners at the heart of the learning process, making them actors in their training while promoting commitment and the anchoring of knowledge. The Serious Games (SG), by their immersive capacity, have found their place in the world of education and “offer in the range of active pedagogies, a privileged means of involving learners, in particular by immersion in a universe realistic” [3] and thus becomes an adaptive learning engine.

2 Observation and problems

First, we note that the heterogeneity of learners and the multiplicity of training provided raise organizational difficulties, both from the point of view of the establishment, the teachers and the learners. This first observation has consequences on the motivation and commitment of learners that are difficult to initiate and maintain throughout the training course. The teacher must therefore constantly imagine new strategies and design teaching methods and artefacts to maintain the motivational flow.

Secondly, the role of teachers through literature is similar to that of an “artisan” where “pedagogical practice oscillates between regulated improvisation and tinkering” [4]. If we make

the link with the continuous evolution of learning devices which leads to a complex modification of the roles of teachers and learners [5], we can determine two effects. The first is that “teachers become real designers who have the task of anticipating and relating, in one or more learning environments, different pedagogical, ergonomic, human, organizational parameters in an engineering process that goes from the design of the learning system to dissemination” [6]. The second leads teachers to abandon their “pedagogical do-it-yourself” to move towards an elaborate and effective orchestration [7].

Thirdly, the new generations of learners (Generations Z and Alpha) [8] lead to thinking about new strategies and teaching tools. We find, in the literature, the components that define this new generation of learners [9]: motivation by affect, need for recognition, difficulty in accepting constructive criticism, diminished sense of responsibility, little link between the effort and the result.

Faced with these findings, since 2021 we have been carrying out a reflective and active approach around ludopedagogy and in particular on the design of SG in the service of skills development. We present our combinatorial methodology around a theoretical framework as well as the first results of the study.

3 Theoretical Framework

Through the literature and much feedbacks, the use of SGs in combination with other tools used by teachers appears to be a probable solution for creating the conditions for engagement in learning and thus maintaining motivation. Enough to develop skills [10]. As part of an active pedagogical approach and design of SG, it is advisable to carefully consider, from the genesis of the pedagogical artefact, the needs of the various actors linking motivation, commitment, immersion and pedagogical strategies [11].

3.1 Motivational Lever

Motivation theory is a set of principles that describe how and why individuals are motivated to act in a certain way. There are many theories of motivation, each with their own key assumptions and concepts. Thus, we highlight the theory of intrinsic and extrinsic motivation, which can be applied and transposed to SG [12]. Intrinsic motivation theory asserts that individuals are motivated by the personal satisfaction they derive from an activity while extrinsic motivation theory asserts that individuals are motivated by rewards or penalties associated with an activity. SGs can thus use these two motivational levers by creating playful and enriching situations for learners by offering feedback to encourage and promote good performance. Games can also use the self-determination theory of motivation [13] which argues that individuals must feel in control of their lives and their environment to be motivated. Games that offer choices and options in the unfolding of the game scenario can therefore help players feel more in control of their immersive experience and therefore be more motivated.

3.2 Interactions Between Learners

Stimulating pedagogical interactions between learners is a key concept in group learning. These are verbal exchanges and non-verbal signals that take place between learners working collectively towards a common goal. Pedagogical interactions can be formal, such as debates and guided discussions, or informal, such as exchanges of knowledge and personal experiences [14]. These interdependencies can therefore enhance learning by allowing learners to share knowledge and experiences, ask questions, receive feedback and ideas, and motivate each other. Educational interactions can also encourage learners to develop important social skills, such as active listening, conflict resolution, and group decision-making [10]. There are different transferable strategies in SGs to promote interactions, for example by using technological tools for online collaboration, by creating learning situations that promote group discussions, or by using active

methods that involve learners in the problem solving and debating [15]. Teachers can also use facilitation techniques to guide learners to build positive relationships and communicate effectively with each other [16].

3.3 Concrete Representations

Offering concrete representations with SGs is a strategy to support learners' understanding by promoting the retention of new information and memory anchoring. Concrete representations are objects or images that illustrate abstract concepts. These can be transposed into SG, notably through the mediation of images, animations, simulations and visualizations to address difficult concepts [17]. In addition, concrete representations can help learners assimilate ideas or skills by linking them to familiar images or objects.

4 Serious Game Design

4.1 Serious Game Design Method

The design requires a reflective approach to create a conceptual balance that reflects and serves the learners. Thus, we based ourselves on a design-based research type methodology seeking to solve the problems of learning, skills development, pedagogical engineering mobilized in the design. By placing ourselves in this combinatorial methodology, we are part of a dynamic of emergence of ideas which will be discussed, prototyped, tested and analyzed throughout the development process. First of all, our research approach is based on a pedagogical engineering model allowing analysis, design, development and evaluation. Thus, we favored an iterative approach based on the successive approximation model [19]. This model encourages quick feedback and flexible work processes. The methodology of Design-Oriented Research [21] is based on the idea that the design of pedagogical artefacts or training devices requires the formalization of researcher-teacher relations around strong collaboration, sharing of praxeologies and implementation. place of tools allowing the exchanges between research and field of experimentation. Reference is often made in the literature to the “classic position, the research team ensures the development of tools, the conceptual approach, the collection and analysis of results, then yields to decision-makers and practitioners the initiative to 'adapt the knowledge produced, and even the instruments, to the local context” [21]. Thus we have built a combinatorial method allowing the crossing of visions: designers of SG/educational engineer, researchers, learners, teachers pooling and capitalizing the traces throughout the design iterations. In addition, we have completed our approach with the conceptual method of the “10 commandments of SG Padawan” which offers key steps and recommendations to help teachers create their own SG [11].

4.2 Realization of the Serious Game *Wonder Vendeur*

“*Wonder Vendeur* : devenir un vendeur qui déchire” is an SG in which learners play while developing their skills in sales and commerce. By immersing themselves in this universe, learners must go through all the stages of a sales interview by answering questions related to six educational objectives:

- Identify the eight key stages of the sales conversation.
- Master the techniques/methods and tools associated with each stage: active listening, identification of customer needs, removal of barriers to purchase, interpersonal skills, posture, etc.
- Use reception techniques/methods, search for needs, reformulation, presentation, argumentation, processing of objections, conclusion, associated with a transactional and relational loyalty method.

- Mobilize skills in a professional context.
- Evaluate and co-evaluate sales techniques/methods.
- Follow and trace the training course via an individual skills passport

This SG explores the activities and skills of « *Bac Professionnel Métiers du Commerce et de la Vente* », the « *Certificat d'Aptitude Professionnelle Equipier polyvalent du Commerce* », the « *Certificat d'Aptitude Professionnelle Métiers de la Coiffure* » and « *Brevet Professionnel Coiffure* »

To verify our hypotheses, we have implemented tools and techniques to mobilize and activate three motivational springs:

- Intrinsic motivation: mobilized through quests, challenges, progress in the game. It is activated by personal success using mechanics of rewards, ranking, *Wonder Vendeur* skills passport but also by exploration and creation (choice and personalization of an avatar).
- Extrinsic motivation: can be activated by promoting team play (guild/team), recognition and social belonging among players via the personalization of a team avatar.
- The combination of intrinsic motivation and self-determination: identifying with a personalized avatar, becoming an actor in its progression by choosing the feedback offered by the narrative structure of the SG.

Our serious game is made up of 700 cards, divided into four items that we describe below:

Items	Objectives
<i>Method</i>	Acquire and assess block skills: <ul style="list-style-type: none"> • Advise and sell / Accompany the customer in their purchase journey. • Customer relations and participation in the activity of the company / Advising and selling products, materials and services.
<i>Enigma</i>	Develop and acquire the skills expected in the other blocks of the repositories: tracking sales, building customer loyalty and developing customer relations, receiving and tracking orders, highlighting and supplying.
<i>Live my life</i>	Put into practice the knowledge to be expected in a professional context by confronting real situations.
<i>Brand</i>	Mobilize informal knowledge of general culture.

Tab. 1. Theme of the game *Wonder Vendeur*

The narrative structure of *Wonder Vendeur* mobilizes three anchoring methods to accompany and support learners to better assimilate concepts by associating them with images, sounds, interactions and/or familiar objects.

- Visual anchoring: all the stages of the sales interview present on the board and on the “Method” cards are represented by a single pictogram. Players implicitly associate the technical vocabulary of the stages of the sales conversation through these constituents. This strategy also enables allophone learners to associate pictograms with professional vocabulary. Finally, these are found on the training materials in order to form a cohesion and a link between the game and the theoretical contributions, creating an educational ecosystem: each skill targeted in the course is associated with a game theme.
- Auditory anchoring: this anchoring process is also mobilized through the rules of the game. Indeed, the players must read the questions aloud to all the learners. If the player does not find the correct answer(s), the card is repositioned above the deck. Thus, players who have been attentive can memorize the answers and progress faster on the game board.

- Interactive anchoring: an interactive dimension is exploited via the implementation of QR-Codes readable from a personal digital tool. This strategy provides additional depth allowing the dissemination of slogans on the “Brand” item.

Given our problem of engaging and retaining learners in a training system, we have favored four pedagogical methods to mobilize, diversify and combine learning:

- Complete game session over 2 hours: acquisitions and/or revisions of the activities and skills expected by the reference systems.
- 30-minute focus session: the teacher can validate the professional skills developed and over a shorter session by using the *Wonder Vendeur* passport which certifies the passage of learners on a specific stage. This co-maintained link between the theoretical and practical contribution allows learners to measure their progress and retrace their training path.
- Fan mode: the cards can be used alone, thus offering a new playful dimension that promotes autonomy and the social interactions that result from it.
- Battle mode: the addition of a buzzer as a fun spring allows learners to compete by mobilizing the speed of response, thus enriching *Wonder Vendor* with a stimulating spring.

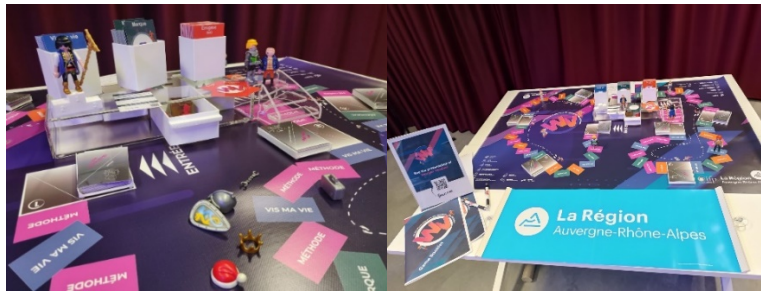


Fig. 1. The serious game *Wonder Vendeur*

5 Experimentations

5.1 Methodology for Feedback Collecting

The experimentation sessions mobilized the teacher-designer, an educational engineer, the learners and a researcher specialized in SG and EIAH. Thus, we propose the adaptation of an observation tool [20] allowing the collection of data (observations, actions, positions, indicators) according to the objectives of the edutainment sessions and the elements to be observed according to the points of view of the player and game designers (Annex 1).

The game session mobilizes different actors in the service of the design of a training device taking on distinct roles:

- The facilitator or “master of the game” presents the rules of the game, the organization of the session, encourages dialogue, animates, guides, maintains the atmosphere of the game and the debriefing phase.
- The players are active participants in the edutainment session.
- The observer is responsible for collecting data using the observation grid (Annex 1).

The players and the animator can also participate in the data collection through the evaluation sheet (Annex 2). Depending on the objective of the session and the human resources available, the roles of moderator and observer can be performed by the same person.

5.2 Experimentation Context

Wonder Vendeur has been tested within the Professional Training Institute 43, Apprentice Training Center in Haute-Loire (AURA Region). This training center has been active for more than thirty years and has been developing Information and Communication Technologies for ten years in the teaching and supervision of learners. The *Wonder Vendeur* experiment lasted 12 months, starting in September 2021. These observations relate to levels 3 and 4 of the sales - commerce - hairdressing sectors, with an average number of 15 learners per group, aged 16 to 25. The total number of experiments is 41 learners (27 women and 14 men). Each Return of Experience allowed us to measure the commitment of the learners.

6 Results and Analysis

Feedback from experience has shown that the “traditional” phase of an educational session on the theme “The stages of the sales interview” is well perceived by all the learners (Appendix 2), we also note a good felt at the end of the session (61%) associated with a profit-sharing rate (73%). Learners have made the link with their professional activities and the session, but have difficulty memorizing the stages of the sales interview (37%) as well as the associated techniques (59%). They also express the complexity of reinvesting these skills in a professional context. Finally, by analyzing the results and following the debriefing phases, the learners tell us about their feelings about time: “time passes slowly sometimes” and this generates a certain form of weariness and boredom (73%). In comparison, the SG session reflects better results with positive feelings (88%) and interest in the session (98%). There are also differences in the notion of memorizing the stages of the sales interview (76%) and associated techniques (71%). The latter transferred their teaching skills more easily to their professional activities (78%).

The first analyzes of the edutainment sessions show that the contextualization is more obvious, memorization is facilitated and that the approach is very well perceived by the learners. We notice almost unanimously that they have not, or very little, felt the effects of time during the edutainment session: “Is it already over?”, “Is it already...?” They also told us that they felt motivated and engaged throughout the game: “Can we do it again ?”.

The game mechanics used make it possible to make up for the “dead times” observed during “traditional lessons”. In addition, they verbalized and very quickly understood that we could learn in stimulating conditions: “we learn while having fun, it's great and in addition we all exchange together”. This SG approach also allowed some learners to assert their personality, others revealed themselves completely. During the experiments, we observed that the use of the SG facilitated the lifting of inhibitions: the learners let themselves be guided, carried by the mechanics of the game and a favorable work climate established by a feeling of fairness, of respect between players.

From the designer's perspective, we identify and emphasize the importance of agile design centered on player feedback, through iterative design loops, enabling strong learner buy-in to the game atmosphere (71%). We emphasize the importance of a design based on the “10 Commandments of SG Padawan” method [11] offering real support thanks to the key steps necessary to create and develop an engaging, motivating SG with a real pedagogical impact. Indeed, all the learners understood the rules of the game and 95% of the players appreciated the game mechanics used. In addition, we were surprised that a board game could generate so much support from a very technocentric Generation Z and Alpha: 83% of players appreciated the manipulation of cards, figurines and the roll of the dice.

Nevertheless, these results should be taken with caution, given the size of the panel of learners, they remain very encouraging and deserve to be verified on larger cohorts and to understand their levers more precisely (graphic universe, games, social interactions, use of several explicit or implicit memory anchoring techniques, etc.).

7 Conclusion

Indeed, our iterative design method of the design-based research type shows that the design phases of an SG articulated around the “10 commandments of SG Padawan” [11] and combined with the exploitation of traces (learners, designers) lead to an approach with measurable impacts on skills development and SG ownership. These two intertwined and simultaneous processes must be monitored and analyzed throughout an iterative design process. Through our experiments, we relate and demonstrate that it is an effective, efficient combination giving rise to a balanced SG with a strong membership rate and a unanimous rate of interest in the edutainment sessions. We also emphasize that this approach promotes motivation and commitment on the part of both learners and designers : each being at the heart of the whole process and players in this subtle balance.

In addition, the use of game mechanics allowed learners to develop transversal skills and we emphasize that the approach with an SG has a positive impact on creating and maintaining learners' motivation in learning knowledge and skills development. The comparative analysis between traditional courses and edutainment sessions highlights the commitment by placing active learners at the center of their training. Finally, it should be noted that the designed SG created team cohesion by valuing everyone's experiences, optimizing their potential under better conditions. This promotes the teacher-learner bond with interactions, moments of sharing. To strengthen and perpetuate this feeling of respect and belonging, each participating learner was able to integrate and share their professional experience by creating "Brand" and "Live my life" cards.

The future prospects of this collaborative design work by SG consist in further supporting a methodology by crossing perspectives between research, development/engineering, feedback from learners and teachers. The idea is to support designers more closely in all phases, to ensure a balance of forces to obtain a balanced SG consistent with the educational expectations of teachers and those of learners.

ANNEX 1

Tab. 3. Grid for collecting traces

Objectives	Player View Observable non-verbal elements	Player view Observable verbal elements	Instructional designer Observable verbal elements
Promote knowledge transfer and learning	obs + pos : change of action performed by players in response to game mechanics and manipulation of artifacts (card board, etc.)	obs :assimilation and transfer of knowledge in relation to each item. obs : verification questions by players on the dynamics of the game and explanations provided.	obs : control of the assimilation of sales methods. obs + ind :Mastery of sales techniques. obs + ind : Transfer of skills in the professional context (company).
Express the values of the players (preferences, what they consider good or bad, fair or unfair, equitable, etc.)	obs : change in posture/mime/attitude obs : Sacred/superstitious reference gestures (blows on the dice before advancing, hands clasped before a question, eyes raised).	obs : sentences expressing value judgments, feelings in relation to his evolution on the board and the evolution of other players).	ind : assessment of the relevance of the questions and answers associated with each item.
Explore new individual/collective strategies.	obs+ act : new actions performed by players outside the rules of the game.	obs : verbalized proposals for new practices/strategies when negotiating or trying to destabilize other players.	obs : application of progression or regression mechanics. obs : follow-up of figurine customizations. obs + ind : follow the rules of the game. obs + pos + ind :monitoring the use of the game board.
Stimulate the emergence of new practices (new rules, variants, game mechanics, etc.)	obs : implementation of a legal or illegal non-verbal communication strategy.	obs : spontaneous request to create a collective. obs : transfer of resources between players. obs + act : relationships between individuals during the game.	obs : use of the playbook. obs + ind : understanding the rules at the start of the game and applying them during the session. obs + ind : management of miniature accessories.
Foster relationships between players.	obs : signs of empathy. obs : Appearance of new roles/positions in the game or in the group. obs : formation of groups favoring exchanges between players. obs + pos : learner proxemics. obs + pos :use of the different artefacts offered in the SG.	obs : sentences expressing group dynamics, power plays, and their opinions. obs : conflicts, tensions, collaborations, cooperations, solidarity, trust. obs + pos : emergence of leader, follower and disruptor.	obs + ind : quality of questions and relevance of bonuses/penalties. obs + ind : dimensions of the tray and accessories. obs + pos : layout of the play area, squares, accessories, etc.
Test, validate and improve the artifact.	obs : postures, gestures, mimicry, facial expressions, gaze reflecting interest or disinterest	obs :expressions of interest, disinterest obs :suggestions for improvements. obs : understanding brakes in the questions, the rules of the game. obs :link of transferability in a professional context. obs : request to continue or end the game. obs : asks to invite other people, groups/classes of learners to participate.	obs : item count. ind : distribution of game artifacts on the miniatures, on the board. obs + ind :number of slower progressing players.

ANNEX 2

On a sample of 41 learners, we obtain the following results:

Tab. 3. Result of the traditional approach versus gamified approach

Evaluation criteria	Traditional approach					Gamified approach				
	1	2	3	4	5	1	2	3	4	5
Note the organization and conduct of the educational session	0%	7%	46%	39%	7%	0%	0%	15%	46%	5 ¹
Were the educational objectives clear?	0%	0%	24%	49%	27%	0%	0%	2%	88%	39%
Was the teaching content clear?	0%	0%	27%	54%	20%	0%	0%	5%	34%	10%
Rate the quality of teaching materials	0%	0%	24%	56%	20%	0%	0%	5%	56%	61%
Rate the animation of the educational session	0%	5%	7%	71%	17%	0%	0%	0%	59%	39%
Note the dynamism of the educational session (alternating theory/methodology/practice)	0%	2%	17%	63%	17%	0%	0%	2%	54%	41%
How do you feel at the end of the educational session?	0%	7%	32%	46%	15%	0%	0%	0%	7%	44%
I plan to reuse the elements learned during this educational session?	2%	5%	20%	41%	32%	0%	0%	12%	78%	93%
I memorized the stages of the sale?	2%	12%	22%	44%	20%	0%	0%	5%	61%	10%
I memorized the techniques of the sale?	5%	20%	34%	34%	7%	0%	0%	24%	49%	34%
Was I able to work independently during this session?	12%	17%	49%	15%	7%	0%	0%	29%	44%	27%
Was I able to work in a group during this session?	12%	15%	49%	17%	10%	0%	0%	0%	0%	27%
I felt like I was taking your time?	0%	10%	46%	20%	24%	41%	54%	5%	0%	100%
I plan to reuse the concepts learned?	2%	15%	59%	20%	5%	0%	0%	44%	44%	0%
I have the feeling that I have understood the stages of the sale?	5%	7%	44%	27%	17%	0%	0%	10%	71%	17%
Did the educational session interest you?	0%	5%	22%	49%	24%	0%	0%	0%	0%	20%
Is the educational session related to your professional activity?	0%	0%	0%	5%	95%	0%	0%	2%	5%	100%
Did the class time go by faster?	2%	12%	59%	20%	5%	51%	5%	7%	2%	93%
I felt bored during this educational session?	0%	5%	73%	12%	10%	88%	7%	5%	0%	34%
In general, how would you rate the ergonomics of the board game?						0%	0%	5%	12%	56%
Is the game easy to install and understand the rules?						0%	0%	0%	0%	83%
Are the parts and trays easy to handle?						0%	0%	5%	17%	100%
Does the game offer enough variety to keep it interesting ?						0%	0%	0%	5%	78%
Are the game's artwork and graphics clear and attractive?						0%	0%	10%	19%	95%
Is the recommended number of players for the game right for your group?						0%	0%	0%	5%	71%

¹ Scale of 1 to 5: totally disagree to totally agree

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Limits to Growth: From Modelling to Gaming

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Abstract. In this paper, we explore the process of transforming the complex model World3 from the Meadow's report into a commercially viable game. Our main goal is to provide players with a fun and engaging experience that allows them to experiment with the model, and draw their own conclusions. By making this topic more accessible, we hope to promote a greater understanding of their underlying issues. This paper delves into the various game design choices that were made to create a successful commercial version of the game.

Keywords: Serious game, prey-predator models, Limits to growth

1 Introduction

In 1972, a book called "Limits to Growth" was published [1]. It documented the research and findings of D. & D. Meadows and J. Randers, as well as with the Club of Rome colloquium. Out of the major outcomes was a descriptive model of the world and the complex interconnections between its parameters called World3. This groundbreaking work was pivotal in our understanding of the global system and its correlation with human influence. Decades later, it continues to inspire and capture the attention of scientists [2, 3, 4].

However, the challenge with this work is that it remains largely unknown to a broader audience. The model is accurate and complete, but its complexity makes it difficult for people to comprehend it. It requires a significant amount of time to invest and the availability of an individual who can help explain it. This is why games come in as an effective communication means [5], especially for knowledge from modellings. By incorporating the model's concepts into a game's rules, people can learn and experiment with the model in an engaging and empowering way as players and budding scientists [6, 7].

Creating a game based on the model requires careful consideration and balance between the constraints of the game medium and the complexity of the model. A successful game designer must ensure that the game is commercially viable while having the meaning and importance of the model to players.

In this paper, I start by explaining the rules of the proposed game. It will allow the readers to see the arrival point (section 2). Then I describe shortly the model World3 and propose an easier example of this kind of modelling. I highlight why models are good candidates for gamification (section 3). The middle part of the paper is dedicated to explanation on what was done to make a game from this model (section 4, 5, 6, 7). The last part of this paper points the difference between this proposed game and a more usual serious game (section 8).

The paper is then organised as follow:

- Section 2: The game's rules.
- Section 3: Modelling and the World3 model.
- Section 4: Model simplifications.
- Section 5: The role of the player.
- Section 6: The time in the game.
- Section 7: What is victory for players ?
- Section 8: Is this a serious game ?
- Appendix 1: the cards of the game.

2 The game’s rules

In this section, we describe the game as if it were a commercial product, excluding certain details such as the game setup process, to simplify explanations.















2.1 General description

The game is a civilization-building game where players (ranging from 1 to 6) govern a country in consideration of their neighbors and the planet's limitations. The game is simulating our world from roughly 1850 to 2050: from pre-industrialisation to our near futur. The game is classified as expert-level, much like other civilization games, and typically takes around 30 minutes per player to complete. During each turn, known as a generation, players select political actions from a set of cards, play them, and adjust the game board accordingly.

The game consists of one game board and one game aid per player, along with a set of cubes, meeples, and tokens. Additionally, there is a central board and a deck of identical cards for each player. The objective of the game is to accumulate points by increasing one’s population, education level, social peace, and land ownership. While the game can be competitive, cooperation between players is also possible and beneficial. The game concludes after either eight generations or four major crises (which can be financial, ecologic or military).

2.2 Game’s main variables

To begin our explanation, we introduce the game's variables, their corresponding icons, and provide examples in the following table.

Game variable	Definitions / Example.	Icon	Game object
Land	Piece of the planet.		Wood cube
Renewable resources	Water, crops, fish, cattle, wood, solar energy, ..		Green cube
Fossil resources	Oil, uranium, coal ...		Black cube
Goods	Houses, cars, books, clothes, handspinnners, ...		Grey cube
Weapons	Tanks, rifles, knives, nuclear submarines, ...		Red cube
Money	Unified world money.		1 to 10 Mrd bills
Education	Equivalent to wealth .		5 Squared blue tokens
Social peace	Level of stability of populations.		1 Blue cube
Pollution	Plastics, CO2, uranium wastes, chemicals ...		Skull token
Factories	Production of  ,  and  .		3 Blue houses
Population	Size of each player population (in Mrd)		1 Blue Meeple

2.3 Player’s board

The player board below displays the game's variables for each player, which are subject to change based on played cards and adjustment rules. Further details and explanations can be found within the image.

Production of Renewable goods and weaponry
 It costs some fossile ressources and generates some pollutions

Scale of social peace
 - This value tells if the population is able to supports changes and charges.
 - The red part of the scale are revolutions
 - It brings points at the end.

Quantity of population
 - A lot of game costs or gains are indexed to this value as the food consumption per population.
 - It brings points at the end.

Distribution of the education
 - It contains 5 tokens that represents 20% of the population. They evolve at different education levels (abscissa of the array).
 - The median token (the 3rd) conditionnates the consumption, the demography, the taxes.
 - The highest education token (the 5th) will impact the card draw, i.e. the capability of the population to develop new technology and behaviours.
 - The gap between the minimum and the maximum token impact the social peace (class conflict).
 - It gives points at the end.

Lands
 - It is the quantities of territory owned.
 - It limits the renewable production.
 - It give points at the end.

Ressource storages
 - It is the location to put the produced ressources.
 - It contains the rules in case of ressource shortages (famine, unemployment ...)

2.4 Player's aid

This aid outlines all the stages of the game happening during a generation and is a reminder of the adjustment rules that can be applied during the game.

0 Draw cards
 1 among 5 from 1 of the. The 4 left are put back under the pile.

1 Play the cards
 1 or 2 cards per turn

2 Production

3 Class conflict

4 tax fraud
 -1

5 Consumption
 -1

6 Development
 +1 +1

7 Conscription
 +1

8 Tax incomes
 +2 +3 +3 +5 +5



9 Financial crisis
 -1 for each +10


10 Military crisis
 -1 or -1 for each max back: -1

11 Ecological crisis
 -1 for each max: -1 min: +1

Phase 0: Draw cards. Players draw cards, and the maximum number of cards they can hold and draw is determined by the column in which the fifth education token appears on their education track. Greater possibilities are available to players with a more educated elite.



Phase 1: Play cards. Players take turns playing their cards, one or two at a time, in a clockwise direction until all players are unable or unwilling to play any more cards.

Phase 2: Production. Players gather resources based on the level of their token on the three factory scales on their player board. If the production level is deemed high, this comes at the cost of consuming fossil resources  and generating pollution . In the event of a shortage in fossil resources, an unemployment crisis occurs, reducing social peace and factory production.

Phase 3: Class conflict. The level of social peace  is negatively impacted if there is a gap between the education level of the first and last education token on the player's board.

Phase 4: Tax evasion. If the population has reached a certain level of education, some money is removed from the game supply which is placed on the central board.




Phases 5 to 8 are linked to the median education token. Each column represents a different type of society. The first two columns depict agrarian societies with high population growth, low tax incomes, and strong conscription. Columns 3 and 4 represent capitalist societies with a fixed population after the demographic transition, a need for goods, and a rise in industrialization. The last column represents a service society with a greater need for goods and a decrease in industries.

Phase 5: Consumption. Players must spend their available renewable resources  token and/or goods token  per population. However, if they lack these resources, it can lead to a famine or consumption crisis.

Phase 6: Development. The level of the factory increases (or decreases).

Phase 7: Conscription. The players acquire weaponry based on their population size.

Phase 8: Tax incomes. Players earn money based on their population size.

Phases 9 to 11 are closely tied to the central board of the game, which displays the global supply sizes of weapons , bills , and pollution . If any of these supplies run out, it triggers the corresponding major crisis.

Phase 9: Financial crisis. When the amount of money available in the game is insufficient to sustain the economic system, either due to its size or tax evasion, players must return a portion of their money to the central board. This results in a decrease in social peace.

Phase 10: Military crisis. Once all available weapons are produced, the global tension becomes too high and it triggers a worldwide war. At this point, players must return all weapons and the level of social peace decreases, along with their education level.

Phase 11: Ecological crisis. When the planet's pollution threshold is exceeded, players lose land, renewable factories, and social peace. Additionally, ecological migration occurs from the players with the highest pollution levels to the players with the lowest pollution levels.

2.5 Card's game

The cards are categorized into three decks based on their color. The blue-back cards refer to policies that benefit the population. The orange-back cards relate to industry and ecology, while the red-back cards include effects that impact other players. The back of each card is always kept visible to everyone, as it is an indicator of each player's strategy.

The following figure provides a few examples of the possible cards, and how to read them. The complete list can be found in Appendix 1.



3 Modelling and the World3 model

3.1 Generalities on modelling

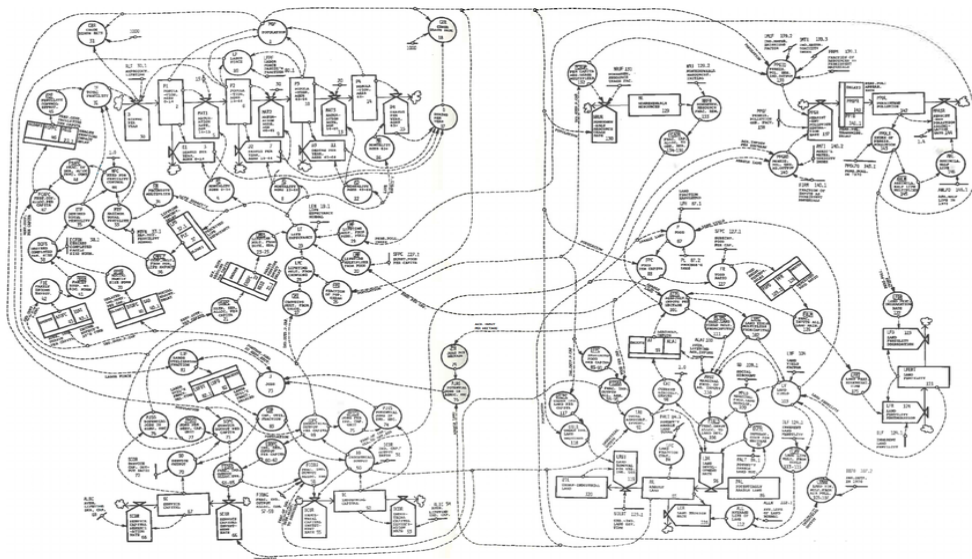
In this paper, as well as in the work surrounding the book "Limits to Growth," the modelling approach views the Earth system as a set of variables and fluxes between these variables. These fluxes alter the variables and command the system's evolution. This description can be translated into equations to simulate observed phenomena. The equations representing the system's variables and fluxes can be solved analytically or numerically to generate forecasts. These predictions should be tested through experimentation to validate the modelling. Once validated, the modelling and its outcomes can inform the development of new technologies. However, the accuracy or the validity of the modelling may be called into question if new discoveries emerge that challenge its underlying assumptions or its results.

Occasionally, some models are utilized as extrapolation tools, beyond their validated range. World3 is an example of such models. These models no longer serve as predictive tools, but rather as tools to enhance understanding, and provide insights within the approximations and frameworks they offer.





3.2 The model World3

The World3 model interprets the world as a set of variables and fluxes between them, with functions describing the relationships between these fluxes and variables [8, 9]. The selection of meaningful variables and realistic fluxes is given particular attention in the model, resulting in impressive results that appear predictive, despite the lack of experimental validation. Furthermore, the model's size and complexity - with 315 variables - add to its impressive nature.

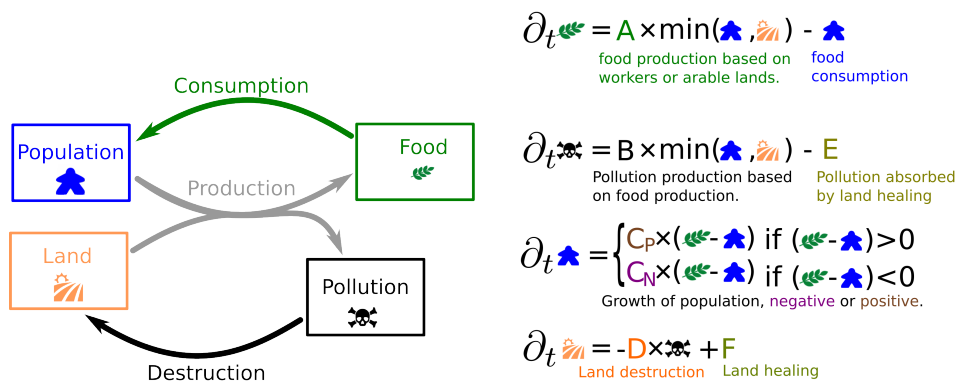
The World3 modelling approach is based on the principles of variables and fluxes, consisting of 315 variables and their associated fluxes. The diagram of this model is presented in the figure below. While we will not delve into the complexities of this model or show the list of equations, it is worth noting that it is divided into five main classes of variables, including population (divided by age groups), capital (industries, services, unemployment), agrarian (food, lands), pollutions, and erodible resources such as copper and oil.



3.3 A simpler model

To illustrate the concept of modelling, I created a simplified scenario of such current situation (note the various modelling possibilities [10]). The model includes variables such as a population  living in a territory  that produces resources  and generates pollution . The population consumes these resources, and if enough resources are available, the population can grow. However, if there is a shortage of resources, famine occurs, and the population decreases. Additionally, the pollution generated by the population reduces the available territory and the production capacity.

This simple model can be represented using a scheme and equations. This give the following:







The current equations include a feature not present in the scheme, which is land healing, represented by parameters E and F. In the previous situation, the population was doomed since pollution was accumulating and destroying the land without any possibility of recovery. However, in reality, the land can heal and recover from pollution, which is taken into account in the current equations.

The time derivative ∂_t of each variables is the flux of those variables. They are quantified with parameters A to F and with the variables. This modelling are solved numerically following this process :

- 1) Setting an initial state (initial value of parameters).

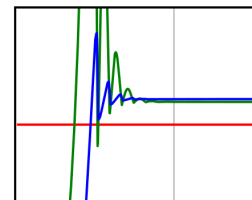
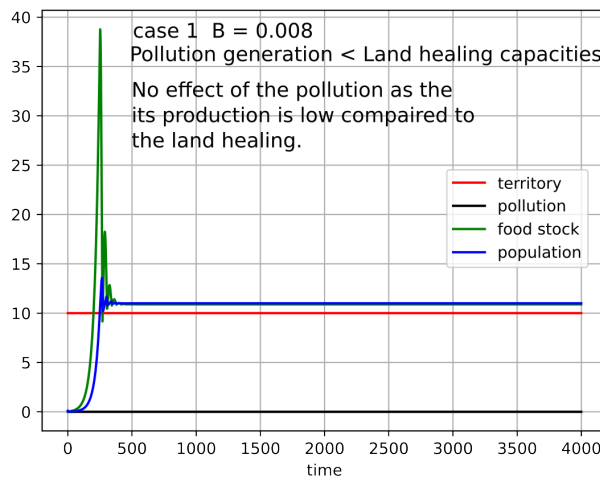
- 2) Computing the fluxes based on the current state of the system.
- 3) Updating the state of the system by evolving it with the computed fluxes.

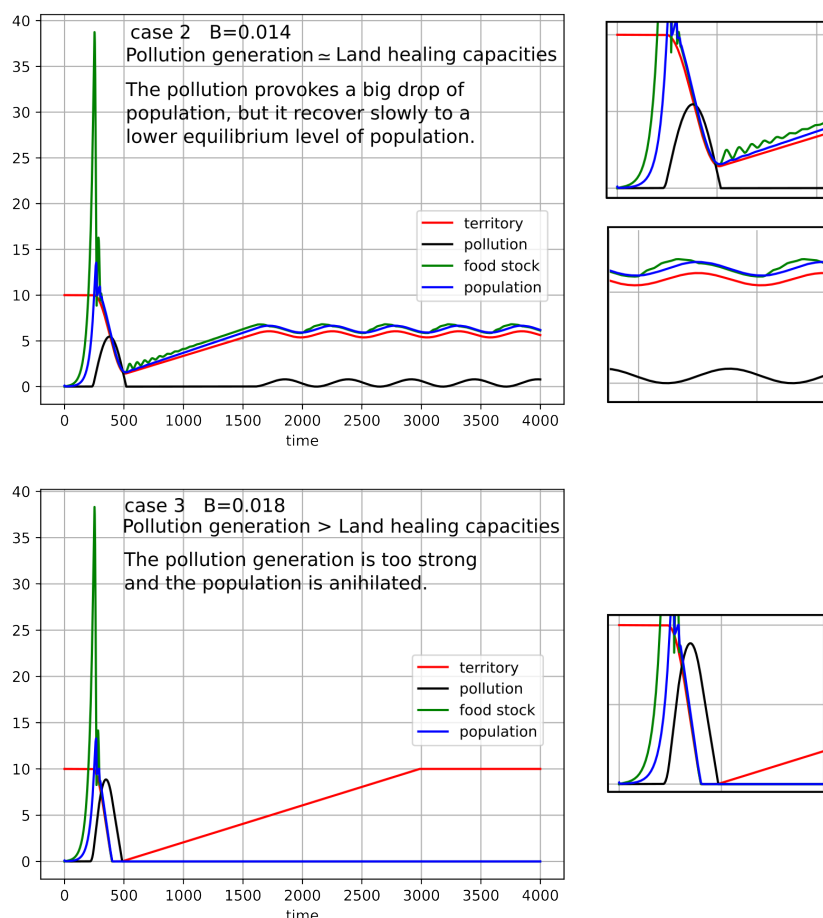
The steps 2 and 3 are repeated as many times as needed to allow the system to fully evolve. For example, let's take these three simulations. The initial state and the parameters are the following :

	= 0.1	A= 1.1	D = 0.01	Case 1: B = 0.008
	= 10	Cn = 0.5	F = 0.004	Case 2: B = 0.014
	= 0	Cp = 0.01		Case 3: B = 0.018
	= 0	E = 0.08		

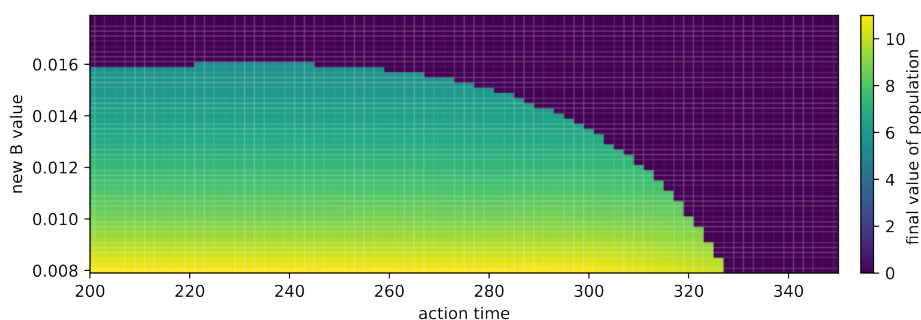
The graphs below show the results of the modelling. The initial oscillation of the green (food) and blue (population) curves is caused by the limitation of land, as food production is restricted by available land (as shown in the food equation). However, there is still some food in stock when the limitation takes place, allowing for a temporary increase in population before reaching a new equilibrium, as seen in case 1.

The cases 2 and 3 illustrate the effect of pollution on land availability. The peak of pollution reduces the available land, resulting in a decrease in population. In case 2, the population recovers slowly and reaches a new equilibrium state, whereas in case 3, the lack of land for food production leads to the population's demise. Such behaviours is typical of the prey-predator modellings [11].





One may question how one could avoid the fatal outcome in case 3 (with $B=0.018$).. To address this, we could explore the possibility of reducing the pollution generation parameter, B . However, the questions of when and by how much to reduce B remain. We can approach this by running simulations where we vary the value of B at different time points. Then the population reached at the end is measured in simulations and reported on a graph:



From the simulation results, we can observe that a reduction of pollution generation by a factor of 2 (from 0.018 to 0.08) is required to achieve maximum population growth. Furthermore, it is apparent that the magnitude of the reduction has a direct impact on the maximal time to change B . With a drop in B to 0.015, one can wait until time = 280 to have an effect. With a larger drop in B to 0.008, one can wait until time = 320. It is also evident that any insignificant

reduction in pollution generation is ineffective, and any activation after time 320 will be too late to avoid population collapse.

3.4 Why building a game out of a model?

The World3 model is highly complex, but it provides valuable insights that should be widely shared. With modelling, we can conduct experiments like the one conducted in the previous section. The simulations that led to the creation of the map in previous figure required trial and error when selecting values for the two parameters (B and its activation time). This repetition of parameter choices ultimately led to the conclusion that pollution generation must be reduced before it is too late.

We have all the elements of a game: the ability to make choices that have no real-life consequences in a system that follows specific rules, all for the sake of entertainment. In this case, the choices are the changes you apply to the system, but since it is just a model, there are no real-life consequences to worry about. The system itself is defined by its rules. The insights gained from the model can be both informative and engaging, but acquiring this knowledge can also be daunting for the general public. Therefore, I developed the game described in Section 1, taking great care to enhance player immersion without compromising the meanings of the modelling results.

Looking at game design from a reverse perspective, it becomes apparent that having a model as a guide is highly inspiring when deciding what to include in the game. The themes used for the game mechanics come naturally since each effect in the game mimics a part of the model. The model serves as a guide to determine which ideas should or should not be included in the game. It helps to ensure that each element included in the game has a meaningful connection to the story that the game is trying to convey.

4 Model simplifications

4.1 Reducing the number of variables and their fluxes

To ensure playability, it is necessary to simplify the model. Keeping all 315 variables from the original model would result in poorly calibrated choices. Obvious choices must be removed since they are not really choices. Inconsequential choices should also be removed. Choices that are too deep or have too many options should be simplified since they become impractical for players. In the World3 model, it is evident that not all variables and fluxes have an equal impact on the overall modelling. There are simply too many things to analyze. The number of variables that can be managed depends on the type of expert game being played, but it generally ranges up to few tens. Simplification is therefore necessary to keep the players flow [12, 13, 14].

Simplifying a model for a game can lead to a loss of accuracy and even potential falsity. However, these issues can be addressed through rigorous testing and analysis. The game developer should ensure that the game is consistent with the outputs of the model. At a minimum, the game developer should ensure that the learnings shared by the game are consistent with the model.

Consider the example of pollution modelling. Pollution can be characterized by several criteria such as permanence or absorbability rate. It can be localized or global, and can cause different types of damage. To account for these different aspects, the model includes several pollution variables, such as CO₂, nuclear waste, plastics, each with their corresponding characteristics. Therefore, pollution is not a single variable, but rather a set of variables that capture different dimensions.

The simplification process begins with the variable name, which is simplified to just "pollution". As the game does not have a map or location feature, the location criterion is removed. In the game, pollution is considered permanent, as it is easier for players to track an increasing level of pollution reaching a threshold rather than tracking the difference between

pollution generation and absorption reaching a threshold. This can be explained by the healing capabilities of the planet, where all pollution that can be absorbed is already absorbed, and only permanent pollution remains. Damage is only applied to land but not to population. As reducing land also reduces food production, it ultimately affects the population.

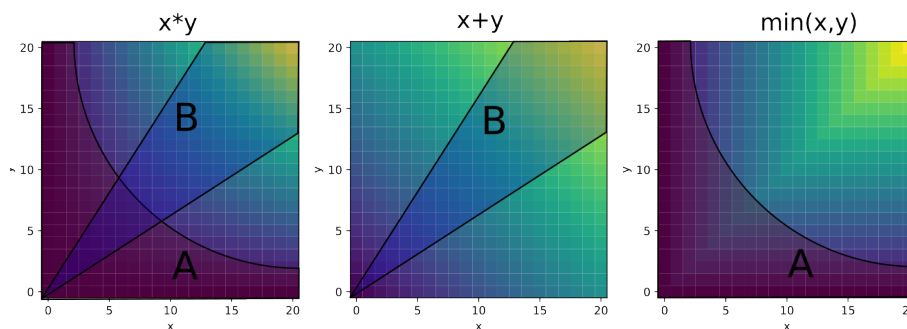
Continuing with the example of pollution, the model's accuracy would increase if pollution were accounted for during the production of goods and consumption, with a fraction being absorbed by territories. The land healing process that reduces pollution was already addressed by only considering permanent pollution. Additionally, accounting for pollution from consumption is not mandatory since goods must first be produced before they are consumed. Combining these two fluxes into a single flux simplifies the game mechanics with no loss of accuracy.

Another instance of significant simplification pertains to the economic system. Ideally, it would be characterized by the fluxes of various currencies with varying conversion rates and values, which can become unstable and result in inflation or deflation crises. However, in the game, there is only a fixed amount of a single global currency. This money can be directed to a player's supply, a tax haven, or to the central supply. When the global economy is emptied, it triggers a financial crisis, leading to players returning money to the global economy and causing a decrease in social stability. While this system may not accurately represent reality, attempting to incorporate a more realistic economic system would make the game overly complex. This simpler economic model tracks primary money fluxes, and the crisis threshold provides sufficient justification for the occurrence of an economic crisis.

4.2 Simplify the mathematics

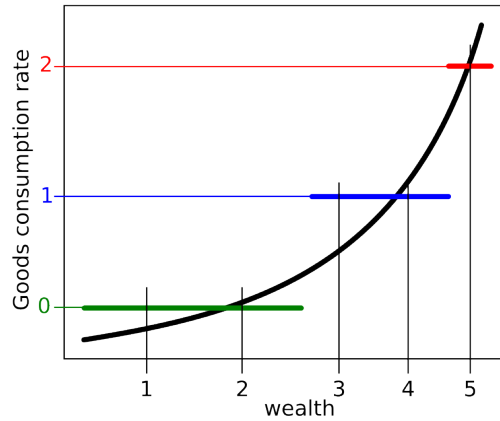
The game is not run by computers, but rather by humans. Typically, only simple mathematical operations such as addition, subtraction, and basic multiplication are used, allowing for linear mathematical relationships. Nonlinearities inherent to complex systems can be addressed by introducing successive thresholds; however, the number of thresholds should be kept to a minimum.

As an example, consider a model that requires the multiplication of two variables, x and y , but no one wants to perform tedious calculations. Instead, the multiplication can be approximated using addition or comparison. The figure below shows the value topology of $x * y$, $x + y$, and $\min(x, y)$. If the usual operations are located in the region A, the simplification of $\min(x, y)$ preserves the topology ($x * y = 0$ if either x or y are null). If the region of interest is B, the simplification of $x + y$ is preferable as it preserves the continuity of variations. In either case, the calculation is much simpler.

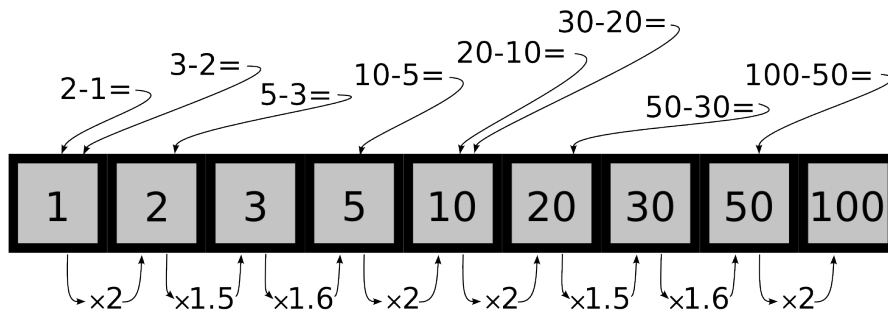


As a second example, we can use thresholds to describe non-linear relationships, such as the relationship between a population's wealth and its consumption of goods. One could envision that the curve shown in black in the next figure would continue to rise as the population's wealth increases. Although this relationship cannot be directly incorporated into a game without complicated calculations, it can be interpreted using certain thresholds (in this case, 3). Based on

their level of wealth, players can use from 3 different consumption rates, which roughly approximate the curve. This simplifies the calculation considerably, as each range of wealth values is associated with a constant consumption rate.



Another simplification used in the game is scale simplification. As values of variables can vary across several orders of magnitude over time and between players, using a long and precise scale involving heavy-to-calculate numbers, such as 176-37, can be cumbersome. Therefore, the game uses logarithmic scales to reduce the number of points on the scale, allowing for the desired precision at the current scale level. For example, one can ignore units when dealing with values in the hundreds. The second simplification involves the choice of the numbers that appears on the scale. Since the game is about costs, the primary operation is subtraction. Thus, the scale is designed so that the result of subtracting two successive numbers is also on the scale. This short series of numbers reduces the calculation required in the game. The drawback of such simplification is the irregular ratio between the points on the scale, which varies between 1.5 and 2. This can lead to some imprecision in the game, especially when dealing with very small values.



5 The role of the player

5.1 The player's choices

As mentioned in section 3, the World3 model utilizes simulations where the equations are solved numerically. The process involves calculating the fluxes of variables from an initial state, and then using these fluxes to derive a new state. By repeating this process, the temporal evolution of the variables is modeled, resulting in a scenario of the system. While this approach may be engaging for curious individuals or scientists, it does not offer the level of immersion that most players seek. This is because the only choice available to the player is the initial state, which does not provide the same level of engagement.

By introducing action cards that allow players to modify certain parameters of the simulation, the game provides a more immersive experience by giving players agency and control over the scenarios. This creates a sense of investment in the game with each player's current world situation. By allowing players to make decisions as rulers of countries, they can see the impact of their choices on the system and experience a range of emotions, such as hope, frustration, and satisfaction. The different possible outcomes of the simulations are crucial in eliciting positive, negative, or mixed emotions, which can facilitate a deeper understanding and appreciation of the modelling [15].

5.2 The multiplayer set-up

Normally, board games are designed for social interaction among players, providing opportunities for shared emotions and opposing viewpoints. The World3 model, however, was not initially intended to be played as a multiplayer game. Since it simulates a single planet, there can only be one player who assumes the role of the planet's ruler.

One solution that was considered was to have each player control their own parallel universe, with each player striving to create their best planet. However, this idea was rejected as it would eliminate any interaction between players throughout the course of the game, except for a final comparison. This would also lead to a low replay value, as once a player finds the best strategy, the game would lose its interest, like a solved puzzle.

Another option was to divide the system into multiple sub-systems, with each player managing one part. However, this approach was discarded due to the challenges of managing the number of players and the potential need for an artificial agent to replace any missing roles, reducing the entertainment [16]. Additionally, this approach would have made it difficult for players to understand the overall system, given the complexity of the links between the sub-systems. Players would have needed to play multiple games to fully grasp the system, and would have had to recall previous games to get the full picture.

A third solution involves dividing the planet into parts and assigning each player a region with established links between them. This solution avoids the issues of the previous two solutions as it allows for a lot of interactions among the players and puts the entire model in the hands of all the players. However, this solution poses a new problem: the need to integrate geopolitical fluxes that were not initially included in the model, such as warfare and market. To address this, cards are introduced to simulate aggression and aid between players. These choices are made to be as realistic as possible given the media and modelling constraints. While these direct interactions represent a reality, they also serve the purpose of evoking emotions to players, such as resentment, mercy, friendship, wrath, and so on.

6 Time in the game

6.1 Storytelling

The World3 model is based on three fundamental principles: inertia to change, erodible resources, and a desire for growth. These components are essential in order to mathematically simulate the possible scenarios that characterize our world, and are integrated into the core of the game. Erodible resources are finite and exhaustible quantities such as oil. The desire for growth is manifested in Phase 6, while the inertia to change is represented by the difficulty of modifying one's hand of cards, which represent the player's actions in the simulation. In the game, cards played are returned to the player's hand each turn. However, the player can only replace one or two cards per turn, and the hand size is limited. These three mechanisms ensure that the game progresses into a state of crisis, as the population grows and the player strives to sustain that growth in order to win (the winning conditions are explained later in the next section). However, since the resources needed to sustain this growth are finite, catastrophes inevitably occur.

To ensure that the crisis occurs at the appropriate moment during the game, it is necessary to adjust the variable's values. The game's narrative must be structured like a movie plot: the higher the player's development, the more severe his decline in the game and the stronger his emotional impact. The number of territories, the level of pollution prior to an ecological collapse, and the available quantity of oil are chosen to induce shortages during gameplay. The numbers may be determined through estimation, calculation, or trial-and-error testing.

6.2 The game rhythm

Once the narrative elements of the game story are appropriately settled, attention must be given to the game's pacing, as boredom can undermine the emotional experience. The player must be constantly engaged in the game, and this can be particularly challenging with five or six players, as gameplay can be very time-intensive. For instance, if each player takes one minute to play, the waiting time between turns would increase to five minutes, which is unacceptable, as it would make the game tedious.

To address this issue, the game difficulties are split into two different moments. The complexity of the model is incorporated into the phases where the player develops his situation (phases 0 and 2 to 8). During these phases, each player can manage their own board independently, with the only decision to make being the choice of the card in phase 0, which is kept secret. Phases 2 to 8 are scripted by the game and can be executed mechanically. These phases contain most of the desired effects in the modelling, such as demographic transition, tax evasion, industry capitalization, shortages, class conflict, conscription, and more. The second part of the complexity is the interaction between players, which happens with in phase 1 when the player plays the cards. The cards are intentionally kept simple to reduce waiting time between turns during this turn-based phase.

7 What victory for players?

A serious game and a commercial game do not evoke the same motivations in players. In a serious game, players are driven by an external motivation, such as a desire or a requirement to learn something, and the serious game is a tool to achieve this specific goal. In contrast, the motivation for playing a commercial game is intrinsic, i.e. the entertainment value of the game itself. The primary goal of a commercial game is to provide fun and engaging gameplay, and any incidental learning that occurs is a secondary consideration that may be intended by the designer, but not necessarily desired by the player [17].

When designing a commercial game, one of the most obvious source of fun is achieving victory, although it is not the only one. However, determining the winner can be a challenging task, particularly if one wants to avoid promoting specific point of view in a game like Limits to Growth. If victory points are awarded to specific variables, it can lead to the promotion of certain values, potentially resulting in proselytization. The effect of proselytizing in a game like Limits to growth is highly undesirable for several reasons. First, it can divide the potential customer population into those who are for and those who are against some of the potential game stance, which would limit its reach. Additionally, the very purpose of the game's modelling is to describe phenomena objectively, to extract understandings and learnings. Introducing bias through a proselytizing victory criteria would render the model untrustworthy, and its benchmarking with reality impossible.

The game's stance would differ depending on whether a reward for money, social peace, or army is prioritized. However, players generally expect a winner in strategy games, so victory points must be included even if the game aims for neutrality (with all cards being political actions and not judgments). The inspiration for the victory point system in Limits to Growth is derived from previous civilization games such as Civilization and Through the Ages. In Limits to Growth, I chose to use different variables to support the victory points, including education ,

territory size, social peace, money, and population. However, the choice of these variables is highly debatable.

An example of a question that arises is whether to include industry in the list of victory point variables and, if so, whether to incorporate pollution as well. It could be argued that the industry is already encompassed within the population and money variables, as industrial development is necessary for generating income and sustaining the population. Furthermore, rewarding industry and penalizing pollution simultaneously would be counterproductive as it would increase and reduce victory points at the same time. These two arguments make a strong case against including pollution and industry as variables for victory points.

However, the issue of victory points can also have a moral dimension. Should a player be rewarded for causing a major economic, military, or ecological crisis? On one hand, it seems counterintuitive to reward a player for creating a crisis that could harm the world. But on the other hand, if a player prepares for such a crisis and triggers it, is it not a clever and strategic move that deserves recognition?

Although the observations during the tests revealed that some players were ashamed of their victory and some losers were proud of their board situation, this does not justify removing the victory points altogether. It is important to consider that a significant portion of players are gamers, and as such, the presence of a winner is necessary to provide a satisfying experience.

In some of the game tests, I organized a post-game vote for the winner among the players, regardless of the score results. The preliminary results indicate that about half of the players voted based on moral considerations, while the other half based their vote on gaming criteria. Nevertheless, this voting process always initiated a discussion about the situation presented in the game, which is ultimately one of the primary objectives of the game.

8 Is this a serious game ?

The World3 model has been previously incorporated into a game called Stratagem, designed by D. Meadows in 1984, which is still in use today [17]. Stratagem allows players to modify the model parameters during the simulation. However, due to its variety in terms of player roles, technical parameter settings, and duration (lasting up to 12 hours), the game is challenging for a general audience.

The version proposed here has been designed to be commercially available through a game publisher (to be released in 2024/2025 by Ludonaute). The focus is primarily on the player's experience, or fun factor, rather than on learning the complex system, which becomes a corollary aspect. The approach taken in this game differs from that of serious games in several ways. First, there is no formal review session, but rather players are encouraged to discuss the game organically. Second, successive games by players are not systematically structured to aim for an exhaustive study, but players are expected to want to play it again to discover more. Third, there is no predetermined message or conclusion at the end of the game, but players are expected to interpret the model output which reveals the status of the planet under their governance. All those elements that make this commercial game a "game about serious stuff" are possible with a good gamedesign and honesty in the modelling.

Since this game is intended for commercial release, it may be difficult to obtain accurate feedback and assess its impact through surveys or game masters as in serious games. Additionally, players may misinterpret the output of the game. However, it is hoped that players will recognize the benefits of the game, including the entertainment it provides and the opportunity to explore and learn about the modelled system.















However, despite the limitations of measuring feedback and impact in a commercial release, I have faith in the potential benefits of the game for players. The engaging and entertaining gameplay, combined with the opportunity to explore and understand the modeled system, encourages players' curiosity and fosters a positive learning experience.

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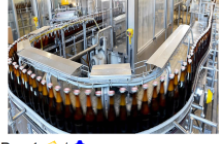

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Appendix 1: the cards of the game

















The card of the game are listed below. The blue cards represent political actions done for the population or ask to the population. They mostly cost/give money or social peace and change the rules of the phases 4 to 8.

<p>Production control ⏸</p>  <p>Lose 2 🪙.</p> <p>Skip phase 6 if 🗳️ is on column 3,4 or 5.</p>	<p>Education ⚡</p>  <p>Pay 1 🪙 / 🗳️</p> <p>Move up 2 🗳️.</p>	<p>Birth control ⏸</p>  <p>Lose 3 🪙.</p> <p>Skip phase 6 if 🗳️ is on column 1 or 2.</p>	<p>Corruption ⚡</p>  <p>Pay 10 🪙 to the 🗳️.</p> <p>Earn 1 🪙.</p>
<p>Public investment ⚡</p>  <p>Pay 1 🪙 / 🗳️</p> <p>Earn 1 point in 🪙.</p>	<p>High Education ⚡</p>  <p>Pay 2 🪙 / 🗳️</p> <p>Move up 4 🗳️.</p>	<p>Tax fraud fight ⏸</p>  <p>Pay 2 🪙 / 🗳️</p> <p>Protect from Tax evasion. Ignore phase 4. +1 🪙 / 🗳️ at phase 8 if 🗳️.</p>	<p>New Deal ⚡</p>  <p>Pay 2 🪙 / 🗳️</p> <p>Earn 3 points in 🪙.</p>
<p>Propaganda ⚡</p>  <p>Use 1 🗳️ / 🗳️ -2 🗳️. If 0, can't be played.</p> <p>Earn 2 points in 🪙.</p>	<p>Over consumption ⚡</p>  <p>Consume 1 🗳️ / 🗳️</p> <p>Earn 2 points in 🪙.</p>	<p>Overtax ⚡</p>  <p>Lose 1 🪙.</p> <p>Earn 2 🪙 / 🗳️</p>	<p>Vegetarianism ⏸</p>  <p>Lose 2 🪙.</p> <p>✔️ consumption is done with -1 🗳️.</p>
<p>Efficiency politics ⚡</p>  <p>Take back in hand one card ⚡</p>	<p>Soft consumption ⏸</p>  <p>Lose 2 🪙.</p> <p>✔️ consumption is done with -1 🗳️.</p>		

The brow cards implies actions towards industry and ecology. They will mainly change the rule of production, phase 3.

<p>Bio Industry ✓</p>  <p>Lose 1 🏠 and 1 🌿.</p> <hr/> <p>Spend 2 🌿 for 1 🏠.</p>	<p>Farming research ⚡</p>  <p>Pay 1 🏠 / 🌿</p> <hr/> <p>Gain 2 🌿 for 🌿 production.</p>	<p>Green Production ⌚</p>  <p>Lose 1 🏠.</p> <hr/> <p>Take 1 🌿 less at 🏠 production.</p>	<p>World Cleanup ✓</p>  <p>Paid 50 🏠. Several players can participate to the paiement All the players put back 1 🌿 token to the global supply.</p>
<p>War effort ✓</p>  <p>Lose 1 🏠 and 1 🌿.</p> <hr/> <p>Spend 2 🏠 for 1 🌿.</p>	<p>Tax haven ✓</p>  <p>Pay 10 🏠 to the 🏠.</p> <hr/> <p>Hide 🏠 under this card. It is not reachable anymore. It give you 1 🏠/30 🏠 at the end of the game.</p>	<p>Extraction ⚡</p>  <p>Take 1 🌿</p> <hr/> <p>Gain 2 🏠 from the game box.</p>	<p>Offshored work ⚡</p>  <p>Pay 1 🏠 / 🏠 to a target player.</p> <hr/> <p>Product 🏠 with the 🏠 of another player. Use your 🏠 but he keep the 🌿.</p>
<p>Recycling ⌚</p>  <p>Lose 1 🏠.</p> <hr/> <p>Gain 🏠 consumption rank (minus)3 in 🏠.</p>	<p>Military research ⚡</p>  <p>Pay 1 🏠 / 🌿</p> <hr/> <p>Gain 2 🌿 for 🌿 production.</p>	<p>Urbanisation ⚡</p>  <p>Consume 1 🏠 / 🌿</p> <hr/> <p>Move up 2 🌿.</p>	<p>Handcraft ⚡</p>  <p>Pay 1 🏠.</p> <hr/> <p>Gain 2 🌿 or 2 🏠 or 2 🌿 or 🌿 + 🏠.</p>
<p>Industry research ⚡</p>  <p>Pay 1 🏠 / 🌿</p> <hr/> <p>Gain 2 🌿 for 🏠 production.</p>	<p>Over production ⚡</p>  <p>Lose 1 🏠.</p> <hr/> <p>Make a production of 🏠 or 🌿.</p>	<p>Industry ⚡</p>  <p>Pay 1 🏠 / 🌿</p> <hr/> <p>Gain 1 🌿 of any production.</p>	<p>Space Craft ⚡</p>  <p>Pay 20 🏠.</p> <hr/> <p>Gain 1 🌿.</p>

The red card are used for the interaction between players. It includes the war, the market but also positive interactions.

<p>Market access ⚡</p>  <p>Get 1 🏠 access.</p> <p></p>	<p>Massive destruction ⚡</p>  <p>Use 10 🏠. Can be countered for 10 🏠.</p> <p>Give 3🏠 to target and destroy one of his 🏠</p> <p></p>	<p>Colonisation ⚡</p>  <p>Use 5 🏠.</p> <p>Gain 1 🏠 and 3 🏠 from free lands</p>	<p>Conscription ⚡</p>  <p>Lose 1 🏠.</p> <p>Gain 1 🏠/🏠</p>
<p>Humanitarian aid ⚡</p>  <p>Give 10 🏠 to another player.</p> <p>Gain 1 🏠.</p>	<p>Invasion ⚡</p>  <p>Use 20 🏠. Can be countered for 20 🏠.</p> <p>Gain 1 🏠 and 3 🏠 from an target.</p>	<p>Civil security ✓</p>  <p>Lose 1 🏠 and 1 🏠.</p> <p>Spend 2 🏠 for 1 🏠.</p>	<p>Stock market ✓</p>  <p>Pay 10 🏠 to the 🏠.</p> <p>Activate for 1 🏠 access.</p>
<p>Military defence ⌛</p>  <p>Lose 1 🏠</p> <p>The cost of military counter is reduce by 1 rank.</p>	<p>Raid ⚡</p>  <p>Use 5 🏠. Can be countered for 5 🏠.</p> <p>Take 2 🏠 or 5 🏠 and/or 🏠 at a player.</p>	<p>Negotiation ✓</p>  <p></p>	<p>Tax competition ⚡</p>  <p>Pay 2 🏠 to the 🏠. Players with Tax fraud fight are immune.</p> <p>Take as many 🏠 from a player as his highest 🏠.</p>
<p>Terrorism ⚡</p>  <p>Use 1 🏠. Can be countered for 10 🏠.</p> <p>Target lose 2 points in 🏠.</p>			

ISERA: An Innovative Simulation to Enhance the Resilience of Aircrew

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Abstract. In this paper we introduce a scenario-based simulation, Innovative Simulation to Enhance the Resilience of Aircrew [ISERA], to develop autonomous and resilient behaviors in, and enhance the responsiveness of the aircrew during emergent situations. ISERA presents various emergency scenarios to individual participants (pilots, cabin attendants, crew, etc.) using slides and tablet computers. The scenarios are all evolving situations, in which additional information and images are presented according to the roles of the participants. Our simulation is unique in that the participants are given the time to discuss possible solutions in more detail as a group, thus enhancing their emergency preparedness knowledge while emphasizing the importance of efficiently sharing information and communicating with colleagues. ISERA helps participants overcome the limitations of previous training by empowering personnel to better think on their feet. If they are trained with only conventional measures, these workers are required to wait for further instruction from a supervisor or dispatcher, on encountering a situation not covered by manuals; consequently, they tend to be reluctant to make decisions and have poor resilience when faced with unexpected events requiring rapid response. We tested ISERA with 45 aircrew personnel comprised of 36 cabin attendants and 9 pilots. Almost all the participants considered ISERA to be highly effective. In particular, they learned that autonomous and resilient behaviors that may not be covered by manuals during emergencies. Although some minor problems must be resolved, we conclude that the ISERA enhances the resilience of aircrew, and thus the safety of aviation.

Keywords: scenario-based simulation, resilience, safety training, emergency, aircrew

1 Introduction

In this study, we developed an innovative training method based on scenario simulations for airline crew; the method does not require a flight or cabin simulator.

Drills involving flight and cabin-evacuation simulators (hereinafter referred to as “simulator training”) are frequently used to promote flight safety. In addition to the regular training required by regulatory agencies, emergency drills are frequently conducted. For example, pilots and cabin attendants are trained for emergent scenarios presented by trainers using simulators.

Although airline crews are well trained, accidents nevertheless occur and crew members cannot prepare for all possible scenarios. Sophisticated training simulations are used but they involve a limited number of scenarios based on past accidents, albeit being well designed. In addition, crew members are mainly trained using mock simulators; they are busy in learning and following manuals and feedback and debriefing are provided by trainers.

In a time of uncertainty marked by social and environmental changes, resilient behaviors are crucial for professionals and the general public in the face of emergencies, such as natural disasters, plant accidents, and airplane incidents. In this paper, we introduce an aircrew training platform to enhance resilience in emergency situations. The platform is also applicable to other contexts, as described in the Discussion section.

People often respond to unexpected real-life situations in a creative and resilient manner. For example, after the crash of Garuda Indonesia Flight 865 at Fukuoka Airport in Japan in 1996, 257 of 260 passengers evacuated the aircraft before the plane burst into flames [1]. Most passengers could not understand the English instructions of the cabin crew, so a young passenger instructed the other passengers to stay calm and then told them how to exit the plane. Although this passenger was not trained in emergency evacuation of aircraft and did not fully understand the English instructions of the crew, he relayed the instructions to the other passengers in an autonomous manner. The passengers followed his lead and successfully evacuated the plane in a timely manner. This was an example of people's flexibility and resilience.

On 11 March 2011, an earthquake struck the Tohoku region and a subsequent tsunami caused severe damage across Eastern Japan. Haga [2] identified three characteristics common to all organizations that functioned well during this crisis. First, the workers of these organizations exhibited flexible thinking and the ability to act according to the circumstances. Second, local organizations and individuals acted autonomously and spontaneously, rather than in a top-down manner, and made their own decisions. Third, the frontline workers understood the organizational mission and acted accordingly. For instance, the crew of one train, which stopped on a hill, told their passengers to stay on board according to the advice of a passenger who lived nearby. The dispatcher instructed the crew to evacuate the train and guide the passengers downhill toward the shelter, as specified in the safety manual. The decision to stay on the train went against the dispatcher's instructions, but all passengers and crew members survived to be rescued the next day because of their noncompliance [2].

Haga et al. [3] interviewed 104 railway operators who encountered the earthquake and explored the general competencies required to successfully cope with natural disasters and other emergencies. These competencies were summarized as professional knowledge and skills, imagination, sensitivity to risk, decision-making ability, and the ability to act. The study demonstrated that operators should not only passively wait for reliable information, but also actively seek it out from various sources and make decisions accordingly.

The above examples of resilient behavior in the face of emergencies might be attributed to personal characteristics. However, as Boin et al. [4] pointed out, effective crisis management can be achieved by creating resilient organizations, rather than relying on any one person (e.g., a leader or hero) to appear in an emergency situation. Therefore, how to create resilient organizations is an important issue. If the individuals working for organizations are able to acquire resiliency and related skills, changes in the organizational climate should occur, thus leading to a more resilient organization over time. Simulation and gaming could be useful to this end. The above-mentioned railway operator, who showed resilience, also cited the importance of a new training program aiming to change the organizational culture by enhancing the resilience of its members.

1.1 Importance of Resilience

Modern society is characterized by volatility, uncertainty, complexity, and ambiguity, termed 'VUCA', due to technological innovation, climate change, and international and domestic conflicts. Resilience engineering was developed to enable socio-technical systems to be resilient under unforeseeable conditions. It was first established in the early 2000s by human-factor specialists, including Erik Hollnagel and David Woods [5]. Among a variety of definitions, Hollnagel [6] defined resilience as

“An expression of how people, alone or together, cope with everyday situations - large and small - by adjusting their performance to the conditions. An organization's performance is resilient if it can function as required under expected and unexpected conditions alike (changes/disturbances/opportunities).”

Hollnagel introduced the Safety-II concept [7]. In contrast to the traditional concept of safety, in which the risk is low and the number of accidents is small, Safety-II is defined as the situation

in which as much as possible goes well. Management pursuing Safety-II should ensure that things go right instead of avoiding things going wrong.

Training pertaining to resilience engineering and Safety-II has received increasing attention in multiple industries, including rail transportation, construction, and chemical engineering.

The conventional approach to safety training of personnel uses manuals and standard operating procedures, as implemented by management, to modify the behavior of personnel and prepare them in case of an emergency situation. Front-line operators are trained to follow the instructions of their supervisor or dispatcher in situations where manuals are not applicable. As a result, during unexpected events, these workers lose the ability and willingness to make decisions or act in a resilient manner.

Airplane crews should be able to act in a flexible manner in the event of an emergency, because it is not possible to train for all types of emergencies in advance. However, resilience is difficult to develop using current simulation techniques. Therefore, we developed a new simulation method to enhance the flexibility and resilience of aircrew personnel in the event of an emergent situation requiring a rapid response to save lives. The method was tested on the airline crew who had not previously undergone discussion-based emergency training.

1.2 Innovative Simulation to Enhance the Resilience of Aircrew

Tabletop-exercise-type aircraft simulations have been used previously for training. One sophisticated large-scale tabletop-exercise-type aircraft simulation was developed by Taylor [8]. Another example of emergency simulation developed by Song et al. focuses on passenger evacuation [9], whose theme is very common. Here we introduce the Innovative Simulation to Enhance the Resilience of Aircrew (ISERA). Our ISERA simulation model has several unique characteristics.

First, participants consider possible solutions to various problems; they are given adequate time to discuss creative solutions as a group and fully analyze the situation in an effort to offer the best response. This procedure enhances the ability of participants to identify unexpected events not covered by manuals. In real-time training simulations, even ones involving discussion, participants tend to act or make decisions in accordance with manuals or heuristic techniques due to time pressure. Traditional emergency simulator training involving mock-ups has the same weakness. However, with ISERA participants can take their time to think of better solutions, which ultimately promotes resilience in the face of an emergency.

Second, participants come to realize the importance of sharing information and communicating with colleagues. Our simulation offers an overview of an evolving emergency scenario to all participants, with the ability to provide individual crew members specific additional information according to their role as a crew member via tablet communication. In comparing ISERA to conventional simulation methods, ISERA can be performed by at least one group of five or six participants, whereas other emergency simulators/games require more participants. In ISERA, participants are able to discuss the situations among themselves. As a result, ISERA has a low cost, is easy to use, and is widely applicable.

Third, participants play roles that accord with their actual job responsibilities (pilots and cabin attendants), which increases the applicability of the simulation. According to the concept of the “cone of abstraction” [10], abstract simulations are unconvincing and perceived as unreal by participants. Conversely, if the simulation is highly similar to real life, as is the case for flight simulators and mock-up aircraft emergency training, participants may be overwhelmed by the complexity of the reality and thus fail to understand the key points. Therefore, we developed an intermediate-level simulation.

We developed two scenarios for ISERA. Here, we present the results of one of the scenarios below.

2 Methods

Participants. Two simulations were performed in October 2022 and February 2023. There were 45 participants, including 36 cabin attendants (3 males and 33 females, aged 20–50 years) and 9 pilots (all males, aged 30–60 years).

In the first simulation, 19 participants were divided into three groups: two groups comprised five cabin attendants and one pilot, and the remaining group comprised five cabin attendants and two pilots. In the second simulation, 26 participants were divided into four groups: one group comprised five cabin attendants and two pilots, another comprised six cabin attendants and one pilot, and the remaining two groups comprised five cabin attendants and one pilot.

Scenario. The scenario, which was the scenario was developed in reference to a real airplane accident by the fourth author (a pilot) and refined by the remaining authors.

Table 1 presents the schedule of the simulation. The simulation comprised two sessions with several sub-sessions. During the sub-sessions, a slide that described the situation was presented for almost 3 min, followed by several discussions related to the situation. Then, the participants discussed the scenarios for 15–20 min. In some sessions, the pilots joined the discussion 5 min after the cabin attendants, depending on the scenario.

Table 1. Simulation schedule

	Time
Briefing: Explanation of the significance of the simulation and the procedure	13:00–13:20
Session 1 (three sub-sessions)	13:20–14:20
Break	14:20–14:30
Session 2 (two sub-sessions and presentations)	14:30–15:30
Break	15:30–15:40
Debriefing: Scenario explanation and debriefing	15:40–16:50

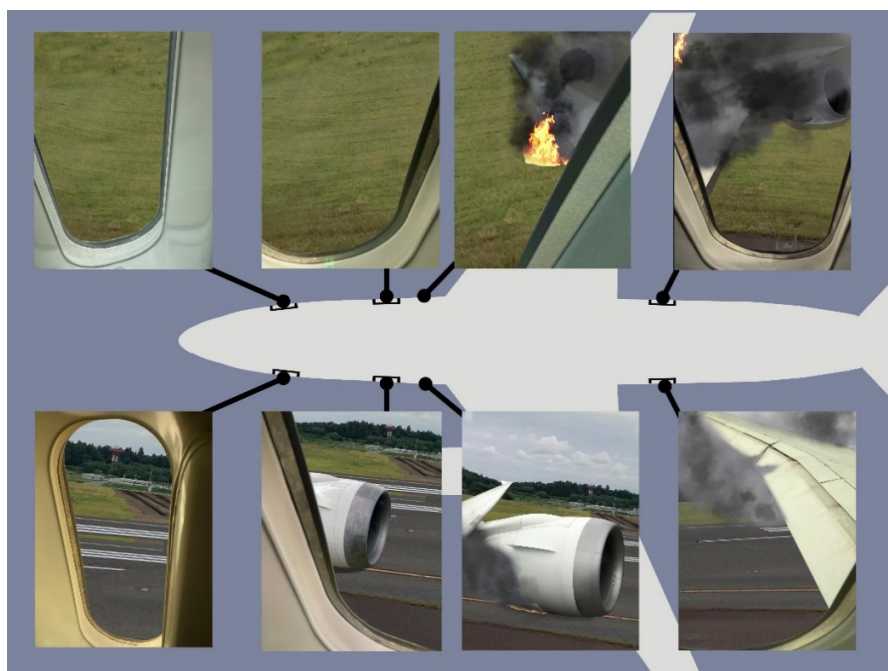


Fig. 1. Photos from the window

The main scenario was shown on the screen for a relatively short time and additional information and images were shown on tablets, according to the roles of the participants. For example, scenery visible from each window of the aircraft was sent to the tablets of the crew, who were responsible for a specific area (Fig. 1). Each crew member was sent only one of the eight photographs shown in Fig. 1. These photos are critical for assessing the situation appropriately and are thus shared among the participants. This is one of the major differences between ISERA and existing emergency training, i.e., situations are described to the trainees in a clearly understandable manner (e.g., via photographs).

During the simulation, cabin attendants were responsible for their allocated areas, similar to real life; however, due to the limited number of participants compared to actual cabin crew, there were no attendants in charge of the two rear doors of the cabin.

The first scenario was a failed “go-around” and runway crash resulting in severe damage to both engines and a fire requiring immediate evacuation.

In this scenario, the fire was not visible from the flight deck; it was visible only to the cabin attendant responsible for a certain area. The pilots would be aware of the fire only when the cabin attendant reported it and would then make a decision regarding evacuating the aircraft. Communication between the flight deck and cabin is necessary, albeit difficult, in the real world.

A crucial point in this scenario is that the cabin crew could see the fire only if the engine was observed from the window located near a particular seat. The cabin attendants had learned this in a simulator and lectures. Once the participants realized this, the group facilitator sent a photograph of the engine fire to the cabin attendant responsible for the area. Otherwise, the groups continued their discussion without this information.

In this type of scenario, cabin attendants are expected to prepare for prompt evacuation before the order to do so is given by the pilot, because even a slight delay could have serious consequences. In other words, the cabin attendants should make an autonomous decision about evacuation in situations where both engines are damaged. The sharing of information (i.e., photographs of scenery) with the flight deck is also crucial.

In this ISERA scenario, there are two key learning points for participants. First, communication between the pilots and cabin crew is crucial; information from cabin attendants is necessary for pilots to make a decision. Second, even if the pilot does not issue an evacuation order due to insufficient information and/or poor communication with the cabin crew, the crew should nonetheless assess the situation (fuel fire and severe damage to both engines) and make an autonomous decision regarding evacuation.

Procedure. In the ISERA simulation (Fig. 2), the main scenario was shown on the screen for a relatively short time (1–2 min). Tablets were used by group facilitators to provide crucial information to the participants, according to their role as part of the flight crew. The simulation comprised two sessions with several sub-sessions. During the sub-sessions, a slide that described the situation was presented for almost 3 min, followed by several discussions related to the situation. Then, the participants discussed the scenarios for 15–20 min as a group.

The first author facilitated the training, while the second and third authors monitored the simulation process. The fourth author (a pilot) explained the scenario during debriefing. The fifth author and other training staff, who are certified trainers for the airline company, facilitated the group sessions.

After debriefing, the participants wrote down what they had learned during the simulation and shared it with the other group members. They were then asked to complete an online questionnaire concerned with the efficacy of the ISERA training exercise.



Fig. 2. A photo during the discussion phase

Dependent variables. The online questionnaire used both quantitative rating scales and open questions. The rating scales were designed to evaluate three main outcomes of ISERA: evaluation of the simulation, self-evaluation of resilience after the simulation, and evaluation of the group discussion. The questions were answered on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Cabin attendants responded to additional questions similar to those asked after training with a real simulator aircraft and scenario training (i.e., conventional training exercises).

Through the open questions of the questionnaire, we collected qualitative data by asking the participants to provide comments about the simulation, given that our approach to emergency training, i.e., training without simulators, was new to the company and crew. This feedback from the crew was considered to be vital for further development of ISERA and frank comments were encouraged for optimizing the platform.

3 Results

3.1 Quantitative Evaluations of the Participants

Table 2 presents the results of the participant evaluations of the simulation. Participants expressed positive opinions about the simulation, which did not involve mock simulators or mandatory lectures by trainers. No differences in responses to the three evaluation items were observed between the participants in the first ($n = 19$) and second ($n = 26$) simulations.

Table 3 presents the responses of the participants to the evaluation of items related to resilience. Initially, the participants had low confidence in their ability to prepare for all unexpected scenarios, but they felt better prepared after the simulation. In addition, no differences were found in the responses between the participants in the first and second simulations.

Because group discussion during training was a new concept for the participants, we solicited their opinion regarding such discussion (Table 4). Although the participants were unfamiliar with training through discussion, the group discussions were not considered problematic and were not

dominated by certain members. No differences were found in the responses between the participants of the first and second simulations.

Table 2. Mean and standard deviation (SD) values of the responses to the simulation evaluation items

	<i>M</i>	<i>SD</i>
I enjoyed the simulation	4.09	1.13
The simulation was important	4.47	0.89
My knowledge about emergency responses was improved	4.56	0.87

Table 3. Mean and standard deviation (SD) values of the responses to the resilience evaluation items

	<i>M</i>	<i>SD</i>
Our emergency responses have improved	4.60	0.58
I feel more confident regarding unexpected situations	3.38	0.81
I feel better prepared for unexpected situations	4.11	0.75
We cannot be prepared for all unexpected situations	4.53	0.63

Table 4. Mean and standard deviation (SD) values of the responses to the group discussion evaluation items

	<i>M</i>	<i>SD</i>
All members were actively involved in the discussion	4.36	0.96
I was actively involved in the discussion	4.38	0.61
I was able to present my opinions to those in more senior positions	4.36	1.00
The discussion was dominated by some group members	2.80	1.16

We asked the cabin attendants to compare the simulator training to an aircraft mock-up and scenario simulation; few participant responses were recorded (Table 5). Although the participants were unfamiliar with this type of training, their opinions about it were generally positive. No differences were found in the responses between the first and second simulations.

Importantly, in the scenario described, although the engine fire might be visible through other windows, it can be seen most clearly through the window located next to the seat at the right side second door. This was noticed by only one of the seven groups in the two simulations. Therefore, the group facilitator sent a photograph (Fig. 3) to the tablet as soon as the view through the window of the relevant seat was referred to during the discussion.

Table 5. Mean and standard deviation (SD) values of the responses to the simulation evaluation items

	<i>M</i>	<i>SD</i>	<i>N</i>
This simulation was more enjoyable than simulator training	4.09	0.88	35
This simulation was more useful than simulator training	3.79	0.93	36
The simulation provided us with a deeper understanding of emergencies than simulator training	3.97	0.85	35
We could examine a greater number of situations than with simulator training	4.09	0.76	36
I am better prepared for emergency issues after this simulation than after simulator training	4.30	0.73	36



Fig. 3. A photo from a specific window

3.2 Qualitative Evaluations of the Participants

Given that the discussion-based simulation was a new experience for the participants, they did not have any preconceptions of this training format. As such, we encouraged them to provide frank opinions of ISERA. Some example comments are given below. Notably, we did not analyze their comments systematically, i.e., did not employ text analysis methods.

Eight of the forty-six participants explicitly referred to the difference between a real simulator aircraft and ISERA. As shown by the results in Table 5, they acknowledged the importance of ISERA, in addition to mandatory simulator training. The following comments are typical of the feedback received:

“My understanding was deepened by discussing the emergency scenario in detail and hearing other participants’ ideas. On the contrary, in simulator training, we have little time to discuss the situation.”

“Simulator training provides a sense of reality through smoke and alarms; in this sense, the ISERA simulation was not as realistic. However, scenario simulations have an advantage, in that they offer various scenarios that cannot be replicated by simulators. In my opinion, both types of training are necessary for emergencies, as they have unique advantages and complement each other.”

Eleven participants stated that they became aware of the importance of discussion during emergency training. In a real emergency, there is no time for discussion and an immediate decision will likely be required; therefore, thoroughly discussing the situation before it occurs could increase knowledge of alternatives that the crew could consider. The following comments refer to this point.

“Through discussion, we shared our thoughts and learned from other members of the group who had different perspectives and opinions.”

“Even though emergencies differ, the fundamentals of communicating with other crew members and dealing with the situation together are similar. Therefore, I will engage in training involving mental imagery by myself.”

The importance of communication, especially between the cabin crew and pilots, was emphasized by many participants. For example, one participant stated the following:

“It was a good opportunity for me because I could discuss possible solutions with senior crew members and pilots, which expanded my knowledge.”

In addition, we found that participants often referred to the transfer of knowledge obtained from ISERA to the real world; the following comment exemplifies this:

“Since the training was in the form of a tabletop exercise, we could actively exchange opinions, which was very helpful for me. In particular, knowledge about the mechanics of the aircraft and runways provided by the pilots will be useful in my daily work.”

Other comments related to areas of our platform requiring further development in future studies, as presented in the Discussion section.

4 Discussion

The responses of the participants in this study showed that the ISERA simulation training was successful. Because this is the first tabletop-based simulation for aircrews involving group discussion, we were apprehensive about possible negative reactions from the participants, as they would be unfamiliar with this discussion-based format and the simulations did not involve a mock-up aircraft. However, their opinions concerning the new training were generally positive (Table 2).

We expected that ISERA would increase the resilience of the participants during emergencies. Resilience engineering has proposed that the following four basic potentials, or abilities, are necessary: the potentials to respond, monitor, learn, and anticipate [6]. For resilience, these abilities are required at both the individual and organizational level.

Survival during emergencies requires an understanding of how to respond. During the training, the participants did not learn a single “correct” procedure but rather various alternative responses that they suggested themselves. This promotes more resilient behavior during an actual real emergency. The potential to monitor refers to the ability to remain alert and to notice immediately that something is wrong. This ability is based on the potential to anticipate. We instructed the ISERA participants to consider and discuss the current situation, how to prepare for it, and what might happen next. We expected that these exercises would enhance the potentials to monitor and anticipate. Finally, the potential to learn relates to the ability to learn from experiences. At the end of ISERA, the participants wrote down what they had learned during the simulation and shared it with the other group members. Practicing this skill promotes the potential to learn from daily events.

ISERA emphasizes discussion among the aircrew to determine potential solutions. The ability to exchange information, knowledge, and perspective highlights the sharp contrast between ISERA and other types of emergency training. As explained in the Methods section, ISERA includes various scenarios that are not covered by conventional training exercises. Experiencing simulated difficulties, and the need to share information and rapidly uncover potential solutions to an evolving emergent situation with limited information, enhances resilience in real situations.

As shown in Table 3, the participants reported an improved ability to respond to emergencies after ISERA, and felt better prepared for unexpected situations. The ratings indicated high agreement with the statement “We cannot be prepared for all unexpected situations”. Once aircrews realize that they cannot be prepared for all unexpected situations, they will be better able to cope with emergencies themselves rather than wait for directions. However, the ratings for the statement “I feel more confident regarding unexpected situations,” did not reflect increased confidence after ISERA training. In a traditional evacuation training using a mock-up cabin, cabin attendants learn what to do after an order has been given to evacuate, which may lead to overconfidence. However, in real life, there are infinite possibilities. ISERA exposes participants

to various situations beyond the scope of manuals. The realization that there are virtually infinite possibilities in emergency situations may decrease the confidence of participants. However, the confidence of participants regarding their ability to cope with unexpected events may be enhanced by repeated ISERA simulation training.

Cabin crews have a well-defined hierarchy. We considered the possibility that discussion might be dominated by a few participants (e.g., pilots or senior attendants) such that not all participants would be actively involved. However, Table 4 shows that the participants did not hesitate to present their opinions and individual participants did not dominate the discussion. Therefore, ISERA promotes lateral communication and autonomous actions during emergencies. In fact, in this scenario, there is scope for autonomous and resilient behavior, i.e., decision-making related to evacuation in the absence of a command from the captain. If applied to real life, the experience acquired through the simulation may improve resilience.

Table 5 shows that the participants responded more favorably to ISERA than to simulator training. Notably, the score for the item related to awareness of issues was higher than that for simulator training. While simulator training is indispensable for emergency training, introducing tabletop simulations with discussion components may be useful to enhance the resilience of crew members.

In summary, ISERA can help aircrew acquire the autonomous and resilient behaviors required in emergencies, but which are not necessarily covered by manuals.

This study had some limitations. First, we obtained only subjective ratings from the participants; future studies should collect data related to performance improvement, although this is difficult to measure in real emergencies, particularly in relation to resilience. Because performance changes cannot be measured directly, long-term evaluations are needed. Future studies could ask participants how the current simulation impacted their work, as improvements in resilience may not emerge in the short term. Second, the analysis of qualitative data should be refined. In this paper, we only provided some of the participants' comments, and we did not apply a systematic method of qualitative data collection and analysis. The participants seemed hesitant when answering the questions, perhaps because ISERA is an unfamiliar emergency training platform; therefore, we did not adopt the typical methods used for collecting data in academic research. Nevertheless, as mentioned in previous sections, the participants' comments contain information that could inform future studies. More adaptive quantitative and qualitative methods to determine learning outcomes are needed. Finally, and most importantly, the simulation should be further refined. A major advantage of ISERA is its low cost and that it does not require a large training facility or expensive equipment. However, at least one facilitator per group is necessary to transfer the required information to the tablets in a timely manner. Recruitment of a sufficient number of facilitators may be difficult if ISERA is conducted with a larger number of participants.

Despite the limitations of this study, the results suggest that ISERA may enhance the resilience of airline crews, and thus the safety of aviation. We are continuing to improve our simulation and plan to conduct further simulations and report our results in the near future. Although ISERA was originally developed for aircrew training, we believe that it could also be applied to aid the emergency responses to plant accidents and natural disasters, which also require rapid mitigation measures to save lives.

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SWOT analysis of eco-friendly video games using the objectives of sustainable development

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Abstract. Game developers are focusing more on sustainable development and its ideas. The SWOT analysis allows to analyze the “Strengths, Weaknesses, Opportunities, and Threats” that can be a tool to more thoroughly study eco-friendly video games and produce a better result. In this work SWOT analysis was applied to boost the status of eco-friendly video games in accordance with the broad sustainable development goals. Twenty existing video games were selected as case study, analyzing components such as sustainability content and the factors related to the creation of video games. The factors of the games were considered based on the study of available data such as economic parameters, satisfaction rates, and the impact of games on society's awareness. As a result, “logical procedures”, “reasonable help and support systems”, “increasing of both the environmental responsibility” and the “innovative concepts”, were investigated as strengths of the games. “Complexity in processes”, “lack of communication between gamers”, “lack of a system for collecting experiences” and “conducting research”, “more focus on education rather than entertainment”, and “commercial success”, are some examples for the weaknesses of the games in the field of environmental sustainability. Besides, opportunities to promote these games were obtained including aspects as: “urban designing and planning”, “economic and social development”, and “greater collaboration”. Finally, “uncertainty in the political sphere” and “becoming outdated or irrelevant as environmental issues”, were examined as threats for these video games.

Keywords: Video Games, SWOT Analysis, Sustainable Development, Eco-Friendly

1 Introduction

The video game industry has expanded significantly in the twenty-first century and has significantly influenced both economic and scientific fields [1]. It has integrated into daily schedules and has become a significant aspect of human life. The emergence and spread of this phenomenon in today's human world are currently rooted in the human need for leisure activities and the time that can be dedicated to them. Examining a challenging moment in human history, such as the global spread of the coronavirus and the subsequent quarantine and lockdown measures, offers an opportunity to better understand the fundamental human need for entertainment and the pivotal role of video games in modern society. In a quantitative way, studies have shown that video game sales increased by nearly 60% in less than ten days in March 2020, and global spending on video games exceeded \$150 billion in 2019 [2-4].

Video games became popular in the early 1970s and made a significant entrance into society in the early 1980s. Over time, issues such as when, where, and for whom it's appropriate to play, as well as the drawbacks of gaming, were investigated by theorists from various disciplines. Despite this, the question of what makes video games popular remains, including which games should be encouraged [5].

Interdisciplinary research on video games aims to support game designers in creating games that meet basic human needs while promoting health and well-being. They present both positive and negative aspects, and researchers across multiple fields identify four key risks associated

with gaming: injuries from violent content, mental health issues, addiction, and physical health problems such as obesity [4].

Games have been studied from a variety of angles to consider the objectives for social, educational, cultural, environmental, and sustainable development. Studies on the psychological effects of video games changed course and concentrated more on the type of emotion and behavior and how it affected the players' decisions and real-world interactions [6,7]. Green in 2017 addressed this category by concentrating more on action games in a study in the same field [8], stabilizing one of the foundations based on this theory, that is: how effective video games are in the personal lives of the players and in their future decisions; how to design games that can influence players' decisions; and how this knowledge can lead to awareness and even environmental awareness in this field. The latter idea was originally proposed by Schultz and Zelzely and has been expanded upon in subsequent studies [9]. One effective strategy is to utilize the concept that guilt can influence behavior and decisions and promote responsibility [10].

By taking into account the objectives and key performance indicators of sustainable development, we can design games that better protect the environment while also taking into account the player's guilt and responsibility. Mallet discovered that a player's decisions can be influenced by guilt over environmental damage by instilling a sense of responsibility for the future [11]. In turn, this will contribute to the long-term sustainability of the environment.

The number of games generated around "social and environmental transitions", "sustainable development", and "renewable energy" are increasing. Despite numerous endeavors and the usage of fundamental ideas and frameworks, the target group is still in its infancy [12]. Therefore, comprehensive studies are needed to consider the evolution of these games. Because content producers for these games (e.g., academics) and factors involved in the production of these games can identify the strengths and weaknesses, opportunities, and challenges ahead. As a result, they took a step forward to improve these games. Researchers have done comprehensive studies in the field of video games with themes such as sustainable development, renewables, the environment, etc. For example, Yesodharan et al. studied games related to natural security and their roles in the regenerative economy [13]. They found that a sufficient amount of improvement is needed to enhance games and thus increase innovative skills in understanding concepts such as sustainable development. However, these studies do not provide recommendations on how to achieve more and better productivity concerning these games with the specific concepts, and the existence of a research gap is also felt.

Various games with the purpose of entertainment, education, awareness, understanding of different processes, or with more purposes have been produced in recent years [14-16]. Many of these are about the main human concerns related to the environment and global warming, in which the content of sustainable development is focused. However, these types of games are growing and improving [17-19]. Despite numerous attempts, the use of fundamental ideas, frameworks, and the intended group are still in the development stage [12].

The purpose of this study is to analyze the current state of video games in relation to environmental sustainability, with the aim of providing insights that can inform future assessments and strategies for the development of sustainable gaming practices.

The primary motivation behind this study is to explore the role of educational components in environmentally-friendly games in promoting the development of sustainable systems. Through the utilization of the "Strengths, Weaknesses, Opportunities, and Threats" (SWOT) analysis, which is a commonly used methodology for management and planning, this study aims to improve the standards of environmentally-friendly game production and provide guidance for advancing sustainability considerations across the industry. Ultimately, the findings will serve as a valuable resource for enhancing sustainability practices in the gaming sector [20]. Consequently, gaining a more complete understanding of an issue is beneficial for both strategic planning and decision-making.

2 Methodology

SWOT analysis is one of the widely used management and planning methodologies and is taken into consideration to accomplish this goal. This approach enables managers and decision-makers to create a strategic plan and evaluate an organization's competitive position. The analysis is based on factual and data-driven information to identify an organization's strengths and weaknesses, while also assessing opportunities and threats in the external environment.

SWOT analysis helps enterprises understand all variables in decision-making. It was initially for business but also applicable to personal development, community health, and education. Its advantages are simplicity and adaptability to various levels of operation [21, 22].

At every stage of an effort, a SWOT analysis can provide insightful viewpoints. It might be used for: a) examine potential avenues for fresh initiatives or answers to issues; b) choose the best course of action for an endeavor; c) knowing possibilities for success in relation to dangers to success might help making more informed decisions; d) identify the areas where change is feasible; e) modify and improve plans while a new hazard might block an earlier route, a new opportunity might widen existing paths. Therefore, SWOT is a great tool for organizing data gathered from studies or surveys, as well as for communicating about ventures or programs [23, 24].

The methodology employed in this research has been delineated into four distinct stages, each of which will be elaborated upon in greater detail (Fig. 1).

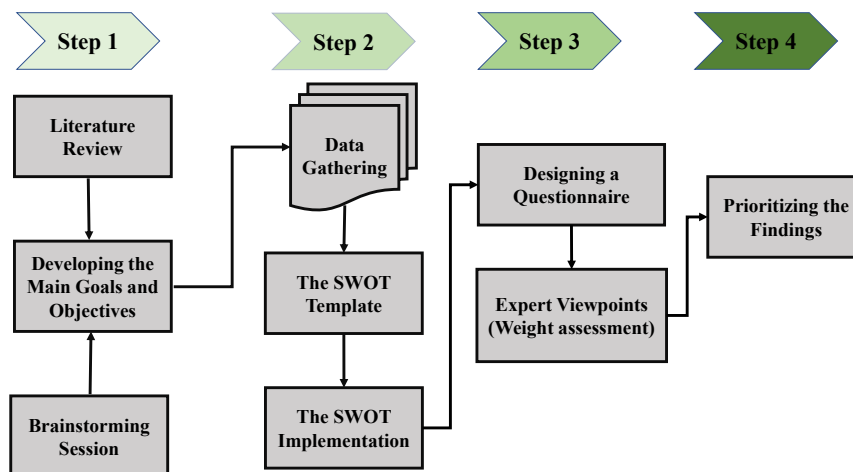


Fig. 1. Conceptual model

In this study, twenty games with an environmental theme based on the study conducted by the “chaos theory games” website [25] were selected as a case study for the SWOT analysis.

3 Development and partial results

3.1 Step one: literature review, brainstorming, and the goals

The step 1 including literature study, brainstorming meeting, and finding the main goals. In the literature study, conducting a comprehensive review of existing research and publications related to environmental themes and messaging in video games that involves gathering information on the latest trends, successful strategies, and best practices related to environmental impact.

Literature review

This method has been widely used in various sciences. For example, further investigation into the “Web of Science” (WOS) database yielded significant results. The results indicated that these

sectors such as environmental sciences (12.3%), management (10.8%), green sustainable science and technology (8.2%) have the highest number of studies (Fig. 2).

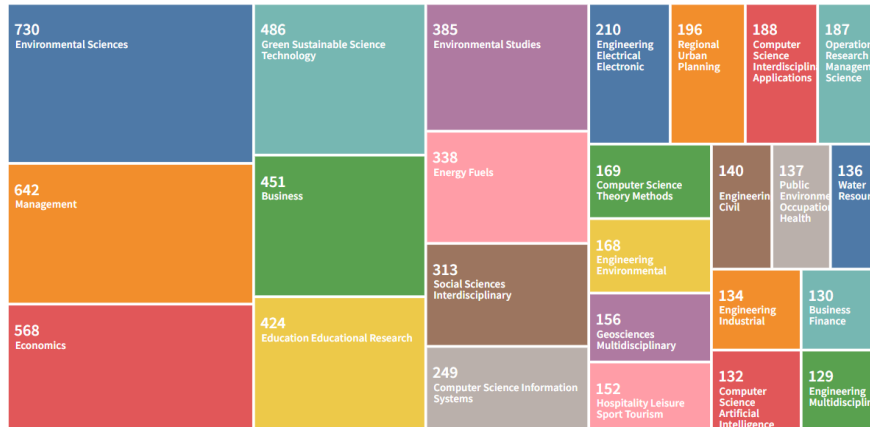


Fig. 2. Domains of knowledge that have used SWOT (source: *Web of Science*¹)

In the gaming literature, SWOT analysis has been mentioned in various cases. Menconi et al. has used the conceptual framework of SWOT analysis to develop a card game (playable face-to-face) and online in the form of learning citizens and their participation in the process of park renewal [26]. It used this method simultaneously for multiple and alternative participation to adapt to the different technical skills of citizens and their inclinations. Jiménez-Hernández et al. used SWOT to find out the critical elements for the serious games about the software developed to learn life cycle processes [27]. The analysis carried out made it possible to identify areas of improvement that could be used to support present and future serious games. Kavak et al. carried out the possibility of a game related to organic compounds to better understanding of chemical education for students [28]. In this case, SWOT analysis caused students the learning process is pleasant and valuable.

In game design and adding new concepts to the games, Tap et al. utilized a questionnaire survey, a SWOT analysis, and the validation of concepts in the game design document tool prototype [29]. Takeda et al. performed this analysis for the development of flight simulation in a game. The authors provided a SWOT analysis of the market for commodity flight simulation software [30]. To create a game with the theme of "Create Awareness and Design Policies for Transboundary Cooperation in River Basins," Douven et al. utilized this analysis to assess the effectiveness of the policies and frameworks as well as to identify potential modifications to the framework [31]. Aldea et al. suggested a serious game designed to teach players how to approach an organization's strategic planning process in a methodical manner. They studied various literatures on the application of different planning methods. The SWOT method was one of the most widely used methods whose concept was used in the game [32]. Kodalle et al. gamified strategic thinking on how to implement commercial off-the-shelf as a board game for learning scrum, strategy development, and strategy implementation, which SWOT analysis has completed as a management tool for developing and implementing strategies in a competitive environment marked by volatility, uncertainty, complexity, and ambiguity [33].

There are several literatures on SWOT analysis and sustainable development, but there isn't any literature that expressly analyzes video games for their environmental sustainability-related content. However, related results are not displayed when searching in databases like WOS and Scopus.

¹. <https://www-webofscience-com>.

Brainstorming and goals orientation

In the brainstorming meeting we came together to engage in a session focused on generating new ideas and insights for improving the environmental impact of video games, effective parameters, vital factors and favorable goals. Participants are encouraged to think creatively and challenge existing assumptions about what is possible in terms of environmental messaging and themes in video games (by focusing the issue that the United Nations has introduced various seventeen goals for sustainable development, known as SDGs). The information gathered from the literature study and brainstorming meeting to identify the main goals of the study. This involves defining the objectives and scope of the analysis, and clarifying any uncertainties or ambiguities related to the analysis.

3.2 Step two: data gathering, the SWOT template preparation, and the SWOT implementation

Step two involves three sub-steps: data gathering, the SWOT template preparation, and the SWOT implementation. The first sub-step, data gathering, involves considering factors to create video games and collecting all available data related to the twenty video games.

There are many factors to consider when creating a video game. In general, the factors influencing the design and development of a video game including the following [34-38]:

- a. Target audience: Who is the game designed for? Age, gender, interests, and other demographic factors will affect the game's content, design, and marketing.
- b. Genre: What type of game are you creating? Will it be an action game, puzzle game, role-playing game, or something else entirely? Each genre has its own unique requirements and design considerations.
- c. Platform: What platform will the game be released on? Different platforms have different technical limitations and requirements, and the game's design and development must take these into account.
- d. Storyline: What is the game's story, and how will it be told? The storyline will influence the game's art, music, dialogue, and gameplay mechanics.
- e. Graphics and sound: What visual and audio style will the game have? This includes the game's art, animation, music, and sound effects.
- f. Gameplay mechanics: How will players interact with the game? This includes the controls, the rules of the game, the level design, and the difficulty curve.
- g. Technical considerations: What programming languages and development tools will be used to create the game? What hardware requirements does the game have, and how will it be optimized for performance?
- h. Marketing and distribution: How will the game be promoted and distributed to players? This includes creating a website, social media marketing, creating trailers and demos, and working with publishers and distributors.
- i. Budget and timeline: How much money and time is available to create the game? This will affect the scope and complexity of the game's design and development.

Besides, information on the games includes: creator, publishing year, platform, satisfaction rate, whether the game is free or not, and the type of gameplay. This information can be obtained from various sources, such as the game's official website or reviews on different platforms where it is available (i.e., <https://play.google.com/>, <https://store.steampowered.com/>, <https://www.apple.com/app-store/>).

Table 1 provides the information pertaining to the games that were used in this study.

Table 1. Case studies and their information

Game (year)	Satisfaction rate	Free (f) or not (-)	Type of playing	Theme	Creator	Platform
Plasticity (2019)	80.3%	f	Single player	Waste Management and Recycling	University of Southern California (USC)	PC and Mac
Lumino City (2015)	87.1 %	-	Single player	Renewable Energy	State of Play and Noodlecake Studios	Android, iOS, Mac, PC
Beyond Blue (2020)	87.3%	-	Single player	Ecological Education	E-Line Media and BBC Studios	PC, Xbox One, PlayStation 4 & Apple Arcade
Get water (2013)	86% g	f	Single player	Water Management	Decode Global Studio	iOS and Android
Fate of the World (2011)	78.7%	-	Single player	Global Management	Red Redemption	PC and Mac
Save a Rhino (2014)	91%	f	Single player	Wildlife Conservation	Hello there and Perfect World Foundation	iOS and Android
GreenSpace (2011)	-	f	-	Waste Management	RocketOwl Inc. and WeForest.org	Web and iOS
Ice Flows (2016)	-	f	Single player	Climate Change	University of Exeter and InHouse Visuals	iOS, Android, Web
Working with Water (2020)	-	f	Single player	Water Management	Central Coast Council and Chaos Theory	Web
Save the Park (2016)	-	-	Single player	Environmental Education	Schell Games and National Park Service	iOS
FutureCoast (2014)	-	f	Individually or collaboratively	Climate Change and Climate Fiction	PoLAR Partnership at Columbia University & U.S. National Science Foundation	Web
Habitactics (2015)	-	-	Single player	Wildlife Education	Zachtronics and Touch Press Games	iOS
Never Alone (2014)	-	-	Single player	Cultural Awareness and Environmental Education	Upper One Games and E-Line Media	Android, PC, Mac, PS4, Xbox One, Wii U, PS3, iOS
World Rescue (2017)	-	f	Individually or collaboratively	Global Management	ZU Digital and UNESCO MGIEP	iOS and Android
Eco (2018)	82.2%	-	Individually or collaboratively	Conflict Resolution and Natural Resource Management	Strange Loop Games	PC
Bleached Az (2019)	-	f	Single player	Ocean Pollution and Climate Change	Chaos Theory and We Are Rad	iOS and Android
Niche (2016)	86.8%	-	Single player	Wildlife Education	Stray Fawn Studios	Nintendo Switch, PC, Mac
Morphy (2016)	90%	f	Single player	Wildlife Education	Smithsonian Science Education Center and Filament Games	iOS, Android and Web
Fort McMoney (2013)	-	-	Single player	Conflict Resolution	National Film Board of Canada	International Documentary Film Festival Amsterdam
WWF Free Rivers (2018)	91%	f	Single player	Ecological and Geographical Education	World Wildlife Fund	iOS and Android.

Then, second sub-step is SWOT template preparation. Once the data has been collected, the SWOT template was prepared. The template includes four sections: strengths, weaknesses, opportunities, and threats (Fig. 3).

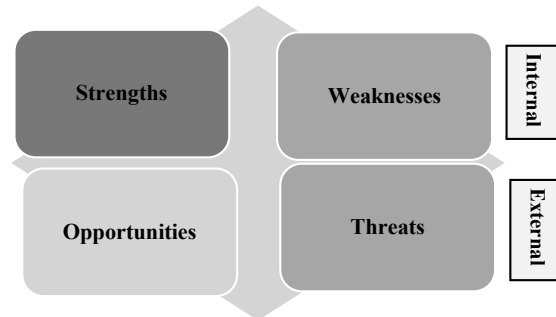


Fig. 3. The SWOT analysis template

3.3 Step three: questionnaire and expert viewpoints

The third sub-step is the SWOT implementation which involves using the SWOT template to conduct a comprehensive analysis. This process identifies areas where the game could be improved, as well as opportunities to enhance the environmental impact of the game. Finally, fourteen final elements were obtained as the SWOT matrix entries.

In the third step, we focused on obtaining expert viewpoints to further investigation into eco-friendly gaming. To achieve this, a questionnaire was designed, then a group of ten experts to provide us with their perspectives was selected. The group consisted of two gamers and eight investigators, who specialize in sustainability, economy, and renewable energy fields. The questionnaire consisted of fourteen different elements, divided into four sections: strengths, weaknesses, opportunities, and threats (SWOT matrix) which were obtained in step two. The questionnaire was designed to collect information on each element's relative importance, with each expert providing a weight ranging from one to ten (the most important by ten and the least one). The weights were used to quantify the importance of each element and allowed us to rank them accordingly. Finally, we calculated the final weights for each element using the arithmetic mean (see Fig. 4). This step was critical in helping us to identify the most important factors to consider when designing eco-friendly games. By soliciting expert viewpoints, we were able to gain a comprehensive understanding of the key strengths, weaknesses, opportunities, and threats associated with this emerging field. This approach enabled us to identify and prioritize the key factors that can influence the sustainability of the gaming, which is essential for developing effective strategies to promote sustainable gaming practices.

3.4 Step four: emphasizing Critical Results

In the fourth step, the SWOT model was prioritized based on the weights received from the expert viewpoints in step three. The final weights were used to rank the importance of each element in the SWOT matrix, with the most significant elements receiving the highest priority.

4 Results

This study used the SWOT analysis framework to evaluate the sustainability and renewable vision of the video games industry. By examining the context of sustainability, it gains a better understanding of how the eco-friendly games can be promoted and contribute to a greener future. The final results of the SWOT analysis were prioritized to identify the key sustainability-related issues facing the video games. These prioritized results are summarized in the Fig.4.

Strengths	Weaknesses
<ul style="list-style-type: none"> • Logical procedures • Reasonable help and support systems • Increasing the environmental responsibility • Innovative concepts 	<ul style="list-style-type: none"> • Complexity in processes • Lack of communication between gamers • Lack of a system for collecting experiences and conducting research • More focus on education rather than entertainment • May not be as commercially successful
Opportunities	Threats
<ul style="list-style-type: none"> • Urban designing and planning • Economic and Social development • Greater collaboration 	<ul style="list-style-type: none"> • Uncertainty in the political sphere • Becoming outdated or irrelevant as environmental issues

Fig. 4. SWOT analysis results

4.1 Strengths

One of the major strengths of the group is the use of logical procedures and innovative concepts in game development, which enhances the user experience. Collaborative efforts between game developers and sustainable video game researchers also serve as a strength by ensuring that environmental and social issues are highlighted in the game development process. Reasonable help and support systems also provide a positive user experience for players. Table 2 provides an example along with specific details highlighting the strengths.

Table 2. Components of strengths and their corresponding properties

Strengths (weight)	Comments	Applications	Example
Logical procedures (8.6)	Employing systematic and analytical methods, align game mechanics and elements Storylines, and other elements align with best practices and scientific principles	Identify and prioritize environmental issues Conduct research on sustainability and environmental science concepts Develop and test eco-friendly game mechanics and features Analyze player feedback and data to improve the game's sustainability impact	"Habitactics" demonstrates logical processes as a strength by integrating strategic decision-making, problem-solving, and an understanding of ecological interdependencies
Reasonable help and support systems (8.2)	Providing players with resources and guidance Understanding and engage with sustainability concepts Promoting learning and behavior change Navigating the game and achieve their goals	Tutorials that explain sustainability concepts and how they relate to the game Feedback systems that provide players about the environmental impact of the actions Adopting the sustainable behaviors, such as virtual rewards or incentives Social features to share information and collaborate	The game "World Rescue" excels in providing a reasonable help and support system that assists players in understanding and implementing eco-friendly practices
Increasing the environmental responsibility (8.1)	Can be considered as a strength for video game companies by providing advantages and offering benefits [39].	Regulatory compliance. Competitive advantage. Cost savings (reducing waste and minimizing the use of resources) [40]. Brand reputation (increases sales and profitability over the long term [41].	The game Beyond Blue by immersing in a compelling narrative, marine educating, conservation, and motivating to make sustainable choices.
Innovative concepts (7.2)	Can be considered a strength for video game companies by making a video game more engaging and immersive [42]	Increased engagement Differentiation	"Lumino City" by introducing a unique world that captivates players with visually striking and imaginative design.

4.2 Weaknesses

However, the complexity in processes and lack of communication between gamers are some of the weaknesses of the group. The focus on education rather than entertainment may limit the commercial success of some games, and some games may not be free to play. It is essential for game developers to address these weaknesses to provide better user experiences and to make the games more commercially successful (Table 3).

Table 3. Components of weaknesses and their corresponding properties

Weaknesses (weight)	Comments	Applications	Example
Complexity in processes (8.8)	Creating difficulties in the distribution of eco-friendly video games Affecting the development, production, and distribution of the game [43]	If the game is not compatible with certain devices, it may limit its reach, reducing its market share	The game's demanding technical requirements may limit its accessibility
Lack of communication between gamers (7.6)	Can lead to confusion, frustration, and ultimately, loss Can negatively impact the gaming experience and community [44]	Ability to share strategies Coordinating actions Creating a sense of community	The absence of clear communication channels within "Save the Park"
Lack of a system for collecting experiences and conducting research (7.1)	Can be challenging to gather data and information about the environmental impact of video games May limit the ability of game developers and stakeholders to identify opportunities	A systematic approach to research and data collection Some conferences to gather stakeholders and developers	The "Future Coast" makes it challenging for game developers and stakeholders to gather valuable insights
More focus on education rather than entertainment (6.9)	Many consumers play video games primarily for entertainment and may not be interested in educational content Educational content in video games may not always be effective or well-received Some educational games may be perceived as boring or tedious, which can also turn consumers away from the industry [45-47]	Shifting their focus away from education and towards entertainment	Some players may find the educational content to be intrusive or uninteresting
May not be as commercially successful (6.4)	Developing eco-friendly video games may be expensive and time-consuming, and the market for such games may be relatively small	Finding ways to balance environmental goals with consumer demand and commercial success [48]	May struggle to achieve significant commercial success compared to non-eco-friendly games (the game Fort McMoney)

4.1 Opportunities

The group's opportunities lie in the potential for partnerships and collaborations with environmental organizations and educational institutions, which could promote the educational value of the games. Urban designing and planning and economic and social development could also be integrated into game development to provide players with a comprehensive experience. Greater collaboration and finding educating game organizations could also increase the reach and impact of the games (Table 4).

Table 4. Components of opportunities and their corresponding properties

Opportunities (weight)	Comments	Applications	Example
Urban designing and planning (8.9)	Can create opportunities by offering collaboration opportunities and tapping into a growing market of environmentally conscious urban consumers	Promoting environmental awareness Encouraging sustainable behaviors Collaboration with urban planning experts	It allows players to create and design sustainable cities
Economic and Social development (8.7)	Eco-friendly video games offer the potential for economic growth and social development through promoting sustainable behaviors Raising awareness about environmental issues	Collaborating with environmental organizations Collaborating with educational institutions Contributing to the market for eco-friendly products and services	Game developers can collaborate with socially responsible organizations that can help increase the social impact and credibility of the game [49]
Greater collaboration (7.4)	It creates opportunities for partnerships and raises awareness through diverse stakeholder engagement Can increase game credibility and impact, as well as foster innovation in game development.	Collaborating with experts in sustainability and environmental science Bringing together diverse stakeholders to raise awareness and promote sustainable behaviors, creating opportunities for partnerships and collaborations Collaboration with other industries, such as renewable energy and clean technology, fostering cross-sector collaboration and creating new economic opportunities [50].	The ubisoft is committed to delivering positive gaming experiences for players around the world by collaboration with health experts and industry partners.

4.2 Threats

The threats identified for the group include uncertainty in the political sphere and the possibility of becoming outdated or irrelevant as environmental issues change. The focus on single-player video games or the lack of consideration of collaborative video game production may also pose a threat to the success of the games (Table 5).

Table 5. Components of threats and their corresponding properties

Threats (weight)	Comments	Applications	Example
Uncertainty in the political sphere (8.1)	Can reduce demand and funding for eco-friendly games, and the introduction of regulations that increase production costs and impact profitability and making them less attractive to investors [51]	Formulating long-term policies Defining the minimum budget threshold	Political uncertainty can disrupt the funding programs or alter the incentives, making it challenging for eco-friendly video game
Becoming outdated or irrelevant as environmental issues (7.2)	The outdated game's player base starts to decline, sales dwindle, and the game's relevance in the industry diminishes Governments around the world are introducing new regulations to address environmental issues, such as carbon emissions and waste reduction	Consumer preferences Government regulations Prevention the reputational damage	The lack of updates and failure to stay aligned with current environmental concerns lead to the game losing its competitive edge, reputation, and financial success

5 Conclusion

The SWOT analysis conducted for a group of video games related to environmental sustainability identified several strengths, weaknesses, opportunities, and threats associated with the games. In the analysis, three components were used, including the environmental sustainability of the games' contents, main factors in creating video games, and feedback factors.

The strengths identified include the use of “logical procedures”, “reasonable help and support systems”, “increasing the environmental responsibility” and “innovative concepts”. However, the analysis also identified several weaknesses, such as “the complexity of the game development process”, the “lack of communication between gamers”, “lack of a system for collecting experiences and conducting research”, “more focus on education rather than entertainment”, and “not being commercially successful”. Additionally, the potential threats to the games include “uncertainty in the political sphere” and “becoming outdated or irrelevant as environmental issues change”.

On the other hand, the opportunities identified for the games include the “urban designing and planning”, “economic and social development”, and “greater collaboration”.

The results of this analysis suggest that while the video games related to environmental sustainability have several strengths, there is also a need for an improvement in certain areas, such as simplifying the game development process, improving communication between gamers, and ensuring a balance between education and entertainment. Game developers should also consider the opportunities identified in this analysis to further enhance the user experience and address important social and environmental issues.

By addressing these factors, game developers can create sustainable, engaging, and commercially successful video games that promote awareness and action towards environmental sustainability.

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Developing Effective Gamification Tools for Career Education from the ESD Perspective

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Abstract. The research aimed to develop career education materials from an ESD (Education for Sustainable Development) perspective that include the environment, economy, and society, moving away from the economics-oriented career education of the past and improving the life career readiness of elementary school students.

The educational material created was “The Game of Life: Beyond SDGs”, developed with TOMY Co. TOMY Co has also developed various versions of "The Game of Life" for the Japanese market. The game has now established itself as a representative board game in Japan.

Recently, there has been an emphasis on thinking about one's career while being aware of one's connections with society and others. Career education from an ESD perspective is essential. However, most studies using the Career Readiness Scale have focused on university and high school students, and few have focused on elementary school students.

In this study, we used t-tests to analyze changes in life career readiness to verify the effectiveness of career materials developed for elementary school students. The results showed that the career educational materials developed in this study showed positive and significant differences in the independence items. On the other hand, it also revealed substantial negative differences for orientation, exploratory and aspirational. The importance of the workshop in this educational material was confirmed, mainly because the values decreased after the workshop.

Keywords: Career Readiness Scale, Gamification Tools, SDGs, ESD

1 Introduction

In Japan, the full-scale introduction of Sustainable Development Goals (SDGs) began nationwide at educational institutions due to revisions to the Courses of Study, which serve as educational guidelines established by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). Specifically, elementary schools began incorporating SDG classes in FY2020, junior high schools in FY2021, and high schools in FY2022.

However, two significant challenges exist in teaching the SDGs in educational institutions. The first is that the SDGs have a target year of 2030. If a 10-year-old fourth-grader learns about the SDGs, they will end by the time they reach adulthood. Therefore, children will learn about matters that do not directly affect their careers. Second, there needs to be more SDG educational materials for teachers in their classes. In Japan, teachers have not had the opportunity to receive training on SDG education. As a result, many teachers need help to learn how to conduct their classes.

In fact, as a result of our interview survey of teachers, we found that although various companies and organizations have produced educational materials on the SDGs, there are "not many reliable educational materials," "it is difficult to judge which educational materials are reliable," and "there are few educational materials that are easy to use.

In light of the above, this study developed educational materials and educational programs for career education and verified their effectiveness in resolving these two problems. Specifically, we developed gamification materials for sustainability with the target year of 2050 and a career

education program using these materials. In our gamification material, we created two components. The first is a serious game component for understanding a gamification method, and the second is a PBL component with a gamification method. In this research, we have focused on the first component. By introducing them into elementary school classes, we aimed to improve the life career readiness of elementary school students.

In the remaining parts of the paper, first, we provide an overview and characteristics of “The Game of Life: Beyond SDGs” developed as educational material. We also outline and features of the workshop to be held after the gameplay to utilize this educational material in career education. Although these materials and workshops can be used for a wide range of age groups, from elementary to high school, this study focuses on their effectiveness in career education for elementary school students. In addition, we will present a validation method to verify the effectiveness of these materials and workshops. We use the Career Readiness Scale (CRS) [1] for validation.

We present the verification results with approximately 80 fifth-grade students at Nonoichi Municipal Sugawara Elementary School in Nonoichi City, Ishikawa Prefecture. In addition, we analyze the results of comparing three surveys conducted before, during, and after using the questionnaires. Finally, we present the study’s results and show how educational materials and workshops developed in this study improved elementary school students’ life career readiness and how they did not. In addition, we present issues that need to be addressed in the future when deploying this educational material/workshop throughout Japan.

2 Method

2.1 Development of an SDG version of the Game of Life

The educational material created was “The Game of Life: Beyond SDGs”, developed with TOMY Co (Fig.1).

In this game, players spin the roulette wheel to advance through squares, aiming to become a millionaire through various life events, such as finding a job, getting married, having a child, and buying a house. In Japan, the game was released in September 1968, during rapid economic growth. The first “The Game of Life” was a direct translation of “The Game of Life” released by Hasbro in the U.S. in 1960. The third version, released in 1983, was a Japanese original and has always been marketed as a topical game, reflecting current trends. Consequently, it is a game with which many Japanese people are familiar. By developing educational materials for SDG education based on such a highly centripetal game, we aimed to lower the hurdle for educational institutions in introducing the game.

There are two reasons for using games as educational materials. First, the Kanazawa Institute of Technology, where the author is enrolled, was selected by the MEXT for the project to promote the development of SDGs Achievers from FY2019 and has owned the know-how of game educational materials and workshops that have been developed. Second, based on the experience of the abovementioned initiatives, it is qualitatively known that workshops using game materials are highly effective for learning and that children can learn while having fun.

“The Game of Life: Beyond SDGs” was officially launched in September 2022 and is distributed free of charge to elementary, middle, and high schools nationwide. As this study was conducted before that date, a beta version of “The Game of Life: Beyond SDGs” was used to validate the game’s effectiveness.

“The Game of Life: Beyond SDGs” was developed as a teaching tool to resolve two issues. The first issue is the SDGs, and their target year is 2030. The second issue is our world with the four sustainable societies; their target year is 2050. 2050 is also the board game’s goal. Players move their frames on the board's squares based on the number obtained by spinning the roulette wheel. The squares describe the expected events between 2021 and 2050 that help players achieve their expected goals.

“The Game of Life: Beyond SDGs” is divided into the first half from 2021 to 2030 and the second half from 2031 to 2050. The second half, from 2031 to 2050, will collect innovation cards depicting the skills and technologies required by society in the future to realize the four sustainable societies.

The four sustainable societies are a decarbonized society, a recycling-oriented society, a society in harmony with nature, and a society with good well-being. The World Health Organization (WHO) defines well-being as physical, mental, and social fulfillment.

The year 2030 is expected to be a turning point for humanity, as it is the year in which the SDGs will be achieved. As life is expected to change drastically depending on how well the SDGs are achieved, the second half is designed to vary in difficulty depending on the achievement status of the SDGs.

Therefore, the learning material was designed to provide an understanding of the transformation from 2021 to 2050 and the transition, which is the path to 2050.

Next, to resolve the issue of the lack of sufficient SDG educational materials that teachers can use in their classes, we developed “The Game of Life: Beyond SDGs” as educational material to enable students to learn correct knowledge about the SDGs.

Players collect the Kizuna cards in the first half of the game. The Japanese government has awarded the cards list organizations for their involvement and excellent work on the SDGs. Examples of awards are the Japan SDGs Award, SDGs Business Award, and SDGs Innovation Education Hub Schools of Excellence.

In addition, the innovation cards to be collected in the second half of the game are based on the book “The SDGs ‘17 Goals’ and ‘What You Can Do’ in Diagrams from 10 Years Old” [2] published by Kanazawa Institute of Technology, one of the Japan SDGs Award-winning organizations, as well as “The Tech Strategy to Seize the Future” [3], and the 11th Science and Technology Forecasting Survey S&T Foresight Synthesis Report [4]. The book describes the skills required for the SDGs and the technologies that can be used to realize a sustainable society based on reliable information.

The squares that describe events that are expected to occur from 2021 to 2050 were created using as reference material the “NRI Future Chronology 2022-2100” [5], published by Japan’s largest think tank. Thus, by developing gamification materials using reliable information sources, many teachers can confidently use them in their classes. In addition, teachers can use the contents of this material for research and study to deepen their students’ learning.



Fig. 1. Beyond SDGs Life Game

“The Game of Life: Beyond SDGs” has also been developed to incorporate the perspectives emphasized in ESD (Education for Sustainable Development). The National Institute for

Educational Policy Research [6] highlights the importance of “connections among educational materials,” “connections among people,” and “connections among abilities and attitudes” in promoting learning and instruction from the perspective of ESD and “The Game of Life: Beyond SDGs” was also developed with these three connections in mind.

First, regarding the connection between the materials, the goal is for students to become aware of the links to other subjects’ curricula, real life, and the real world. Playing “The Game of Life: Beyond SDGs” makes connecting the SDGs and other subjects easier because students think about things in the larger framework of life. In addition, as future events appear as masses, it is possible to be aware of the connection of time from the present to the future and to recognize the link to the real world.

Regarding human connections, the game aims to help players sense the importance of dialogue and communication, empathize with others in their activities, acquire the skills and attitudes necessary for these activities, and generate new ideas and actions. Unlike conventional life games, which emphasize competition among players, “The Game of Life: Beyond SDGs” is a cooperative game in which players work together to achieve their goals. As a result, the game is designed so players can naturally feel a sense of human connection while playing. In addition, this game aims to achieve goals by cooperating and advancing through the skillful use of characters’ special abilities. As special abilities can only be used by people other than oneself, players must work together as a team. In addition, stakeholders from all sectors, including national governments, corporations, local governments, and educational institutions, have participated in developing “The Game of Life: Beyond SDGs”. Therefore, this game is unique because it allows players to feel a sense of connection among themselves and stakeholders working toward the same goal as the SDGs.

Finally, the goal of “The Game of Life: Beyond SDGs” is to develop communication and decision-making skills in a fun way through games in addition to the SDGs and ESD. These abilities are essential in real life and the real world and indispensable for taking action.

2.2 Overview of Work Creation Workshops to Deepen Learning

To deepen learning, we also developed a workshop for participants of this game. In developing the workshop, efforts were made to prevent elementary school students from thinking about careers that were different from what they originally wanted as a result of needing to be more conscious of the knowledge of transformation and transition that they had learned in the game. Specifically, we developed job creation work that combined what the students would like to do with the SDGs to think about their future jobs. The concept is to enable people to lead prosperous lives on their own in the VUCA age. VUCA is an acronym for four key words, Volatility, Uncertainty, Complexity, and Ambiguity. It is essential to create your value to expand your life’s possibilities. We adopted a new combination of innovation creation methods to create new values. Specifically, this method involves multiplying elements by elements to develop ideas. These innovations encourage different careers to be devised by other people even when learning the same material. Many young Japanese people have a strong sense of horizontal alignment and are afraid to express their individuality. Therefore, the workshop was designed to emphasize allowing participants to express their individuality safely when considering their careers.

Precisely, the workshop consists of six steps. First, elementary school students think about the things/products they currently love and about occupations related to those things/products. Next, by thinking about the use of future technologies and resources in the community to help realize a sustainable society, which they learned in “The Game of Life: Beyond SDGs”, they will increase their ability to perform and develop an image of their occupation. Furthermore, they will consider the problems that must be solved in their community and what the residents want to realize in a sustainable society. By doing so, they can think about the value their occupation will create in society and devise a detailed image of their occupation (Table 1).

Table 1. Summary of Job Creation Workshops

Step	Summary
Favorite thing/things	Think about the things/things you like. Select future technology from the bond card with reference to your favorite thing/things.
Future technology	Choose Nonoichi resources based on the things/things you like.
Local resources	Combine titles and come up with a job name.
Job name by title	Understanding needs through quizzes
Needs quiz	Come up with ideas to solve Nonoichi's problems using the characteristics of the
Solving local problems	Work you have considered.

2.3 Verification flow

In all, three surveys were conducted. All subjects were the same students.

Pre-questionnaire: A pre-questionnaire was conducted to understand the current situation. Interim questionnaire: One week after the pre-survey, the students played “The Game of Life: Beyond SDGs”; one month after playing “The Game of Life: Beyond SDGs”, the students completed the interim questionnaire. Post-workshop questionnaire: 3 months after the interim questionnaire. Questionnaire: The questionnaire was administered immediately after the workshop.

2.4 Subject

The program was conducted with approximately 80 fifth-grade students at Nonoichi Municipal Sugawara Elementary School in Nonoichi City, Ishikawa Prefecture (Fig.2).

2.5 Scale to be used

The scale used to measure career readiness is the Career Readiness Scale (CRS) [1].

Readiness refers to a state of readiness for learning, in other words, an attitude of readiness to tackle one’s profession and life. There are two types of career readiness: life and occupational.



Fig. 2. Workshop at Sugawara Elementary

As the ESD perspective encompasses all environmental, economic, and social/cultural perspectives, this study adopts life career readiness, which can easily capture the above three perspectives with equal weight, rather than occupational career readiness, which is strongly related to the economic perspective.

One study used the CRS to measure changes in career readiness from the first to the third year of college for each desired occupational choice at the beginning of the program [7]. Another study measured how college students’ occupational career readiness changed before and after

attending lectures given by working adults [8]. The former found that career readiness improves as the school year progresses, while the latter found that attending classes by working adults improves occupational career readiness planning.

As previous research surveys have yet to examine life career readiness among elementary school students, this study will only identify changes in life career readiness by providing a comparison group.

The CRS assesses broad aspects such as life and outlook on life, which has become more critical over time. It also has a vital ESD component. The following three attitudinal characteristics were identified for career readiness. (1) “Interest” refers to whether one has an active interest in their career. (2) “Autonomy” refers to whether one’s attitude toward their career is autonomous. (3) “Planning” refers to whether the candidate has a future vision and plans for their career.

In addition, each item has three subscales with its questions. Each item is rated on a 5-point scale (5 = applies well, 4 = applies somewhat, 3 = undecided, 2 = does not apply well, and 1 = does not apply at all), with scores ranging from 5 to 1 (1 to 5 for reversed items) to produce a total score for each area of career readiness (subscale) [1]. The questionnaire items were also rephrased to more straightforward wording so that the elementary school students could easily understand them. Table 2 presents the characteristics and subscales of the CRS.

Table 2. Items on the Career Readiness Scale

Upper scale (3 attitudinal characteristics)	Subscale
interest	Intentionality
	Exploratory
	Integrity
Autonomy (Philosophy)	Independence
	Responsibility
	Improvement
	Visibility
Planning	Target quality
	Realistic

2.6 Analysis Method

The analysis method employed was a t-test. Pre-, mid-, and post-questionnaire responses were analyzed using t-tests to examine changes in career readiness.

3 Results

3.1 Preliminary survey

A pre-survey was conducted before implementing the developed career materials. The total number of responses received was 80. The pre-survey shows that the top items enhanced autonomy, responsibility, and interest orientation, and the lower-ranking items were prospective planning, realism, and exploratory interest.

We believe that high autonomy, interest, and low planning indicate a disconnection between reality and the future due to a strong interest in one’s career but unclear planning. This suggests that introducing educational materials incorporating the concepts of transformation and transition into the classroom may be a practical approach to bridging this gap.

3.2 Interim survey survey

An interim survey was conducted about one month after completing “The Game of Life: Beyond SDGs”. The total number of responses was 81. The interim survey showed that autonomy-enhancing nature, responsibility, and initiative were the top items. The lower-ranking items included prospective planning, exploratory interest, and realistic planning. Autonomy increased after playing “The Game of Life: Beyond SDGs”. We believe that this is because of the use of game materials.

3.3 Post-intervention survey

After conducting the job creation task, a post-intervention questionnaire was administered, and the total number of respondents was 75. The post-questionnaire showed that the top items enhanced autonomy, responsibility, and initiative, with autonomy occupying the first three positions. The lower-ranking items were the exploratory nature of interest, the prospective nature of planning, and the integral nature of interest.

Although the survey was conducted approximately three months after the interim survey, no significant decrease in the numerical values existed, suggesting that the effects of the survey were maintained. As a result of interviews with teachers in charge of the class, it was found that some students displayed a change in the awareness of their careers, such as thinking about their future.

3.4 t-tests for pre- and mid-term survey responses

The results of the prior and interim t-tests are presented in Table 3.

Table 3. Comparison of Pre- and Interim Survey Responses

	PRE.	middle	<i>p</i>
Initiative (1)	3.68	3.26	0.0108
Initiative (2)	2.73	3.21	0.0039
Improvement (3)	3.44	3.93	0.0062

Table 3 shows significant differences in autonomy independence items. Autonomy (1) had a significant negative difference, whereas autonomy (2) and (3) had a significant positive difference.

The question for “Initiative (1)” was, “You can make your way in life from now on.” “The higher the score on this item, the more possible it may be that the respondents will become capable of making their way in life.” The reason for the negative and significant difference in the “Proactivity (1)” item is that “The Game of Life: Beyond SDGs” is a cooperative game material. We believe the game’s collaborative nature may have reduced the students’ awareness of the need to think independently.

The question asked in Initiative (2) was, “You can start thinking about how to spend your life when others think about it.” This is a reversal item; a score of 5 points is given if the respondent answers a rating of 1. In other words, the lower the number, the more proactively one thinks about life independently before others do. We believe that the positive and significant difference in proactivity (2) is because the participants discussed their ideas about their ideal future after inputting information about the future in “The Game of Life: Beyond SDGs”, which made the future more familiar to them. They began to think about life on their own.

The question for “Initiative (3)” was, “I will decide how to spend the rest of my life according to the atmosphere around me.” This is also a reversal item similar to Initiative (2). In other words, the fewer the responses, the more independent one must be in making decisions for oneself, regardless of others. The reason for the positive and significant difference in

Proactiveness (3) is the same as that for Proactiveness (2). It is considered to be that the participants discussed their ideas about their ideal future after inputting information about the future in “The Game of Life: Beyond SDGs”, which made the future more familiar to them and encouraged them to think about their own lives.

An interim questionnaire was administered after implementing “The Game of Life: Beyond SDGs” revealed an impact on the autonomy of life career readiness.

3.5 t-tests for pre- and post-questionnaires

A post-intervention questionnaire was administered after the job creation task. The results of the pre-and post-test t-tests are shown in Table 4.

Table 4. Comparison of Pre- and Post-test Responses

	PRE.	POST.	<i>p</i>
Orientation (2)	3.04	2.59	0.0106
Exploratory (3)	3.68	2.88	0.0007
Initiative (2)	2.73	3.33	0.0008
Improvement (1)	3.80	3.40	0.0074

Table 4 shows a significant difference in autonomy independence (2). We consider that the reason for the critical difference is the same as in the interim questionnaire. Furthermore, as no significant decrease in values was present, it is clear that the effect is maintained.

Although there were no significant differences in subjectivity (1) and (3) seen in the interim questionnaire, it is relatively easy to establish the subjectivity of autonomy within life career readiness in career education from an ESD perspective.

In contrast, significant negative differences were found in the items of orientation (2) for interest and exploration (3) for interest and improvement (1) for autonomy.

Orientation (2) is, “I often read through articles about life planning and how to live.” However, this remains a question. We believe the decrease in the numerical value is that, by playing “The Game of Life: Beyond SDGs”, the respondents realized that more things were related to their careers than they had assumed before playing the game. We believe this led them to recognize that they had not collected sufficient information about their careers.

The exploratory item (3) states, “I try to listen to the stories that will be helpful to me in fulfilling my future life.” However, this remains a question item. We believe that this item is a question item, like orientation (2), because by playing “The Game of Life: Beyond SDGs”, the participants realized that more stories are related to their careers than they had expected before playing the game. As a result, we believe that the participants realized that there were some topics they had not heard much about before, even though they were related to their lives.

The aspirational item (1) states, “I try to improve myself daily so that I can lead the life I want.” This item asked whether the respondent was trying to improve their ability to achieve the career they wanted to pursue or the life they wanted to lead. This item asked whether they were improving their ability to perform the career they wanted to follow and the life they wanted to show. We believe that the drop in this item is because the work was based on the things they liked, and the work was about converting one's favorite things/tasks into a job. It was not found on ability, which may have prevented the participants from becoming aware of the need to improve their capabilities in the future.

4 Consideration

Immediately after implementing “The Game of Life: Beyond SDGs”, a significant positive difference was shown in the subjectivity of autonomy in life career readiness. In particular, a

significant positive difference was found in the item of subjectivity (2), " You can start thinking about how to spend your life when others think about it." This item was also found to have a significant positive difference in the "I should think about what to do with my life when others think about it. This item was about the proactive nature of thinking about life on one's own before others do. The fact that the values decreased after the workshop in terms of interest orientation, exploratory interest, and autonomy confirms the importance of the workshop and the need for improvement in the use of this educational material.

Specific results can be summarized in the following three categories.

- 1) Using this material positively affects the autonomy of life career readiness because it makes learning fun.
- 2) By deepening your understanding of transformations and transitions, you will learn that many things in society will affect your career. However, by broadening their perspectives, they will realize they need to collect more relevant information. Therefore, it negatively affects the orientation and exploratory nature of life–career readiness.
- 3) In this material, you can think based on what you like and work on creating an ideal image. However, it does not lead to an understanding of the abilities that one should acquire to realize an ideal vision. As a result, it hurts the improvement potential of life career readiness.

5 Summary

This study aimed to improve career readiness by implementing career education from an ESD perspective, which includes the environment, economy, and society/culture, and away from the economics-oriented career education of the past.

“The Game of Life: Beyond SDGs” and Job Creation Work were developed and implemented as career materials from the ESD perspective to achieve these objectives. In the developed career materials, “The Game of Life: Beyond SDGs” allows students to learn about future events related to a sustainable society so that they can input not only the economy but also the environment, society, and culture. Furthermore, career education from an ESD perspective can be implemented in job creation workshops to create jobs that solve social issues in the environment, society, and culture. This career education material was implemented for fifth-grade students at Sugawara Elementary School.

Since studies have yet to examine life career readiness in elementary school students as far as prior research studies are concerned, this study will only look at the improvement in life career readiness without comparing.

In conclusion, the developed career materials were confirmed to have a positive impact on the proactive item of life career readiness. On the other hand, it was confirmed that there was a negative impact on intentionality, exploratory, and improvement. Since this study was conducted only once, we would like to conduct further research using the results obtained this time as a hypothesis.

In addition, two significant issues remain in the developed career educational materials. The first issue is to improve the career materials workshops. Since the workshop results revealed the work's importance, we will enhance the work to compensate for the adverse effects and improve the quality of career materials. As a specific future measure, during the workshop, participants will have the opportunity to learn methods for collecting information on events related to their careers in the transition from 2021 to 2050 and methods for organizing the collected information and determining their awareness of their career construction. In the process of gathering such information, participants will also have the opportunity to organize the skills they need to acquire to realize the ideal image they have drawn based on the things they like. Finally, they will have the opportunity to think about their first actions to improve their skills and declare them to their friends.

The second challenge was to create a mechanism to promote behavioral change. Although ESD's ultimate goal is behavioral change, this study's scope was to change attitudes. As the survey responses were anonymous, it was impossible to determine how individual characteristics' differences affected career readiness. In the future, we will conduct a responsive analysis and follow-up survey of the results for each individual to determine which individuals are more aware of their career readiness and then disseminate the results as role models. By doing so, we can provide opportunities for vicarious experiences and create an environment that people can emulate. We can create a mechanism that will encourage behavioral change.

"The Game of Life: Beyond SDGs", distributed free of charge to elementary, junior high, and high schools nationwide since September 2022, has already been widely disseminated. Educational institutions in all prefectures in Japan are using it. In addition, more than 250 teachers participated in a community to think together about classes utilizing this material. Having these teachers conduct improved workshops based on the results of this study, we would like more students to understand the paths necessary for realizing a sustainable society. We further hope that they can create satisfactory career paths.

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Appendix

Career Readiness Scale (CRS) developed by Sakayanagi

interest	intentionality	He is very concerned about his future life and how he will live it.
		I often read through articles about life planning and how to live.
		I don't care much about life planning or how to live.
	exploratory	I have looked into how to live the life I want.
		I have read in books, newspapers, etc., what kind of life and way of living there is.
		I try to listen to the stories that will be helpful to me in fulfilling my future life.
	integrity	I have thought seriously about what kind of life is right for me.
		I have never seriously thought about what I am going to live for.
		I take my future life seriously because it is an important issue.
autonomy (philosophy)	independence	You can make your way in life from now on.
		You can start thinking about how to spend your life when others think about it.
		I will decide how to spend the rest of my life according to the atmosphere around me.
	responsibility	You are ultimately responsible for deciding what kind of life you should lead.
		From now on, I will live my life being aware of my responsibilities.
		I don't want to be responsible for a while yet.
	improvement	I try to improve myself daily so that I can lead the life I want.
		Even if I run into difficulties in my future life, I will overcome them in my way.
		To fulfill life, we actively take on challenges, even troublesome ones.
planning	visibility	They are making concrete plans to live the life they desire.
		I don't know what kind of life I will have in the future.
		I can roughly imagine what my future life will be like.
	target quality	I still don't know what kind of life I want to live.
		I have my own goals for what kind of person I want to be in the future.
		The way of life you hope to live in the future may change again soon.
	realistic	There are things we are already working on that are in line with our plan for a fulfilling life.
		I am fully considering my future life plan, both in terms of my personality and my social situation.
		I think I can achieve the life and way of life I hope to live next time in my own way.

Learning about port planning in a complex environment: a study to the use of Port Constructor 2.0

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Abstract. The environment in which port professionals make decisions have become increasingly complex due to advancements in technology, more intense rivalry among ports and increasingly urgent demands from governments and civil rights groups to re-establish the balance of the ecosystem. Advanced understanding of port and city or region – its functioning and increased collaboration among stakeholders - holds important potential for bringing together diverse stakeholders in the much-needed transition of port city regions in the field of energy, digitization, or socio-cultural development. In most port regions, port development companies (PDCs) are taking a leading role in port planning and development. In recent years, PDCs are taking initiatives to develop games, often with local stakeholders, schools, and universities to educate children and citizens or to help professionals to get a better understanding of the long-term effects of their decision making. The focus of port games is shifting to include strategies which aim to tackle global issues. Furthermore, more recent simulation games are centered around collaboration rather than competition. Reaching shared objectives and developing a shared set of values seem to be the new goal. Evaluation of simulation games specifically used as an educational tool in a multi-problem, multi-stakeholder context, have not been done so far. Using a dataset of 137 respondents, the added value of our study is to assess how different ways of embedding games 1) impact the knowledge development, and 2) influence motivation, activation, and engagement.

Keywords: Gaming, Port, Transition, Simulation, Learning, Sustainability, Social dilemma

1 Introduction

Many ports in the world are pivots of social dilemmas: protecting the coast versus port expansion, building attractive urban housing versus air pollution from port activities, jobs versus automation, investing in fossil energy versus renewable energy, logistics efficiency versus strict border control. In a mature port cluster, conflicting interests are usually accommodated by a settlement of differences, which is the outcome of a negotiation process. This approach suggests that the quality of cluster performance is a product of a zero-sum game - the gain for one goes at the expense of the other - or even a negative-sum game when parties cannot come to agreement at all. The biggest challenge of the 21st century is the development and implementation of methods that at the same time strengthen the economy and improve the environment, while making optimum use of the available space for port activities [1].

Whereas on a societal level we understand that the current fossil-based society is devastating for the livability on earth, especially in coastal regions due to sea level rise, it is extremely difficult for individual companies to move away from unsustainable business practices. Reducing CO₂ footprint often means giving up profitability of successful business models. This is what port planners and developers are facing in the process of allocating space to port functions. Advancements in economies of scale, automated terminals, energy transition, more intense rivalry among ports and increasingly urgent demands from governments, labor unions and civil rights groups all must be incorporated in port masterplan planning [2]. At the same time port developers seek to establish a balance with the ecosystem, a place where nature, people communities as well as clusters of companies can co-exist [3].

As an approach to overcome their bounded rationality, port planners and developers are increasingly using serious games to better understand the necessity to innovate the decision-making process. A simulation game is an interactive play, with or without a computer application, which engages the user with concepts of the real world to deliver a message, teach a lesson or adopt an attitude. In Rotterdam, gaming was initiated as part of the Maasvlakte 2 port expansion project [4]. This Maasvlakte 2 project was a cornerstone construction project for Rotterdam, not just because of its size, but primarily for its approach and complex stakeholder management and environmental impact. Related to this project the game SimPort-MV2 has been developed. As this game showed its added value, a follow up PortConstructor and PortConstructor 2.0 was developed.

In this study, we investigate the impact of the embeddedness of a simulation game called Port Constructor on students' knowledge development and the influence of the game on motivation, activation, and engagement.

2 Literature review

2.1 Port development strategies

A perspective in port research that has not been given special focus or stands out from the existing taxonomies in port research is inclusive port development strategies and the needs for collaboration rather than conflicts in port planning and development of seaports [5]. Perspectives and insights are often categorized under port governance reform, environmental management or port planning and development [6,7]. At the same time, the Sustainable Development Goals of the United Nations call upon partnerships as key enabler to realise the Global Goals [8]. With the SDG agenda port stakeholders recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs, including education, health, social protection, and job opportunities while tackling climate change and environmental protection [9]. Review and monitoring frameworks, regulations and incentive structures for investments must be retooled, which also means the need to reassess existing seaport research frameworks, in particular in relation in the field of inclusive partnerships, inclusive business and sustainable development. Sustainability challenges in a port-city context often situate in vulnerable coastal ecosystems. There is an increasing awareness of the continuous interaction of functions especially in urbanised and industrialised landscapes, via emissions into the air, water and into the soil [10]. Ever more stringent regulatory frameworks set limits to both the physical space as well as the environmental space (e.g., caps on CO₂, NO_x, and SO_x), as consequentially limit the license to grow as well as the license to operate. This necessitates a better understanding in the complexity of socio-economic as well as socio-spatial implications of port development.

Port development is traditionally seen through the economic lens, to serve the interests of capital investors to enlarge port capacity and thereby enlarge the potential to generate more revenues and make a profit. However, ports around the world are increasingly seeking to align economic growth ambitions to broader base social benefits. Where sustainable transport is no longer a key enabler to get people from A to B, it is a means to enhance people's access to trade (markets), health and quality of life [9]. Accessibility and connectivity to (air)ports are pivotal in this regard. Traditionally ports have been associated with displacement of communities, landscapes, biospheres, and the change of interaction between them as megaprojects have been established [11]. The entwined ambition for ports to contribute both to societal as well as economic goals calls for an inclusive view on port development. The challenge is firstly how to better understand impact and secondly how to get the message across to port professionals and students. "Instructors should challenge students to acquire cognitive skills that support proactive thinking habits. The inherent limitations of traditional forms of learning can limit an instructors' ability to properly prepare students for changing port management practices" [12]. Simulation games are a tool that is increasingly used in a professional and educational setting.

2.2 Learning from simulation games

For already a long time, games are seen as a valuable to learn about complex systems, such as ports [13,14,15]. Simulation games are valuable for two main reasons. First, simulation games are the only tools that can simulate the socio-technical complexity of a system, where stakeholders with different backgrounds interact as players with the simulated physical environment. Second, simulation games are considered as active and engaging learning tools leading to a higher motivation for learning.

Simulation games are representations of real-world systems and consist of the following building blocks: rules, roles, and resources [16]. The roles represent the different stakeholders and its perceptions, the rules represent the relationships between the roles and evaluation of resources allocation, and the resources represents the state of the system. Duke and Geurts [14] describe games as method in which human participants enact in a specific role in a simulated environment. Games allows players to share their perspectives in a meaningful way which support negotiation and collective decision making. Mayer even argues that “games are probably the only method where real people can be intrinsic part of a model” [15].

Because simulation games can represent complex socio-technical systems they can be used to train specific skills, transfer knowledge, or develop new strategies or policies [17]. These objectives link to the use of gaming in an educational setting. Duke and Geurts [13] summarize the use of games in the five C's: understanding complexity, need for consensus, improving communication, stimulating creativity and commitment to action. These five uses nicely fit with the objectives for port planning where port planners need to understand the new and complex situation of stakeholders, needs to improve communication to learn about different perspectives of the role of the port and the interaction with the environment, to think about new ways of developing ports in its design as well as the process to come to the design. Lukosch et al. [18] shows how simulation games can be used in the analysis and design of complex systems, such as port areas. Therefore, we can conclude that simulation games can also be used for better understanding of social dilemmas, its dimensions, concepts, and mechanisms that drive decision making behaviour of port developers as stated in the previous chapters.

The theories of learning are broad and diverse, without discussing all available theories they often have a component of motivation, engagement, or active involvement. In a constructive learning perspective, the learner is in the lead of the learning process, which means that the learner must be actively involved. From experimental learning theory the focus is on learning-by-doing, where you experience consequences of your action and reflect on the outcome to understand the theory (or world around you) better. Games have the characteristics to give the player authority on his actions and give him/her the lead in the learning. Further the direct feedback in games makes it possible to reflect on your actions and therefore gaming fits within an experimental learning loop [19]. Games are further seen as effective because they are fun and engaging [20,21] as fun promote active participation and deeper learning [22,23]. An atmosphere of fun also helps to produce a safe environment in which to practice and make mistakes [24]. Finally, Leitão et al. [25] claim that motivation is one of the most important factors for effective learning.

While there is evidence that games are motivational for some students, reality is more complicated and depends largely on the specific types of games used and the contexts of use. The conceptual diagram (Fig. 1) depicts the impact of game play on students' knowledge development – as the dependent variable – by means of activation, motivation, and engagement. The embeddedness and type of player are the two independent variables to the set-up of the game play.

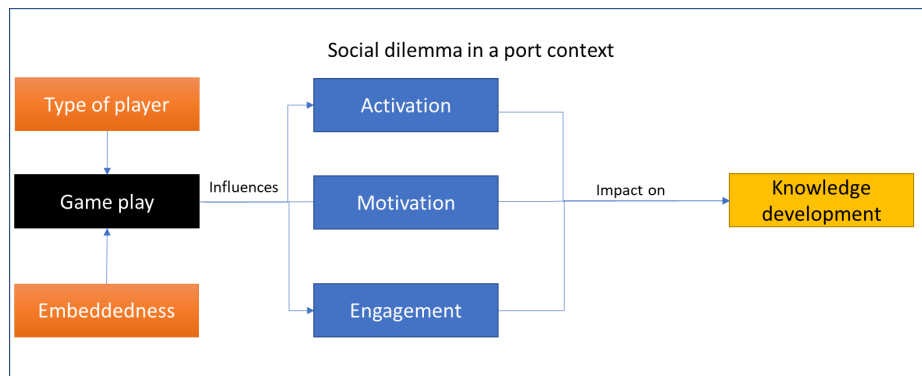


Fig. 1. Research model to research the impact of PortConstructor

In this research, we analyse whether the game PortConstructor 2.0 contributes to an increased knowledge and understanding about the challenges in the design of port areas, via activation, challenge, and engagement.

We investigate whether playing the game contributes to a more active learning behaviour in related learning instruments, such as reading the literature or following lectures. These activities together should lead to reaching the overall course objectives. Therefore, it is interesting to know, if and to what extent playing games not only activate a learner while playing the game, but also if a learner becomes more activated in other course activities. To get better insight in why students increase knowledge about port design we also measure if the students are engaged and motivated to play the game, which contributes to learning according to the theory. To get a complete overview the opinion about the game PortConstructor 2.0 as learning tool is researched as well. Finally, we investigated the difference between type of players (students and professionals) and two different settings, playing a game in a course where the game is part of a learning program consisting of presentations, literature, assignments, and others and playing the game in a workshop setting. See fig 1 for an overview.

2.3 Games for port management and design

The use of games related to port operation and port design already exist for a long time [5,25,26]. However, the last five to ten years we found many new games in this field. We see a high variety of types of game differing from board games [Disruption Game;27], computer-based games [SimPort-MV2;5,15], digital games [27,35] or even with a focus to decision support systems [28]. Not only the type of games differ also the use and objectives of the games differ a lot. From the literature after 2000, the following objectives are found: to understand the complexity of port planning and interaction between stakeholders [5,26,29] to understand the dilemmas between individual and shared goals [30], understanding the complexity of hinterland transportation (Tacotrans;[26]), Mastershipper [31], Rail Cargo Challenge Rotterdam and Amsterdam ;[32]), or a smart use of combining transportation and exploring collaboration [33]), understanding logistic processes and terminal planning [34,35] and finally focus on incident in port areas [27,28,35].

Although many games have been developed and used by students as well as port professionals, less extensive evaluation studies to the (learning) effects of these games or to the drivers of engagement, motivation and active learning have been done. In several studies evaluations are absent [33,34], focus on the design process [12] or the validation or playability of the games for further development [26,29]. If evaluations to learning is done it is with a limited number of respondents [12,30] or on general observations [32].

We found three exceptions of games that are extensively research, the disruption game, yard crane scheduler [33] and SimPort-MV2 [5]. The evaluation of the disruption game concludes that the game in general can be used to be prepared for incident management. Further the study

showed that participants enjoyed the experience, it is interactive and that it was difficult to predetermine the optimal solution. The evaluation of the game Yard Crane Scheduler about operating a container terminal showed that the game was a joyful and motivating experience and foster the learning especially communication and explicit knowledge about interdependencies of the planning tasks [35]. SimPort-MV2 was successful in increasing the knowledge about Maasvlakte 2 (area of the Port of Rotterdam) especially for participants who were less informed about the port. Further the game contributes to a better understanding of the challenges and complexities of the challenges in the area. This research also showed that engagement and motivation was positively correlated with the learning effect [5].

Based on the potentials of gaming for dealing with the complex systems and experiences with games so far in port development and design, we conclude that gaming can be a useful method to teach (future) port designers and developers about the social dilemmas and balancing different performance indicators. For this reason, Port Constructor was developed by a consortium consisting of the port authority with education institutes and a software developer.

2.4 The learning tool PortConstructor 2.0

The game PortConstructor 2.0 is mentioned as learning tool to develop new skills and knowledge about the social dilemmas in port design and management. We assume that the game contributes to an active attitude to study other course materials (in case the game is embedded in a course). PortConstructor 2.0 is a further improvement of PortConstructor [29]. PortConstructor 2.0 (Fig. 2) is a gaming platform, consisting of multiple missions about different challenges in port design and an editor to develop new missions. The game is a single player game, and the player represents the strategic port developer. The main objective of the different missions is to develop a port area, using a development budget, by removing or placing functions (port activities such as container terminals, chemical industry, and rail/road infrastructure). The decisions affect the processes in the port area such as the number of containers transported to the hinterland, amount of hydrogen import and hydrogen use, and the account balance. Further, the decisions affect the score on the indicators people, profit, planet. Dependent on the chosen strategy, a player will try to reach the high score on one or more indicators, which then can be compared with other players. A mission of PortConstructor consists of predefined number of rounds and can be played in 15-20 minutes, the players can easily play several times and explore, test, and reflect on different designs.



Fig. 2. Interface of a mission in PortConstructor. The hexagons represent a map of the port. On the top you can find the action buttons and account balance. On the bottom, a player can request additional information and they see the score on the indicators People, Profit, Planet (own screenshot).

The gaming sessions are flexible. The game can be played in a classroom setting, where all players are at the same time on the same location and the facilitator introduces the sessions and facilitates the debriefing afterwards. Players can also play the game individually after receiving a log in. The instructions can be shared via a learning management system and players can decide when and where to play for themselves. In this paper, we evaluated two different missions: Hinterland and Anyport. They are distinctive in the type of challenge and the way the game is applied (embedded in a course or as independent workshop). The hinterland mission focus on the challenge of growing transport to the hinterland and at the same time becoming more sustainable. The Anyport mission focus more on the strategic choices about the spatial challenges of shifting towards a new type and sustainable port, while staying operational. The Hinterland mission was part of a course, where students also had other learning activities, such as lectures and assignments. Anyport mission is mainly played as an independent workshop. Table 1 gives a summary of the two different missions. As the two different missions are different in challenge and embedding, we evaluated the missions separately and compare them based on the different settings.

Table 1. summary of the two different missions Hinterland and Anyport and the way they are applied.

Hinterland		
Social dilemma	Simulated decision making	Work settings
Accommodate container throughput while maintaining reaching a higher environmental performance, in reducing CO ₂ emissions.	To shift container throughput from road to barge and rail (modal shift), while implementing green alternative solutions. Achieving long term solutions and trading off between people, profit, and plant.	The playing sessions of the hinterland mission was integrated in educational courses. Including a lecture about hinterland logistics, an assignment regarding the game and a debriefing. Players played the mission individually and in teams. The process was iterative, and players had the opportunity to implement different decisions and strategies (play the game multiple times).
Anyport		
Social dilemma	Simulated decision making	Work settings
Accommodating the shift to new port activities, by allocating land to new port functions, thereby replacing old functions at the right time.	To 'play' the transition to a future more sustainable port with new industries. Main dilemma is balancing the available space to build 'new' industries and demolish the 'old' industries while maintaining the profitability of the port area.	The Anyport mission was used as discussion tool mainly during events and courses. The players of the sessions make decisions together in groups for three different rounds. The facilitator of the session implemented the decisions into the game to show the impact.

3 Methodology survey

The main question of the paper is to research how PortConstructor contribute to an active, motivated, and engaging learning tool and how this contributes to skills and knowledge development to deal with the social dilemmas in a port context. To answer this question, we used

survey research in combination with observations of the facilitators and teachers to give meaning to the results.

3.1 Survey

The survey was set up to ask the participants about the five different components of the research model (see figure 1) and in addition we asked educational background information. For privacy reasons, we have not asked about personal background, such as age and gender. First part of the survey investigates the learning experiences of the students and about the learning tool PortConstructor 2.0. Four components are important for a significant learning experience: game play, activation, motivation, and engagement. The fifth component measures the impact of games on the skill and knowledge development. The respondents were asked to give their opinion on 21 statements corresponding with the five categories. Examples of statements are ‘The game provided insight in the complexity of the issue’, and ‘The discussions between the players during the game were good’. The respondents gave their opinion using a five-point Likert scale where 1 means totally disagree and 5 means totally agree. Only the questions related to the category active learning had the options ‘Not at all’, ‘Somewhat’ or ‘A lot’. We chose to change the methodology for one question to prevent that the respondents fill in the form too fast. Changing the options can slow down the process of filling in the survey and keep the respondents sharp.

In the second part of the survey, respondents were offered the possibility to elaborate on their answers. And finally in the third part of the survey we added questions about the game session itself. Besides that, it gives an overview of the target audience of the group. These questions are relevant to compare different game set ups and different missions. In Table 2 the response rate per gameplay session is presented.

3.2 Data collection and analyses

Participants were asked to fill in the questionnaire directly after the gaming session. Before they left the location, the participants received a QR-code which directly linked them to the online survey using Google Forms. Participants were made aware that answers were used for scientific research. The surveys were completely anonymous, and answers had in no way effect on the assessment of the course and respondents were allowed to skip questions.

We analysed the data separately for the mission Hinterland and mission Anyport as they are different on challenge and embedding. For the descriptive analyses we used means and standard deviation. We are aware that Likert scales are ordinal scales and not clearly interval scales, we checked if the answers follow more or less a normal distribution although they are skewed to the lower or higher scores. Our conclusion was that we can apply means for our objectives. To compare the answers on type of players and embeddedness, we used the nonparametric Mann-Witney U test.

4 Results

4.1 Sessions and target group

PortConstructor 2.0 is played and evaluated seven times between February 2022 and June 2022. Table 2 gives an overview of the sessions. The game sessions were hosted by the Erasmus University (EUR), Port of Rotterdam (PoR) and the TU Delft (TUD). The table shows the target group, the mission that is played, if the participants were professionals or students, if the game was part of a course or a workshop, the date, the number of participants and the responses on the surveys. In total 220 participants played the game and 137 participants filled in the survey. The response rate was 62% and varied between 10% and 90%.

The Anyport mission has been played five times by 131 students as a workshop setting and as part of a course. The Hinterland mission has been played two times with 89 students and professionals and is only played as part of a course. The reason is that this mission is more complicated, and more background information is desired and therefore less suitable for a workshop setting. We could not find any statistically significant differences between students and professionals so we can take these groups together.

Table 2. Gameplay sessions PortConstructor 2.0

Host game session	Mission	Course/ event	Student /prof	Date	Group size	Number of responses (response rate)
EUR	Hinterland	Course: Hinterland course for Indian Maritime University	Bachelor students	18-02-2022	51	42 (82,4%)
EUR	Anyport	Course: Introduction to Port Economics	Bachelor students	18-02-2022	46	38 (82,6%)
PoR	Anyport	Event: TUD Maritime Match Day	Master Students	17-05-2022	20	9 (45%)
PoR	Anyport	Event: TUE – Student Symposium (2x)	Students	18-05-2022	40	4 (10%)
TUD	Anyport	Event: All Energy Day	Bachelor / Master Students	24-05-2022	15	8 (53,3%)
EUR	Hinterland	Course: Hinterland course for SENAT Brasil	Professionals	02-06-2022	38	26 (68,4%)
TUD: CiTG	Anyport	Course: CiTG	Master Students	08-06-2022	10	9 (90%)

4.2 Skills and knowledge development

First, we would like to know if the game contributes to skills and knowledge development. Although each session has specific learning objectives, the shared, higher-level objectives are related to understand the socio-technical complexity of port design. The survey had seven statements about what the players learned. Table 3 shows the opinion of the players on these general learning statements.

In general players agreed that they got new insights by playing PortConstructor especially about the insights of the complexity of the issue. These results are supported with the reactions in the open questions of the second part of the survey. A player mentioned “I liked the most that the game shows how complex it is for the port to make decisions regarding the energy transition. Besides, discussing in class did make me see more points from other stakeholders and I liked that a lot.”

Table 3. Results on the statements on skills and knowledge development

Statements about skills and knowledge development	Hinterland			Anyport		
	N	Mean	St. dev.	N	Mean	St. dev.
The game provided insight in the complexity of the issue	69	4,32	,90	68	3,87	1,23
The game supported in understanding the course contents	69	4,23	,91	68	3,34	,99
The game helped me to trade off people, planet and profit	69	4,25	,90	68	3,71	1,04
The game promotes better communication between stakeholders	69	4,33	,72	68	3,65	1,10
The game helped me to better understand roles attributed to specific stakeholders	69	4,12	,76	67	3,66	,90
Through my participation I've gained many new insights about port development	69	4,26	,83	67	3,67	,88
The game provided valuable insights into the technical complexity of port development	68	4,35	,71	65	3,82	,97
Cronbach's Alpha	0,864					

Another player stated, "To balance the people, profit and planet, the complexities behind to balance these factors in developing a port and how to get the best option out of many alternatives." This is showing this player got new insights about the complexity of balancing different indicators. This was also written down by another player: "Overall, I enjoyed it more than I expected. It also showed the complexity of the port and how many tasks a port actually has and what you have to think about." The use of the game to focus on 'social' elements came back in the answers of the respondents. One of the players wrote: "Having to think like a particular stakeholder." and another reaction was: "The game showed me the different perspectives and factors to be taken into account in the energy transition in the port."

The results show differences between the Anyport mission and Hinterland mission, the Mann Whitney U test reject the hypothesis that means are equal except for statement 'the game provided insights in the complexity of the issue' (sig. ,030). This means that there is a significant difference in learning outcome between the Hinterland mission and Anyport mission. This can explain that the Hinterland mission has a more specific focus and the Anyport mission is more generic and has a very broad focus.

4.3 Game play

Before diving into the effects of gaming on learning, we first need to check the opinion of the players of gaming as learning tool. In general, the players are positive about the game as learning tool, especially in the Hinterland mission (see Table 4).

Table 4. Results on the statements related to gaming a learning tool

	Hinterland			Anyport		
	N	Mean	St. dev.	N	Mean	St. dev.
The game helped me to learn	69	4,26	,85	68	3,54	,94
The discussions between the players during the game were good	69	4,43	,74	68	3,91	1,08
If we as a team play the game again, our team performance would be significantly better	68	4,59	,70	68	3,69	1,01
Cronbach's Alpha	.722					

One of the players mentioned in the debriefing that the game helped to understand port connectivity in a challenging environment: "Actually, it's really a good game to understand port connectivity, I like challenging environment. The trade-off between people, revenue and planet is bit challenging. Need many iterations of practice to balance these parameters." Another player liked best: "Fun combination of learning and playing." Additionally, some players mentioned that: "The fact that you learn while playing a game. It is a nice change from learning by reading books and watching lectures." In the suggestion section, some players suggested that the explanation of the game could be more elaborative and clearer. They suggested to make an embedded game-tutorial. Improving the elaboration of the game can increase the learning effects.

The data showed a significant difference between the two missions (Mann Withney U test, sig <.001). The data does not give information about an explanation. However, we see two main differences between Hinterland and Anyport missions. The first is that in the Hinterland mission the players put their decisions in the game themselves and this gives them more control of their strategies. The second is that players of the same mission could play the game multiple times, so they were challenged to improve their performances.

4.4 Contribution to active learning

One of the reasons to apply a game in education is that the game is used to stimulate learning and activate students. A second group of statements asked about how it activates using other learnings in the course. The results are presented in Table 5. We only used the results of the sessions where PortConstructor was part of a course as there were no other learning sources related to the PortConstructor 2.0 workshops at events.

Table 5. Results on the statements related to active learning (Likert scale 1 not at all, 5 a lot)

	Hinterland			Anyport		
	N	Mean	St. dev.	N	Mean	St. dev.
Literature on the subject that was addressed in the game	65	4,32	,95	42	2,76	1,27
Case study materials that were provided with the game	65	4,17	1,05	24	3,08	1,38
Lecture presentations that were provided	67	4,46	1,02	47	3,34	1,27
Other materials in the same course	65	4,02	1,18	44	3,05	1,10
Through the game I am much more motivated to study the course contents	68	4,25	,74	47	3,26	,97
Cronbach's Alpha	.851					

There is a significant difference in how the game contributes to active learning between the Hinterland mission and Anyport mission. The players of the Hinterland mission answered that they were activated a lot to learn the other course content and that they are more motivated to study the course content (M=4,25). For the players of the Anyport mission, the game did not really contribute to active learning.

In the open question section, the respondents did not specifically mention the connection of the game with learning materials, such as lectures and literature. However, in the debriefing of the game, one respondent did mention how the playing session activated the thinking process about how to realize a green transformation of a port in practice: “Combining all factors, checking how to optimize everything every round was fun. The game also got me thinking on how to actually achieve this transformation in real life, and the problems that come with it that are not represented in the game.”

One of the Anyport sessions was part of a course. Only in this course, the game was more used as a gadget and the game was not really well embedded with the other course activities. Also, the teachers of the course were not able to join the gaming session to link the game with the course content. While the embedding of the Hinterland mission was more intense with preparation assignments and short presentations after the game.

4.5 Motivation and engagement

Next to activation, according to the theory gameplay is a motivating (MOT) and engaging (ENG) activity, which contribute to learning. In the survey, several statements focused on these topics. The answers can be found in Table 6.

Table 6. Results on the statements related to motivation and engagement.

	Hinterland			Anyport		
	N	Mean	St. dev.	N	Mean	St. dev.
I lost interest because the aims were not clear (MOT)	69	2,26	1,21	67	2,19	,97
It activated me to understand theoretical concepts (MOT)	69	4,14	,77	68	3,38	1,04
Cronbach's Alpha	n.a.					
Interacting with the game was entertaining (ENG)	69	4,33	,74	66	3,82	1,02
The difficulty of the tasks focused my attention (ENG)	69	4,09	,84	65	3,46	,92
I lost track of time while playing the game (ENG)	69	3,67	1,15	66	3,02	1,07
The tasks at hand stretched my capabilities to the maximum (ENG)	69	3,88	,81	67	2,81	,93
Cronbach's Alpha	.744					

The results regarding motivation show that the players slightly disagree with the statement that they lost interest in the game. Further, the players of the Hinterland mission agree that they were activated to understand theoretical concepts. This was higher than the Anyport mission, where the theoretical context was less relevant. Further we see that the players of the Hinterland mission agree or slightly agree on the statements about engagement. Some players answered in the open question section that they found the game thrilling, addictive or entertaining. Another player mentioned: “Could play again and again so that we could get a better idea about the game and concept and improve in the next attempt.” Besides that, another respondent mentioned: “That it

makes us concentrate and understand better.” For the Anyport mission the players did not agree or disagree that the game was engaging.

5 Discussion and conclusions

This paper tries to answer the questions how simulation games contribute to an active, challenging, immersive and engaging learning tool and how this contributes to skills and knowledge development to deal with the social dilemmas in a port context. Simulation games can be a useful method to teach (future) port designers and developers about social dilemmas and balancing ostensible performance indicators: people, planet, and profit. For this purpose, we collected empirical data from 137 participants that engaged with two distinctive missions of the simulation game Port Constructor. Both addressed the complexity of socio-economic as well as socio-spatial implications of port development. We tested the effectiveness of the game on four aspects: game play, activation, engagement, and motivation. From our research we derive a number of outcomes. The results show a significant difference in the embeddedness of the playing session. This indicates that better learning outcomes can be obtained when the simulation game is embedded in a didactical method in a classroom setting, preferably assisted by both a teacher and a technical game facilitator. A good embeddedness of the simulation tool helps to reflect afterwards on the learning process, its learning aspects (activation, motivation, and engagement) as well as to make the connection between a simulated game setting and the actual social dilemma in a port context.

Another outcome of the survey is that the type of target audience – student or professional – shows no significant difference. This indicates that the type of target audience did not influence the learning objectives of the simulation game. Further to this, we can derive from the survey that the simulation game contributes in general to better engagement, motivation, and active learning. Further research needs to be done on how specific design features contribute to the skills and knowledge development. The following design features could then be examined:

- 1) Reduction of the complexity societal dilemmas in the port context into clear and concrete social dilemmas (e.g., people, planet, profit)
- 2) Visualization of spatial implications of business decisions in relation to port development.
- 3) Performance measurement dashboard to challenge the players to enhance his/her skills level.
- 4) Repetition and multiple iterations of the game create feedback loops that enhance learning.
- 5) Self-control over the learning process activates learning, in and out of classroom setting.

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Evaluating a Game on Sustainability and Collaboration with German Logistic Students

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Abstract. This paper summarizes research conducted by the authors during the ISAGA Summer School 2022 in Stuttgart, Germany. A research design for the exploration of collaborative and competitive game behavior as well as for the thinking patterns of the players was developed and finally conducted. As a simulation game to promote sustainability, the Fishing Game was chosen, played and evaluated with German students during the Summer School. In the results there were novel and unexpected findings, which provided insights into learning and game processes and can be helpful in game development as well as moderation of simulation games. The players showed no signs of collaboration within the game. Even after the game, the majority of the players stated that they would not show any intentions to change their behavior in the future. The reasons for this can be summarized as: 1) economics (sustainability is not compatible with economy), 2) prior knowledge (the problem was already known to the players before the game), 3) sustainability (there should be a greater focus on sustainability), 4) not implementable (a collaborative and sustainable behavior is not realistic). Those individuals with an intended behavior change indicated that a decreased competitive mindset leads to greater sustainability. In this study, the importance of debriefing can also be confirmed for failed game sessions. The implementation of the debriefing led to the fact that considerably more players created a connection to reality and were more likely to achieve the pedagogical goal of the game.

Keywords: Simulation games, game evaluation, debriefing

1 Introduction

Collaboration stands for one of the core competences of societies on the pathway to sustainable development (Lozano, 2007). Although we could expect sustainability games to encourage collaborative attitudes, there was little written on the promotion of cooperative behaviours by simulation games on sustainable development. As a group of students, we decided to conduct a quasi-experiment and investigate the encouraged behaviours among players of a popular sustainability game.

The research presented in this article was conducted under the umbrella of the ISAGA-Summer School and with the aim of exploring game evaluation methods by the participants of the summer school (authoring the article). The ISAGA 2022 International Summer School was held from September 26th to 30th in Stuttgart (Germany) on the theme of “Evaluation and Research in Simulation and Gaming”¹.

As a case study of a simulation game on sustainable development we have chosen *Fishing Game*, a game about common resources management. Preceding the creation of the game evaluation, the game and its mechanics were closely examined and experienced by the research team. Concluding this, we focused on exploring collaborative and competitive behaviour during game play, as well as the extent the *Fishing Game* evokes collaborative or competitive thinking patterns in participants.

¹ The report on the summer school can be found here: <https://zms.dhbw-stuttgart.de/artikel/isaga-summer-school-2022-at-the-centre-for-management-simulation/>

In the course of the study, we formulated the overall research question: To what extent does playing the *Fishing Game* foster more collaborative – rather than competitive – behaviours among German students in logistics. As the participants sample was very specific, this research also focused on the impact of individual character traits on a shift from a game level to a meta level, following the concept of Koodamara et al. (2021). To explore this, the game was played with a group of 19 German students in logistics with an average age of 20.84 within a university classroom. The game evaluation method consisted of survey observations and was constructed based on various methodological concepts and literature.

2 Related work

2.1 Literature

There are common findings, indicating that simulation games have the potential to raise awareness about sustainable actions and to let participants experience the dilemmas related to sustainability transitions (Douglas & Brauer, 2021; Kriz et al., 2001). Simulation games are already widely applied to raise awareness of diverse aspects of sustainability, promote reasoning abilities, as well as to rationalize and synthesize information (Torres & Macedo, 2000). Among meaningful examples, there is KEEP COOL, a board game about climate change designed to provide a discussion platform for people of multiple disciplines (Eisenack, 2013). In general, simulation games for sustainability are important tools for education and teaching (e.g., McGrath et al. 2020). However, different meta-analyses show the context dependency in efficiency and the importance of planned game designs to provide a good learning opportunity for the game players (Platz 2020; Erhel & Jamet, 2013).

To enhance the contextualization process, insights into the play and context-specific learning affordances are helpful. Based on these results, adaptations and adjustments can be made. Here, the simulation game KEEP COOL could be used as an example: the efficiency of the learning opportunities was analyzed and insights into the black box of the learning processes were provided. This revealed that behavior during the game - whether cooperative or competitive - has no impact on potential behavior change. Hence, in the designing and moderating of simulation games there is no need for consideration of desired relations between players, at least in the context of sustainability (Meyer & Eisenack 2018).

Additionally, competitive games can simulate real-world economic and social systems, allowing players to experience the trade-offs and complexities inherent in sustainability decision-making (Farmer 2015). In designing games for sustainability, it is important to strike a balance between collaboration and competition, as both can contribute to players' understanding of sustainability issues and their ability to make informed decisions. Importantly, in some strategic games, which is the case of *The Fishing Game*, there is no imposed game mode and players decide themselves what attitude they would adapt. While this allows participants to examine their competencies, it also poses a threat to the learning process and limits the control of the facilitator over the expected outcomes.

The study by Kolarowa and Ziaran (2016) was an entry point to analyze cooperative and competitive tendencies in the research. The authors elucidated the relation between personality traits and cooperative and competitive attitudes. In the study, they included 11 core competencies and associated them with cooperative/competitive tendencies. The full list of competences is included in the appendix.

Based on the example of KEEP COOL, we decided to investigate cooperative and competitive behaviors of the participants. However, in contrary to the example of KEEP COOL evaluation, we decided to include the post-game survey after the debriefing, not exclusively before. The literature identifies debriefing as one of the most essential phases of a simulation game (McBurnett et al., 2018; Kriz & Nöbauer, 2012; Crookall, 1992). A simulation game without debriefing is described as a missed opportunity (Tafner & Dreisiebner, 2019, p. 134). This

statement can be justified by the fact that also in the framework of the experiential learning cycle according to Kolb (2015), a feedback loop is mandatory, thus, we find debriefing to be an immanent part of simulation games. In this vein, the present study proposes a pre-game survey and two post-game surveys (one immediately after the play session and one after the debriefing).

2.2 The Fishing Game

The Fishing Game is a pool resource dilemma game. It was designed for the Allied Media Conference of 2013, and it was inspired by – and then simplified from – the Fishbanks Game of Dennis L. Meadows (Crookall et al., 2019). The two games address the growth's limits and the “tragedy of commons” phenomenon, also known as “unregulated commons” (Hardin, 1968).

In more concrete terms, the *Fishing Game* players are divided into four teams. Each one of them manages a fishery. All the team-fisheries operate in the same region, selling and feeding the fish to the same population. The goal of the game is to have the most fish by the end of the tenth year (one game round represents one year). This game objective is transmitted to the players deliberately in exactly this formulation. The players are free to decide whether they think of a competitive situation (as most players do) or whether they recognize a dilemma on a cooperative level. A round proceeds as described in the insert card below (Figure 1).

1. SHIPPING: the teams play one of their technology cards simultaneously.
2. COLLECT: in a determined order, each team collects the number of fish corresponding to the technology card they have played - if there are any fish left. Some technology cards can only be activated if there are "more than 15 fish left in the lake" at the time of fishing.
3. MARKET PRICE: depending on the total number of fish caught in this round, the unit price of the fish changes. In a logic of market competition, the more fish the teams have collectively caught, the lower the fish unit price becomes.
4. INCOME: each team receives the amount of money equal to the market price multiplied by the number of fishes they have caught this year.
5. INVESTMENT: teams can choose whether or not to buy a new technology card. (This type of game tends to produce a certain amount of technical inertia as it pushes players to invest in technologies and to make sure they get value for their investment over the course of the game.)
6. REGENERATION: at the end of each round, the fish population is regenerated. For every three fish remaining, one fish is added to the lake. At the beginning of the game, there are 24 fish in the centre of the lake.
7. END OF YEAR: The round number marker moves up one step forward (there are 10 rounds in total). If the total number of fish caught during the round was more than 7, the population is happy; otherwise, they are starving. After three consecutive turns with less than 7 fish caught, the population starves. In that case, the game ends automatically and everyone loses.

Fig. 1. Card 1 - Description of the phases of the Fishing Game gameplay.

The “Market Price” phase proposes a "balancing loop": the greater the supply, the lower the selling price. This feedback loop should normally prevent overfishing. However, if the number of fish available in the lake drops drastically (due to the fish regeneration rule for example), the market can no longer be flooded: in order to win, each team is then tempted to extract the remaining resources to sell them even more expensively. This reinforcing feedback loop is a trap in the system, known as the "tragedy of commons".

The tragedy of commons refers to the draining of a shared resource by individuals who operate independently and rationally based on their own personal interests, even if they understand that this kind of behaviour is contrary to the best long-term interests of the group. When this happens in the *Fishing Game* – when it becomes clear that the pool is not sufficiently regenerated while the population begins to starve – the teams often start to trade, to negotiate (sometimes opening to betrayal) or to blame each other.

2.3 Debriefing

After playing the *Fishing Game* there is a facilitated debriefing. It is designed as a group discussion and led by the same person responsible for gameplay facilitation. Concerning the game session discussed here, the debriefing itself was structured in four *E* questions (adapted from Bartschat & Zürn 2018; Petranek, Corey & Black, 1992): emotions (“How did you feel?”), events (“What happened?”), experiences (“What did you learn?”) and every-day life (“How could you use your learning?”).

The questions were supplemented with additional reflective insights provided by the facilitator, i.e. what an ideal strategy would look like (cooperation, low investment, less fishing with a high price), what is winning – does it mean to possess more than others or could it mean equal benefits for all the participants. Finally, the facilitator explained one sustainable solution of the game and discussed success and failure strategies.

3 Research Design

This experimental session took place on the 28th of September 2022 at the Center for Management Simulation of the DHBW in Stuttgart, Germany. There was one facilitator dealing with the four teams, each composed of four or five students. The teams were assigned randomly and distributed over four tables arranged in an arc in front of the facilitator and a central table (on which the fishing pool was placed). The global game information (such as the year tracker or the fish market prices) were also posted in front of all teams, in this central place.

3.1 Preconditions and Participants

A survey before the actual game starts allowed a better estimation about the players. This questionnaire was used to know about demographic data (age, gender), previous game experience, motivation to participate, and anticipation of the simulation game. In addition, questions were asked about cooperative or competitive behavior based on Kolarowa and Ziaran (2016).

The sample consisted of 19 participants aged 19-26; seven women and 12 men. All participants were students of a Bachelor of Logistics at a German university. The study was conducted as part of compulsory classes. The group had limited knowledge of simulation games. 74% of the players declared little experience in simulation games (1-3 games played before), the rest experienced 4-10 gameplays and only one person experienced over 10 simulation games. The group was diverse in terms of the frequency of playing games. Mostly, however, the participants did not play too often: 53% of the students play less frequently than once a week. Nine participants declared that on average they play games once a month, while one person plays a few times a month, six people play once a week, one person never plays games, and one person uses to play every day.

In terms of the preferred game genres, participants indicated rivalry-oriented games focused on individual results: competitive, strategic, and sport games (59%). None of the players indicated cooperative games as the only choice – even players who play Massively Multiplayer Online Role-Playing Game (MMORPG), sandboxes, or other cooperative games indicated also competitive games (participants had multiple choices in this question).

3.2 Debriefing structure and instruments

To evaluate to what extent playing the Fishing Game fosters more collaborative - rather than competitive - behaviors among German students in logistics, the authors created the following debriefing protocol. After introducing the research context and before starting to play, the participants filled an individual questionnaire to assess their attitudes towards competition and cooperation. Then, during the gameplay, observations of collaborative and competitive behaviors were conducted. It was based on an observation matrix completed by two independent observers associated with each team and with an action-tracking grid completed by the players themselves. Finally, the participants completed another individual questionnaire before and after the debriefing to evaluate the impact of the game on their thoughts about cooperation (with and without the hindsight on the briefing).

The debriefing consisted of two tests: first questionnaire (T1) immediately after the playing part and, therefore, before the debriefing. Then, second questionnaire (T2) after the debriefing. The role of pre- (T1) and post-debriefing-survey (T2) was to determine the influence of debriefing and its effectiveness. To avoid declarative statements regarding the knowledge gained, participants were requested to answer an open question with minimum 3 statements. Similar question was asked after the debriefing. Eventually, the outcomes of the comparison of the two questions were analyzed.



Fig. 2. Research design with the assignment designations

The pre-debriefing questionnaire (T1) included the question “What would you change if you played again?”. The structure of this question was an attempt to gather reflections from the game before the debriefing. It was expected to trigger the core learning points acquired by the participants.

The post-debriefing questionnaire (T2) was conducted immediately after the debriefing. It consisted of a similar question to the initial one: “What advice would you give future players?”. This way, it verified whether participants reached or not the meta-level in post-game reflections. The question was formulated in a different way to avoid repetitive answers; however, the sense remained the same. In addition, participants were asked three direct questions about the impact of the game. The first one was a close-ended question: “Do you think that the game will influence your future behavior?”. Participants were asked to explain their answer. Then, two Likert scale question/sentences were proposed: “How likely is it that you would recommend the game to your friends?” and “I enjoyed the game” (Strongly disagree - Disagree - Neither agree nor disagree - Agree - Strongly agree).

3.3 Observation

To gain insight into decisions and considerations during the game process, the teams’ behaviors were observed. Two observers were assigned to each team – one observer representing the students (who then did not participate in the game) and one external observer (a participant of the Summer School). Data points were collected through an observation sheet followed by the questions to be found on figure 3.

GRUPPE Nr: The letzten drei Stellen deiner Handynummer:

Answer the following questions about every round:	Scale	ROUNDS									
		1	2	3	4	5	6	7	8	9	10
Did your team talk to any other team?	YES or NO (Y/N)										
Did your team suggest any collaborative activity with other teams?	YES or NO (Y/N)										
Did your team agree to any form of collaboration with other team/teams?	YES or NO (Y/N)										
- If so, did your team decide to cheat the agreement?	YES or NO (Y/N)										
Was the most important team's goal to maximize its own result?	YES or NO (Y/N)										
Was the most important team's goal to achieve "the greater good" ? (<i>feeding the population, regenerating the lake etc.</i>)	YES or NO (Y/N)										
Did your team intentionally catch fewer fish that they could have? (<i>e.g. you could catch 3 but decided to catch only 1</i>)	YES or NO (Y/N)										
What was the overall level of positive emotions in your team? (<i>happiness, satisfaction, pride, enjoyment, etc.</i>)	5 – very strong										
	4 – strong										
	3 – medium										
	2 – weak										
	1 – very weak										
What was the overall level of negative emotions in your team? (<i>anger, fear, powerlessness, shame etc.</i>)	5 – very strong										
	4 – strong										
	3 – medium										
	2 – weak										
	1 – very weak										

Fig. 3. Observation sheet.

4 Results

This chapter outlines the results of the study. First, the preconditions of the players from the T0 surveys are explained in order to get a better understanding of the group – the focus is on the dispositions between cooperative or competitive. This is followed by an analysis of the results from the post-test questionnaires, considering both quantitative and qualitative aspects. Finally, qualitative data obtained from the questionnaires is compared and evaluated. Due to an unexpected and special game dynamics (the players had hardly sought cooperation throughout the game), no more significant results emerged in the observations: therefore, they have been omitted in this chapter. However, if this project is pursued further and cross-national games are played, a renewed observation should nevertheless not be dispensed with.

4.1 Personal Characteristics of Test Group (T0)

Eight questions under the umbrella of the administered pre-game questionnaire provide insight into characteristics of the participants commonly associated with either collaborative or cooperative thinking patterns (Kolařová & Pavel, 2016). For each question (Q1-Q8), a 5-point-likert scale was used ranging from "Very unlikely" (1) to "Very likely" (5). All participants (n=19) answered all questions. The results can be seen in Figure 4, which shows the relative distribution of responses per category. Particularly noteworthy are the high values of social capacity (Q1) - 52.6% indicated "very likely" and 21.1% "Likely". Likewise, the group shows high ambition (Q7) with 68.4% indicating a score of 5 and 31.6% indicating a score of 4. Finally, the question on "Capacity to influence people" shows a distribution from "Not sure" (3) to "Very likely" (5), with 4 being the most frequently indicated with 42.1%. Figure 5 shows the average scores per indicator question on a scale of 1-5.

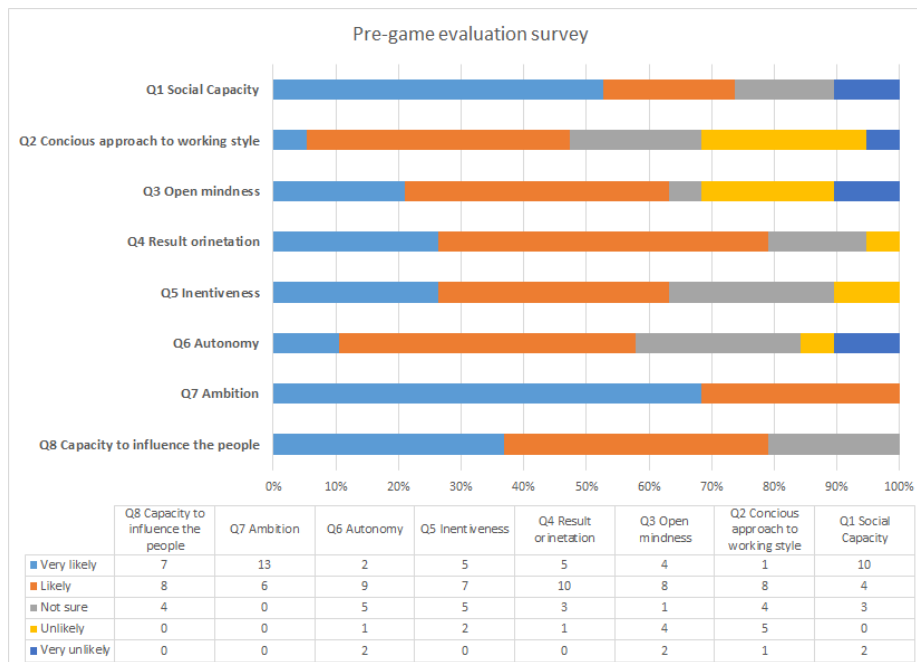


Fig. 4. Pre-game questionnaire results.

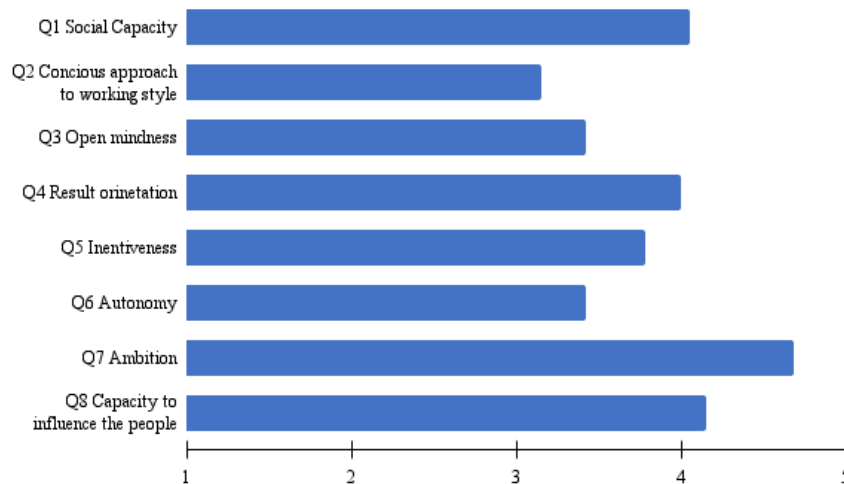


Fig. 5. Average values per indicator question on a 5 points Likert-Scale.

To investigate the relationship between our variables (items) further, a Principal Component Analysis (PCA) was performed in SPSS. The KMO value can be reported as insufficiently strong (KMO = .314), however communalities for all items showed a sufficient explanation of total variance (>.7) by components in the model of analysis (4). While the amount of variance explained by each component is limited due to a low data count, the variance for the first components may well be indicative of the underlying structure of the data. This analysis resulted in 4 components explaining the total variance of the 8 items. Here, it was apparent that (Q4) “Result orientation” - (Q8) “Capacity to influence the people” loads strongly into component 1, whereby the remaining three components demonstrate inconclusive data. Bartlett’s Test of

Sphericity suggests a significant correlation ($p < .001$) in the data. Summing up, the groups revealed significantly individualistic and ambitious preferences with strong goal-orientation, what could influence the further course of the study and the gameplay.

4.2 Post-Game Questionnaires (T1)

Under the post-game questionnaire (T1) participants were asked whether they think that the game will change their future behavior. Possible answers were “If yes, in what way?” and “If no, in what way?” An inductive, qualitative approach was taken and resulted in various index terms that were identified from the answers given by all participants ($n=19$). Five students marked “yes”, 13 students “no” and one student abstained.

Firstly, data under the umbrella term “Economy” (I1) was identified. The term business was mentioned, and keywords such as “companies” were also included in the answers. It was mentioned twice that economics is incompatible with behavior change. Further, participants indicated that the economy does not work as shown in the game, overall negative thought patterns were dominating. All participants that included this index term in their answer also indicated “No”, as for whether they expect that the game will change future behavior. Related to that, one participant stated with a negative connotation, that the game was “far from reality”, and does not reflect how economic trade works. Therefore, we can assume that collaborative behaviour was perceived as less profitable, both in the game and in everyday life.

Four out of 19 participants included in their answers the topic of “prior knowledge” (I2). It was stated that the problem is already known, and that for example, the environment is already considered. Here, twice a positive thinking pattern underlined the overall answer given, whereby the remaining two participants mentioned prior knowledge in a neutral way. Thus, positive change would require either new setting or more engaging representation.

“Sustainability” (I3) was mentioned by three participants, whereby two indicated “yes” when asked whether playing the game will change their future behavior, and one indicated “No”. Under sustainability, the participants mentioned that there should be a greater focus on sustainable thinking, and that their knowledge was already present before playing the game. Overall, no clear change in behavioral intention can be linked to the index term “Sustainability”. Although participants were aware of the significance of sustainability, they did not link it to collaboration.

Moreover, “Not implementable” (I4) was mentioned by four participants and occurred within the context of strong negative connotation. One participant mentioned that it is in practice not realisable, in reference to acting more sustainable.

However, “collaborative thinking patterns” (I5) were recognizable in four participants. Three showed positive thinking patterns and also indicated “Yes” for the item on expected change in future behavior, while the participant that indicated “No”, provided a neutral statement towards collaborative thinking. The focus here took the overarching theme of collective behavior change, and communication. One out of the four participants noted that competitive thinking should be minimized.

4.3 Comparison between T1 and T2

The results were obtained using category-guided qualitative-oriented text analysis, which was derived from the open-ended responses in the pre-post debriefing questionnaire (T1 and T2). The responses in this questionnaire were analyzed using deductive categories, for which a coding guide was used. Since the simulation and the questionnaire were conducted in German, the evaluation was also done in German and the English translation was performed in the last stage.

Guided by Mayring’s (2010) process model for deductive category application, the methodological procedure is outlined below. First, the object and the research question are formulated. The general question refers to the changes of the players through the debriefing. The focus of the analysis is the hypothesis that debriefing is essential for the players to move from the

game level to the meta level. In the second step, the structuring dimensions are defined as categories. Regarding the hypothesis, the categories of game level and meta level are chosen. Regarding the learning objectives, the categories cooperation and competition are also included. In the third step, the categories are presented in a coding guide (see Appendix 2). In the next steps, the first categorizations and revisions will be made before the basis of the data is created in a final material run. The last step is the evaluation, which in this case is a simple frequency analysis and is shown below.

As the debriefing is considered as one of the most important elements, it is essential for the intended learning processes to transfer what was experienced from the game to reality. The evaluation of the questions about the recommendations of further rounds of games have shown on the game/meta level that only few transferred conclusions (reflection on the meta level) took place before the debriefing. While there were only 6 mentions on the meta level before the debriefing, there were 23 afterwards. In this context, the mentions on the game level also decreased from 42 to 32, although this value is difficult to classify without reference.

Of special interest is the increase of a cooperative strategy based on the debriefing. This could lead to the conclusion that the players would choose cooperative strategies in a further game run (or also in the transfer to similar situations in practice). While there were only 11 mentions before the debriefing, there were 25 afterwards. The low number of mentions of competing strategies can be neglected in this case.

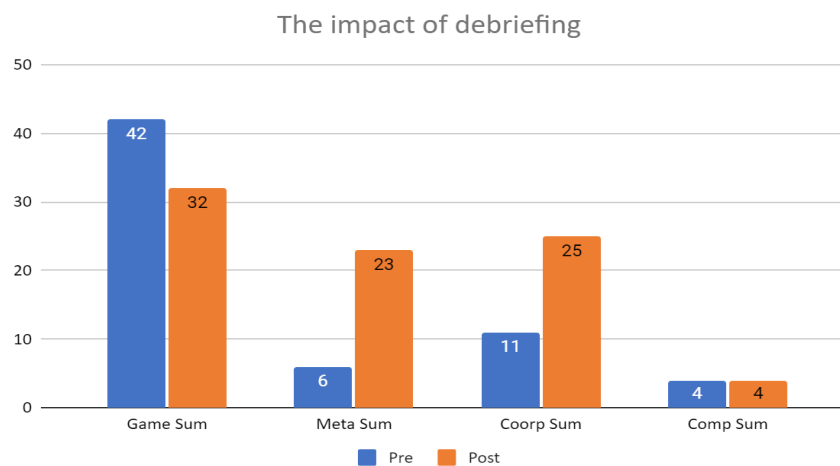


Fig. 6. The impact of debriefing.

5 Conclusions, limitations and future research

This study cannot report a congruent shift in opinion on the matter of collaboration for sustainable resource management. This is not in line with other research such as by McGrath *et al.* (2020), where hospitality students reported an improvement in understanding of the role of collaboration for sustainability matters after undergoing a teaching simulation game on sustainable practices in tourism. However, the students under this study were familiar with theories from hospitality management also involving sustainable practices. This stands in contrast to the logistics students in this research study, who were not educated on the particular matter. Hence, this kind of frontloading may explain the discrepancy of both studies.

The non-collaborative and unethical thinking patterns seen in this study may relate to a variety of factors. Firstly, openness to experience is associated with unethical behavior (Koodamra *et al.*, 2020). This trait is related to divergent thinking, the creation of new ideas, which in turn, relates to inventiveness (Nieß & Zacher, 2015). Hence, the high levels of inventiveness in this study may have contributed to the negative connotation in the thinking of the participants. Moreover,

low levels of agreeableness are seen in people that are unwilling to cooperate, which was seen in this study. This in turn negatively correlates with ethical behavior and may further explain the findings. Lastly, conscientiousness negatively correlates with unethical behavior (Koodamra et al., 2020). Since this trait scored low in this study, this might have promoted the positive correlation instead. As Platz (2020) suggests, anticipation of the challenges by effective game design, in this case with stronger impact on collaboration enhancement, could be beneficial.

The research outcomes can also be looked at from the perspective of personality traits. Research by Visser *et al.* (2011), for example, maps out traits of individuals in leading roles with strong sustainable thinking. An inclusive, collaborative, committing, and participatory style was associated with sustainable thinking. This can be complemented by an altruist worldview and a focus on the greater good of the community (Visser *et al.*, 2011). However, these traits were not strongly present in the participating student group, where we found a rather individualistic view. This shall explain the non-sustainable behavior patterns. Additionally, students that score higher on the scale of extraversion are more prone to engage in unethical behavior (Koodamra et al., 2020). In a study by Aydoğmuş and Koyuncuoğlu (2021), extraversion was positively associated with social capital. Hence, in this study, high levels of social capacity, and capacity to influence people can be seen as markers for extraversion. Overall, there might be a connection between the individual's personality traits and seen behavior patterns.

Furthermore, the overall consideration for sustainable practice was moderate to low in this study, while ambition was high. Although participants were aware of the importance of sustainability, they did not appreciate collaboration as one of its main prerequisites. The concept of “relative distance” may add to the understanding. “Relative distance” from a topic can reduce ambition for a certain goal but may increase it for other goals. There is a structural component to relative distance, which can be the field one is most involved in, which in this case is business studies and logistics (Keller & Zavalloni, 1946). This structural component may result in ambitious thinking under this structural component, but the relative distance to sustainability studies decreased ambition in the area of sustainable behavior.

Another explanation could be seen in the cultural dimension. Hofstede and Caluwe (2010) have cited unwritten laws regarding cultural biases of gamers as a meaningful determinant of a simulation games's success. Lukosch et al (2017), in examining cultural differences in gaming behavior, found German gamers with higher performance. With regard to the present study, the rationale for competitive gaming behavior could be considered in the cultural background of the gamers. Annotated that game performance has no impact on learning efficacy. In this case it opens up a question about game design driven by the character traits of future users: to what extent a designer should consider character traits and does it matter to measure them, if the game is dedicated to a specific group of people.

Although little cooperative behavior was observed in the game, an increased tendency toward future cooperative behavioral intentions is very much evident after the debriefing. In addition, this demonstrated the importance of debriefing. Without debriefing, the game is simply considered as such. Through debriefing, however, even an unsuccessful game could be seen as a learning opportunity for many players – whether they consider a change of disposition or not. However, as stated by Erhel & Jamet (2013) and confirmed by the study, the context of learning plays a vital role.

It was shown that the importance of debriefing is also confirmed in this study. Debriefing is essential to get out of the game world and create connections to reality. Without debriefing, it would have been merely a game with a missed learning opportunity. Overall, while playing the sustainability game did not influence the tendency to collaborate, it did raise participants' awareness of the importance of cooperation in managing commons.

This research was subject to several limitations. Firstly, the sample size of 19 is not strong enough to formulate generalizations. Similarly, conclusions and assumptions can only be drawn based on the context of students within the German educational system. This way, it cannot be transferred into other cultural contexts. In the same way, this study was conducted with a group

of students with a homogeneous study background, therefore findings cannot be assigned to students in general.

Consequently, the authors of this article plan to replicate this study in other cultural contexts, with a larger number of participants, and with students from various disciplines. This will add valuable data to further explore, understand, and confirm the findings of this study.

Another limitation in the paper lies in the nature of some closed questions and the short time frame. The question immediately after the simulation about a self-assessment about future behavior cannot provide information about an actual behavior. If students continue to talk about the findings after the simulation game, a change in behavior cannot be ruled out – in the context of this study, such could not be evidenced. It would therefore be interesting to ask students sometime after the simulation game in order to be able to speak of actual learning effects or behavioral changes.

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Appendix 1. Personality traits correlated with competitive and cooperative tendencies. Adapted from Kolarowa and Ziaren, 2016.

Competence	Definition	Competitive	Cooperative
Influence	Capacity to influence the others, obtain understanding, approval and support	✓	
Social self-esteem	Understands his or her own value in the society, good predispositions for networking		✓
Sociable	Open for communication, extroverted, enjoys social events		✓
Cooperative	Prefers cooperative solutions		✓
Result-oriented	Focused on solutions and activities with clear and well accomplished results	✓	
Systematic	Prefers to plan, is organized and prefers clear structures and well-defined priorities	no statistically significant outcome	
Conscious	Respects the rules and processes		✓
Prudent	Prefers to think in the long-term horizon	no statistically significant outcome	
Inventive	Enjoys searches for the new approaches and solutions	✓	
Autonomous	Prefers to act on his/her own initiative	✓	
Ambitious	Determined to achieve his/her goals	✓	
Competitive	Enjoys competitive environment and challenges	✓	

Appendix 2. The table of categorization

Categories	Definition	Synonyms	Examples as indicators
Meta-Level	<p>The definition of this category is based on Kolb's (2015) description of abstract conceptualization, which should be achieved in the debriefing. According to this, the transfer of what was experienced in the game to reality is in the focus (Kriz & Nöbauer 2008).</p> <p>The question therefore arises whether the players can step out of their game role and reach the phase of generalized transfer.</p> <p>This category describes the type of play in which the players reflect on the learning goals.</p> <p>If the participants describe that they want to cooperate more, communicate more or behave more sustainably, they reflect on the meta-level.</p>	Cooperation, communication, sustainability, think	<p>"Work together"</p> <p>"Coordinate better with others"</p> <p>"Doing business together in a sustainable way"</p> <p>"Making compromises"</p> <p>"Making balanced decisions"</p> <p>"Not just thinking about maximising profits"</p> <p>"Think less selfishly"</p> <p>"Talk it out"</p>
Game	<p>The game category describes the level in which the players are still in their playing role and the reflect on the basis of the game.</p> <p>If the participants describe that they want to buy other ships or pursue a different strategy when fishing, then they are only reflecting on the game level.</p>	Pond, Ship, Fish, Fishing, play	<p>"More fish in the pond"</p> <p>"The radar is illogical, you can't fish with a radar"</p> <p>"Shop better"</p> <p>"Play less selfishly"</p> <p>"Keep a minimum of 15 fish in the lake"</p>
Cooperative	<p>In this category, team members think about working together with others.</p> <p>This can be agreements, actions of sanctions or any type of collaboration.</p>	Team, together, collaborate	"We should make an agreement with the other teams, for not fishing all fish"
Competitive	This category is for when the players refuse to collaborate and act in strict concurrence and conflict with other teams.		<p>"We have to fish more than the other teams"</p> <p>"We should invest into the better boat, before the others do"</p>
Not classifiable	<p>If no clear classification can be made from the statements, these should be declared as "not assignable".</p> <p>This refers to statements consisting of individual words that cannot be interpreted without context.</p>		<p>"Simple communication"</p> <p>"Save"</p>

Development of ELSI Game for Engineers

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Abstract. Ethics, law, society implications (ELSI) is the possible risk for cutting-edge technology conflicting with the established social order. The debate on the harmful effects of artificial intelligence (AI) has prompted the development of solutions to possible risks. However, anticipating the abuse of technology before the occurrence of incidents is difficult. If a university enforces the attendance of the faculty development program to limit ELSI risk in conventional one-way lectures, engineers may not feel incentivized to study ELSI concerns. Game-based learning is an effective method to learn ELSI. Therefore, in this study, an ELSI card game was developed. The game has two types of cards sets: “Topic Card,” which describes an example of easy ELSI issue, and “Solution Card,” which presents simple ideas in short words. In this game, two players try to solve the ELSI issue by using ideas prompted by solution cards. Next, they present their ideas simultaneously. They determine a different story may exist on the same problem. Diverse solutions should be considered to resolve the ELSI issue. Although the ELSI game has three types of cards sets, namely traffic, energy, and foods, new sets can be easily developed. The ELSI game provides a flexible framework to prevent future incidents.

Keywords: ELSI, Game Based Learning, Card Game

1 Definition of the ELSI Issue

The purpose of engineering is to make people happy. Although latest technological innovations provide numerous benefits, such technology can be abused and cause conflict within our community. For instance, the development of an AI may result in people becoming highly dependent. Staying on social networking services for too long may result in kids losing their ability to interact with each other. Such a problem is called ethics, law, society implication (ELSI). With the third AI boom, these concerns have only become intense.

Engineers should prepare not only for actual but also potential ELSI issues. For example, engineers participating in autonomous driving vehicles should consider how to resolve a legal status as well as accountability for the society. However, such concerns are not related to technology itself in a highly competitive cutting-edge level. In the case of a future case, imagining an incident that is yet to occur is difficult. Therefore, engineers may be dismissive of some scenarios. However, similar to research ethics, intellectual property, personal information protection, or conflict of interest, universities should manage ELSI as well. However, a good teaching method may not exist. Therefore, the authors were determined to develop a gaming simulation to let engineers learn ELSI problems with cards, discussions in a fun manner.

2 Literature Review

In 1991, National Institute of Health (NIH) and Department of Energy (DOE) launched the Human Genome Project. U.S. Committee of government Operations (1992) introduced discussion on the potential violation of human rights caused by human genome analysis by using “ELSI.” NIH and DOE designed to preserve budgets on ELSI related topics 3%–5% at the beginning (U.S. Congress Office of Technology Assessment (1993), p.8). NIH launched the National Center for Human Genome Research to conduct the ELSI academic research in

both NIH and DOE (Langfelder, Jungest (1993)). Bostrom (2006) reported the word has been used in nanotech research. In AI-related research, the word appeared around 2006. Boddington argues AI has a broad nature and expansive possibility for application. Therefore, an ethical code should be established as soon as possible, and researchers should change their mindset. For the government, Cath et al. (2018) introduced the “Good Society” and discussed the role of the government and researcher.

In gaming simulation, Fritzsche and Rosenburg (1989) suggested the business game should mention to ethical surface and provided tips on predatory dumping and bribery. Gosen et al. (2007) detailed the criteria required on business games from the perspective of ethics. Buck (2022) reported the invention of an ethics simulation game in 2013, which has played by more than 800 students in his university.

3 ELSI Issue Characteristics

3.1 Past ELSI problems

The conflict between technology, society, and business is not the first conflict. Table 1 details examples of conflicts between Information Communication Technology (ICT) and law.

In early days, most conflict cases were recognized by society and technology-abused incidents. They are broadcasted by mass media, and the parliament discussed legislation to avoid such incidents. However, official legislation is a time-consuming process. To prevent such incidents, the industrial society or academic association on the target technology often compile guidelines. Those organizations warn users to stop the abuse of technology, conduct common users how to protect their bodies, human rights, properties, health, and safeties.

Table 1. ELSI appearance on information communication technology (ICT)

Problem Names	Years (Raise-Resolve)
Copyright of program, database	Mid 1980s–2000
Availability of legal enforcement in the cyberspace	1990s–2000
Transborder Data Flow	Mid 1990s
Obscene, explicit Contents	1990s–2010
Harmful Information	2000s–
Cybercrimes	1990s–
E-Commerce and Customer Protection	2000s–2020s
Personal Information Protection	2000s–
Fake News	2010s–
GAFA’s power v. consumer protection	2010s–
The 3 rd AI Boom	2016–
Generative AI	2023

3.2 Conflict between ELSI and Technology, Business

Generative AI such as “ChatGPT” has attracted considerable attention worldwide. ChatGPT can benefit many people. However, if people become overly reliant on such systems, they may stop resolving issues by themselves. Academicians have expressed concern that if students use such technology for their homework or reports, the quality of education may degrade severely. Conservative medias have demonized such technology because engineers did not consider the effect of technology before implementing them in society.

However, forecasting such event in advance is difficult. From a business perspective, if a company waits until such potential risk is removed, some other company may develop a similar

idea and commercialize it. ELSI has different concerns with both technology innovation and business.

3.3 Difficulty of interdisciplinary dialogue

With the third AI boom, people have welcomed new technology but are concerned that highly capable AI systems may replace human beings, and subsequently, computers may enslave humans. If we understand deep learning, “singularity” never occurs, because statistical analyzes of enormous samples gathered in the past may never exceed the total sum of human knowledge.

However, arguing on a such a technological premise is extremely difficult for lawyers. A lawyer cannot evaluate the capability of cutting-edge technology like an engineer. He can only assess potential legal risk, so, his idea must be conservative and imperative, with limited margin for compromise.

From the perspective of corporate interests developing AI technologies, legal restrictions and obligations may be considered onerous. However, all engineering inherently involves non-technological issues such as social impacts and abuse, so considering ELSI issues in the development of emerging technologies is straightforward. However, cutting-edge technologies are often *intentionally* disruptive, and ordinary legal restrictions may be seen as an undesirable burden. Naturally, this approach can easily lead to significant social impacts or harm, which is one key reason that governing, regulatory, and legal frameworks already exist for most fields.

Hence, a conflict may originate from differences in outlook between engineering and legal perspectives. Despite the seriousness of the conflict, a solution should be limited to “continue thinking”.

3.4 Learning ELSI using game-based learning

ELSI is the risk for university. Most university professors were free from institutional order. However, the commission from affiliations is increasing, like an intellectual property treatment, research ethics, and conflict of interest. For each topic, faculty development is planned, and attendance is compulsory for researchers. Regarding ELSI, when damage could occur in the future, imagining, estimating, and prevention, cannot be performed until the incident occurs. If the university miss a potential risk of research, not only the inventor but also the organization may be accused by society.

If the university stipulates researchers to mandatorily attend faculty development to prevent potential ELSI risks, researchers may not adhere to the directive, especially for a conventional lecture style. Even though they may know potential ELSI risks, they may not consider the problem. This problem is dangerous and paradoxical. Therefore, a solution is required to avoid future incidents, decrease damage, save people and reduce efforts of engineers.

This study proposed the application of game-based learning to resolve ELSI issues. Only researchers positive to learn ELSI join the game. The role defined by the game rule is an active, experiential learning opportunity, and they accept ELSI as their topic, not someone else’s story. To circulate the game with researchers in other fields to share ELSI problems and finding a common answer could be fun. Therefore, this study designed the ELSI card game.

4 Overview of the ELSI Game

4.1 Basic rules

1. Students are separated into ten to twenty teams.
2. Two students form a team.
3. They receive a card deck, a share capital 300 for each.
4. Draw one “Topic Card.”
5. Draw five “Solution Cards” individually.

6. Try to make a scenario to resolve the issue by using five factors.
7. If it is difficult, you may release up to five cards, and draw cards up to five including a card you hold.
8. Make a scenario to resolve the issue by using five factors.
9. Introduce the scenario to the teammate.
10. Player who made a better solution can receive 100 from the rival.
11. Repeat 4)–9) for five times.
12. A player who holds the most money among all teams will be champion.

4.2 Cards

The game consists of two card sets: 18 topic cards, and over 90 solution cards.

Topic Card

This card detailed the ELSI problem example. Authors have three series of topic cards, namely traffic, energy, and food and health. Here are some examples (Figure 1,2).

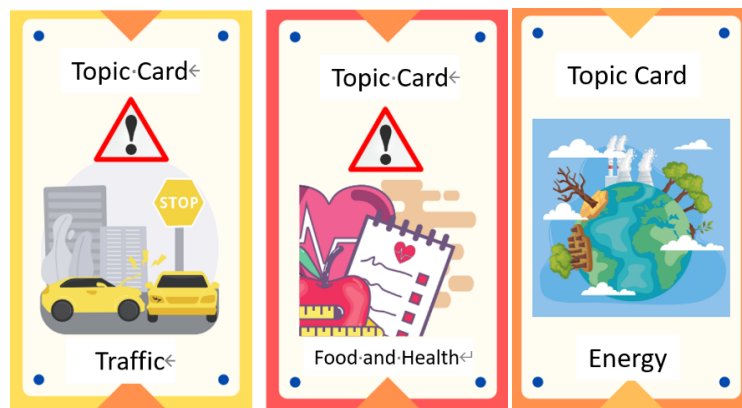


Fig. 1. Topic cards (surface)

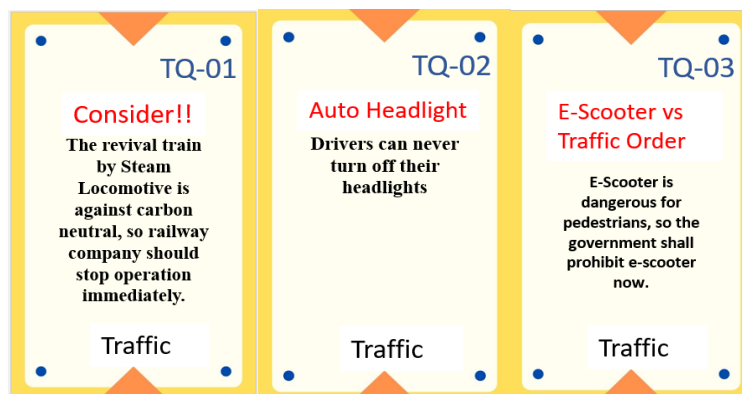


Fig. 2. Example of topic cards (contents, traffic)

Example 1(Traffic) The revival train by steam locomotives is against carbon neutrality, so a railway company should stop operations immediately.

Example 2 (Energy) Nuclear power plant is wrong because in a natural disaster, humans may not be able to mitigate nuclear meltdown. We should shut down immediately.

Example 3 (Food) To eat chicken at Christmas is an egoism of humans and can be perceived to be against animal welfare. We should mitigate such habits.

Topic Selection

The authors selected and compiled the topics by following policies:

1. Topics should be easy to read for anyone.
2. Topics should be based on current issues and not a future story.
3. Topics should be resolved by fusions of diverse aspects, and not be a one-sided solution.

If a topic is too complex technologically, nonengineer players should not be able to join. In such a case, the discussion is not interdisciplinary. Playing ELSI game with different background allows participants to recognize something new. Second, if the story is a completely future story. For instance, “Mining on the moon” cannot be imagined currently. Players prepare scenarios based on prejudices. Therefore, their ideas are not comparable. Thus, they cannot compromise. Therefore, current or past ELSI issues only were selected. We compiled strings carefully, not to lead only one solution. For example, “Resuming open-air nuclear test” is open for debate and may not extend discussion. Therefore, the authors did not consider such topics.

Solution Card

“Solution Cards” detail small ideas expressed in short words. Figure 3 displays the images. For three categories.

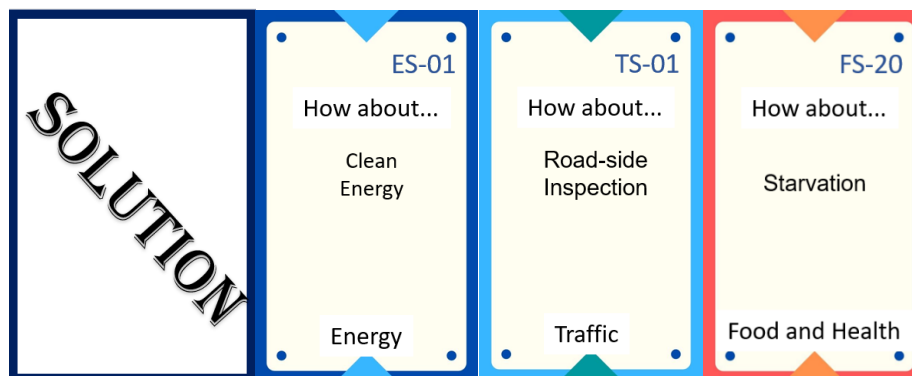


Fig.3. Examples of solution cards

A total of 90–120 cards were used for each category, including multipurpose words available for any topics. Here are some examples.

Traffic: Law, enforcement, license, patrol, inspection, insurance, smart mobility, exhaust gas, fuel efficiency, hybrid, connected, ecology, No_x, tollway, and automobile tax.

Energy: Safety, stable, voltage, blackout, professional, treaty, greenhouse gas (GHG), CO₂, power resource mix, solar, windmill, dam, engine, battery, charging station, hydrogen, new energy, carbon neutral, carbon zero, and zero emission.

Food: Calory, protein, fat, nutrition, diet, breakfast, starvation, food loss, vitamin, lunch, taste, alcohol, vegetarian, cigarette, sick, disorder, cancer, cure, treatment, counseling, and mental health.

Multipurpose: Safety, accident, education, learning, E-learning, school, Internet, smartphone, movie, virtual reality, augmented reality, television, police, punishment, science skill, innovation, public pollution, sustainable development goals, cost, time, security, sustainability, environment, discussion, negotiation, settlement, comprise, and lawsuit.

The authors gathered short words because people do not consider the solution based on the difficult theory. Easy words that appear randomly, suddenly, without context, inspire common people. For example, you visit lake, imagine artificial lake is developed by dam, focus on the

dam generating power, and understand the dam does generate green house gas. Thus, dam is the useful idea to prevent global heating.

Mismatch

Our thoughts are like clouds in the sky. “Dam,” is a useful word to be included in your scenario in energy-related story. However, this word has no meanings in food and health. Authors recognize such nature of human being’s consideration and provide an opportunity to change solution cards just once. The scene represents real people’s thoughts after the player had the topic.

4.3 Compiling scenarios

The player picks five solution cards. In case of necessity, they can draw cards again. Next, the player has five solution cards. The player compiles the scenario by using all cards, which is better than a rival.

For example, the authors demonstrated that when the topic is “shutting down the nuclear power plant” case.

Topic: *Nuclear power plant is wrong because it is beyond human control in a natural disaster. We should shut down immediately.*

Players A and B select the following solution cards:

Card Set of A: *Earthquake, Stable, Accident, Price, Greenhouse Gas (GHG), and Risk Management.*

Card Set of B: *Teacher, Dangerous, Solar, computer, Safety, and Propaganda.*

Players compile the scenario by using all words carefully. Now, both parties are ready and start to introduce ideas.

Scenario of A: *“Nuclear power generation because of its **stability**, low uranium **price**, and its **GHG** saving effect. But the possibility of sudden **Earthquake or Accidents** should be considered and preparation for **risk management** is necessary.”*

Scenario of B: *“**Teachers** taught us that nuclear power plant is **safety** technology, but it is a **propaganda**. We should learn the truth of **dangerousness** on March 11, 2011. We can learn alternative power resources by using **computer**.”*

4.4 Decision

Determining which scenario is better is critical. In scenario B, to assume that the school is cooperating government’s propaganda is too extreme. We should find clean energy resources, but a computer is just a one tool that we can use. We can easily imagine the “computer” from card and B was forced to use word computer, despite its awkwardness. In scenario A, a contradiction does not occur, and most people agree the opinion. Therefore, in this match, A wins, he receives 100 from B.

4.5 Debriefing

At the end of the game, the players report their learning throughout their experiences, following the most frequently appearing “Topic Cards.” While listening to many other ideas, the students gradually recognize that, even though the story is the same, there are no exact or perfect solutions. We can proceed to the ultimate solution only by gathering such thoughts and understandings—that is a nature of ELSI issue.

5 Experiment

The authors experimented the ELSI game at National Institution of Technology, Kita-Kyusyu College, in Fukuoka, Japan, on January 6, 2023. We testified the Energy version, for fourth-year college students (freshmen grade). Students majored in robotics and mechanics. The number of participants was 40. The authors conducted the questionnaire after playing the game, and major results are presented in Table 2.

Table 2. Questionnaire result after playing ELSI game (n = 40)

Question No.	1	2	3	4	5
Question	The Resolution of ELSI issue includes not only technological matter, but also social matter.	We must recognize the issue over science, Technology, and Society in our daily life.	There are many ELSI issues that we don't pay attention in our daily life.	I recognize there are ELSI issue which has no solution yet.	We need to learn ethics, law, society, or media to learn science or technology
Average	4.325	3.925	4.25	4.125	4.225
Strongly Agree(5)	45%	20%	40%	33%	35%
Weakly Agree(4)	43%	53%	45%	48%	53%
Normal(3)	13%	28%	15%	20%	13%
Weakly Disagree(2)	0%	0%	0%	0%	0%
Disagree(1)	0%	0%	0%	0%	0%

Total percentage of “Strongly Agree” and “Weakly Agree” is higher than 70% overall questions. Negative Answers are zero.

Questions 1, 2, and 3 query students whether to recognize ELSI is an issue or not. For Q3, 85% students answered “we did not pay attention” to those issue, and for Q2, 73% people responded that the ELSI issue should be recognized. For Q1 and Q4, we asked participants to resolve ELSI issues. For Q1, 88% students responded that ELSI resolution is not only a matter of technology but also a story of society. We can estimate a result of Q4 reflects their learning experiences. They could not make a fine solution but made an incomplete resolution. Furthermore, Q2 and Q5 detail understandings on required further learnings, and more than 80% students agreed.

Although we did not have data before playing the game, nor experiences, or knowledge came from other lectures, this game raised student’s motivation to recognize and learn ELSI issues. However, further examination of learning effectiveness is urgent, and we should improve the quality of the game by repeating practices and evaluations.

6 Discussions

The rules of the games are easy, and most students understand how to play the game. By repeating the match, they understand only one correct answer does not exist on ELSI and learn different ideas that could be built based on ideas previously provided. This method is crucial for ELSI education. We should not impose others own opinions. If such a force is involved in discussion, they cannot compromise together. Discussions from diverse ideas are effective, and they are the only method to confront the ELSI issue.

Currently, we have only three series of card sets, namely traffic, energy, and food and health. The idea can be extended to other topics. The ELSI game has a flexible framework to apply other ELSI issues.

Most engineers do not welcome ELSI, but authors wish to improve the opportunity to learn, share, and discuss ELSI issue by playing the ELSI game.

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Technology Transfer SIG
Board Game in Region SIG
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A motivator game for forensic vigilance training

Exploring the potential of the card game ROTBEESTEN?! as compared to treatment as usual*

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Abstract. In the field of forensic mental healthcare, forensic vigilance is an important skill of healthcare professionals to deal with criminal behaviour of patients. The facilitated, collaborative card game ROTBEESTEN?! was developed to motivate professionals to enrol in forensic vigilance training. A controlled experiment was conducted with professionals from a Dutch forensic mental healthcare facility to explore the potential of the motivator game. The control condition involved ‘treatment as usual’: an oral presentation followed by a group discussion. Questionnaires, interviews and observations were used to measure certain participant characteristics, the quality of the game, and the user experience in both conditions. Respondents expressed significantly higher preferences for active, experiential learning styles than for learning from theoretical sources. In addition, respondents evaluated the quality of the game positively. Finally, respondents reported significantly higher scores on four out of five dimensions of (game) experience in the experimental condition than in the control condition. Limitations of the study include a low response rate to the post-questionnaires. As a result, the effects of both the game and presentation could not be established reliably. From the results, we may conclude that the game ROTBEESTEN?! was evaluated more positively and has more potential to motivate participants for follow-up training activities than ‘treatment as usual’ (an oral presentation). These findings are in line with the preferred learning styles reported. Games seem promising tools to motivate (healthcare) professionals to enrol in training activities. Future research will establish if indeed the game’s motivating effects exceed those of an oral presentation.

Keywords: motivator game, controlled experiment, forensic vigilance, learning styles, game experience.

1 Introduction

In the field of forensic mental healthcare, healthcare professionals provide care to patients with generally complex psychiatric problems and criminal backgrounds. The primary goal is to contribute to public safety by reducing and managing risks of patients committing crimes. In addition, at patient level efforts are made to build up protective factors and increase quality of life.

Organisations for forensic mental healthcare employ various types of healthcare professionals, such as psychiatrists, psychologists, psychotherapists, nurses and social workers. They have different educational backgrounds and are all required to attend periodical training on topics such as risk assessment, suicide prevention, and *forensic vigilance*. The latter is an umbrella term of all competences necessary for forensic mental healthcare professionals to deal with (the risk of) aggressive/delinquent behaviour (Clercx et al., 2021).

Fivoor, an organisation for forensic mental healthcare care in the Netherlands, offers an elaborate training programme for their healthcare staff. Although the programme has high quality

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standards, participants have voiced dissatisfaction with the teaching methods employed. Traditional methods, such as oral presentations, are perceived as being monotonously focused on cognitive skills and leading to passivity among trainees. The management recognises that consuming information passively may reduce the motivation to learn or continue learning. If training does not meet the needs of their staff (in terms of content or form), they mentioned it may prove ineffective and therefore not lead to the intended improvement of knowledge, skills and attitude. The latter is particularly an issue with regard to forensic care, which, according to the management, requires healthcare professionals putting theoretical knowledge into practice in interaction with patients and other stakeholders. The management believes that “doing and experiencing, and above all practicing, can prove to be more effective than a traditional teaching approach”.

Therefore, Fivoor and Delft University of Technology joined forces to develop and evaluate the card game ROTBEESTEN?!¹ to explore how game-based approaches may motivate healthcare professionals to make better use of the existing training portfolio. For this paper we established how healthcare professionals evaluated the quality of the game and how they experienced playing the game. We compared the game to an oral presentation followed by a group discussion, a method commonly used by healthcare organisations for motivating healthcare professionals (treatment as usual).

It was decided to design and deploy the game specifically within the context of outpatient treatment, where patients are treated who live at home (i.e., not being admitted to a closed ward of a forensic mental healthcare hospital). Section 2 provides theoretical background about forensic vigilance and its importance in outpatient treatment in particular. It also discusses game-based activities in relation to oral presentations. Section 3 outlines a controlled experiment, that was used to explore the potential of the motivator game as compared to treatment as usual. It also discusses the design of the game and game session (including debriefing). The experimental results are presented in Section 4 and discussed in Section 5 where the conclusions are drawn as well.

2 Background

Below, we explain the concept forensic vigilance in the context of outpatient treatment. Also, we hypothesise how the organisation may benefit from a game-based approach, instead of a traditional approach, to motivate staff for forensic vigilance training.

2.1 Forensic vigilance in outpatient treatment

Until recently, the construct *forensic vigilance* lacked a clear definition, despite its widespread use in the field of forensic mental health care in the Netherlands. A study by Clercx et al. (2021) provided a first definition:

“Forensic vigilance is anticipating on possible escalation of a situation before it happens, by actively observing your surroundings and colleagues, and knowing when an observation requires action. Forensic vigilance requires awareness of the patient(s), their mental disorder, criminal history and awareness of the context of a forensic setting. It is being able to recognize even subtle signs of possible escalation, the capacity to communicate with colleagues about observations, doubt, uncertainty or gut feelings, and the willingness to act when necessary.” (Clercx et al., 2021, p. 14).

¹ ‘Rotbeesten’ is a Dutch translation of ‘dirty beasts’ (the title of a poetry book for children by Roald Dahl). We chose this ambiguous title (and deliberately added ‘?!’) to refer to the fictitious patients featuring in the game (in the analogy of an animal world). The reason is that although forensic patients can behave truly badly and dangerously to others, they are also stigmatised as “unwanted members of society”. Forensic patients often struggle with their lives, due to severe problems dating back to childhood and few possibilities to improve their personal circumstances.

In our research, we focused on forensic vigilance in the context of outpatient treatment. Forensic mental health care distinguishes *inpatient* treatment (in a forensic mental healthcare hospital) from *outpatient* treatment (where patients live at home and are visited by their therapists or come to de outpatient clinic for treatment). Due to the specific context, experts at Fivoor expressed that forensic vigilance in outpatients settings differs from inpatient settings in three main ways. First, while inpatients are incarcerated, outpatients live their life amid other citizens and, therefore, sometimes pose a direct threat to their environment. Weighing a possible threat to the community versus the wellbeing of the patient presents a prominent tension between interests in outpatient treatment that professionals have to consider. Compared to inpatient treatment, in outpatient treatment this tension is often exacerbated by limited resources and judicial measures, i.e. even when the forensic risk is high, therapists may have limited means to admit a patient involuntarily to a forensic psychiatric hospital. Second, while in inpatient clinics the patients' behaviour can be observed by an entire team of care professionals, the therapists in outpatient facilities often need to rely on what their patients and their relatives tell them. Finally, while inpatient treatment is mostly limited to a short period, outpatient treatment is often long term. As part of their forensic vigilance, outpatient therapist have to take into account that coercion – which is sometimes necessary to reduce the forensic risks – might damage the often crucial long-term relationship with their patients.

Because of the three aforementioned complicating factors in outpatient treatment, enhancing forensic vigilance of therapists working in forensic outpatient facilities was considered to be of priority. Therefore, it was decided that the game ROTBEESTEN?! was designed and deployed within the context of forensic outpatients treatment.

2.2 Game-based activities vs oral presentations

The benefits of game-based activities have been studied extensively and include increased motivation, more pronounced learning effects, and longer retention rates (see, *e.g.*, Prensky, 2001; Sitzmann, 2011; Duchatelet, Jossberger, and Rausch, 2022). In the medical domain, a recent study showed that a certain computer game promoted flow, motivation, and learning achievements of third-year students due to the activating features of the game and its focus on problem solving (Zairi, et al., 2022). However, few examples exist of studies that compared game-based activities to oral presentations in a systematic way. Grimley et al. (2012) compared computer games to traditional lectures for the instruction of first-year students enrolled in a Computer Games and Education course. The experiment showed that participants who played the computer game felt more challenged and valued the activity more than the participants that attended regular lectures. Although the context of the aforementioned study differs substantially from our situation (different types of participants, different learning goals, and different type of game) we used its outcomes to formulate a hypothesis for our study: professionals in mental health care will feel more challenged in game-based activities and will value the activity more than oral presentations.

3 Experimental design

A controlled experiment was conducted with approval from the Human Research Ethics Committee of Delft University of Technology (application ID 2233). In the experimental condition, participants played the card game ROTBEESTEN?! and participated in the plenary debriefing afterwards. The control condition involved treatment as usual: participants attended an oral presentation followed by a group discussion moderated by a facilitator.

3.1 Participants

The participants were members from four teams of healthcare professionals at the Fivoor outpatient facility in The Hague. Participants were motivated by their manager to attend both the

game and the oral presentation (on different days). Participants were exempted from other work activities during the parts of the days when the experiment was conducted and participants were offered a free lunch. Participation to the research activities (questionnaires, interviews) was on a voluntary basis.

3.2 Materials

We adopted a mixed-methods approach with a sequential explanatory design (quantitative outcomes informed the use of qualitative methods). Anonymous questionnaires, semi-structured interviews, and observations were used to establish various background variables and to measure the quality of the game and the user experience in both the experimental and control conditions.

The pre-questionnaire (Pre) measured the following background variables: gender, age, profession, years of experience, frequency and enjoyment of playing games as a leisure activity, and participants' learning style (Learning Style Inventory; Kolb, 1985). The post-game questionnaire (PG, experimental condition) measured: quality of the game (eight items on a 5-point Likert scale, developed by the authors) and user experience in the game (in-game experience questionnaire (iGEQ); IJsselsteijn, de Kort, and Poels, 2013). The post-presentation questionnaire (PP, control condition) measured user experience during the video presentation and group discussion. For this, certain questions from the iGEQ were selected and adapted by the authors). More details on the psychometric constructs and measurement scales used can be found in Section 4.

All questionnaires were implemented on the Qualtrics XM platform. To match pre- and post-questionnaire responses anonymously, participants were asked to enter the last three digits of their mobile phone number in either questionnaire.

To explore explanations for the quantitative results, an independent interviewer conducted semi-structured interviews with volunteers who had entered their e-mail address in the post-questionnaire. Interviewees were asked how they evaluated the game as compared to the presentation and to explain the differences in their evaluations. Due to the exploratory nature of the study, no specific coding scheme was applied. Instead, we used quotes for possible explanations of the quantitative results.

Independent observers were present at the game sessions and presentations and took anonymous notes of the participants' behaviour in both the experimental and control group. Again, in line with the exploratory nature of the research, no structured observation protocol was used.

3.3 Procedure

The experiment consisted of two rounds of activities and three questionnaires (see **Fig. 1**). The first round of activities was scheduled on 13 September 2022. For the sake of continuity of patient care, the sample of participants was divided into two groups. Due to the limited availability of the facilitators, the first group played the game (experimental group) in the morning while the second group was the control group in the afternoon. In the second round of activities (three weeks later on 4 October), the experimental and control groups were reversed. Informed consent was obtained from the participants by means of the opening statements of the questionnaires.

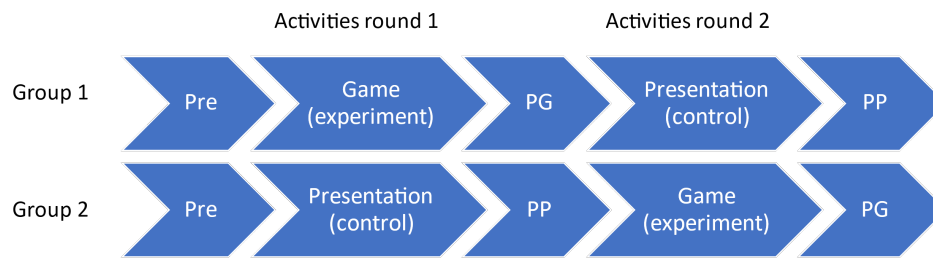


Fig. 1. Activities in the experiment. ‘Pre’ refers to the pre-questionnaire; ‘PG’ and ‘PP’ refer to the post-game questionnaire and post-presentation questionnaire, respectively.

3.4 Design of the experimental condition (game)

The game ROTBEESTEN?! was designed as a facilitated, collaborative card game that is played by multidisciplinary teams of 8 – 15 healthcare professionals from outpatient forensic mental healthcare facilities (see Fig.). The game is situated in a fictitious world inhabited by various animal species with typical human traits. Some animals in the game world suffer from mental health problems and have a tendency toward criminal behaviour. These animals are treated by the healthcare professionals playing the game. The game world was deliberately modelled as an animal world, as interviews with potential players revealed that the use of real, human patient data (even if anonymous) would infringe a feeling of safety and security during game play.



Fig. 2. Participants playing the game ROTBEESTEN?!

The game is played in four rounds of 10 – 15 minutes each. In every round, the players choose a team leader who is in charge of treating an animal patient. The facilitator (not a player) gives the team leader a card containing a case description and three options for treatment: continue the treatment as is, intensify the treatment (scale up) or lighten the treatment (scale down). The team leader then explains the case and treatment options to the other players. All players now receive three game cards representing three categories of information about the patient based on knowledge, intuition, or experience. The front of each card features a question about the patient, while the back presents the answer to the question (see example in Fig. 3). Players cannot read the answers until they selected one card and discarded the other two cards. Only then they may turn around the selected card and read the answer. The team leader now starts a discussion about

which of the three treatment options to choose. Team leaders may ask the other team members for information about the patient (stated on the game cards) but they ultimately choose a treatment option themselves.

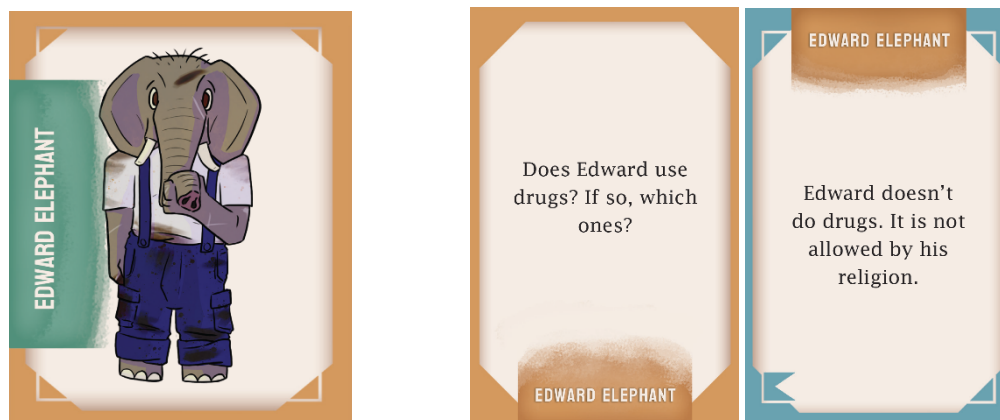


Fig. 3. Examples of game art for game character Edward Elephant. The middle and right-hand figure are the front (question) and back (answer) of the same game card pertaining to a patient.

At the end of each round the team leader rolls a die to determine how the patient behaved in response to the team's treatment: the patient may have either committed a crime or improved their behaviour, depending on the die roll. The chances of either behaviour also depend on the treatment option chosen: intensifying the treatment costs resource points, but may reduce the risk of criminal behaviour, *vice versa*. The aim of the game is to minimise both the criminal behaviour of patients and the use of resources: less criminal behaviour and less resource use result in a higher game score.

In round three or four, the facilitator interrupts the game: one of the patients that was discussed in a previous round goes through a crisis and requires immediate help from the team. The players have two minutes to decide how to respond.

The game was led by experienced facilitators from the Delft University of Technology's Gamelab. In future, a game session will feature two facilitators from the Fivoor organisation itself: one therapist and one support staff member who focus on the contents (*e.g.*, debriefing) and logistic aspects of the facilitation process, respectively. Combining both facilitation aspects in one person appeared to be unfeasible. A facilitation manual and a facilitator workshop were developed to instruct future facilitators from the organisation.

An introductory story was developed for the content facilitator to brief the participants and ease the transfer of a player's mindset into the fictitious game world. After the briefing, the technical facilitator takes over while the content facilitator observes the session and makes notes for the debriefing after the game.

The debriefing consisted of four activities and/or group discussions. First, the content facilitator selected and read a game epilogue – six different epilogues were developed for different ranges of the team's final score. Second, participants were given the chance to blow off some steam. For this, the facilitator asked plenary questions like "How did it go for you?" or "To what extent were you absorbed in the game?" Third, the participants were encouraged to collectively investigate the game and its meaning. For this, the facilitator asked plenary questions like "What do you think is the game about?" or "How does the game relate to your daily work?". Fourth, the participants were asked to discuss the concept forensic vigilance. For this, the facilitator asked plenary questions like "What does 'forensic vigilance' mean to you?" or "How

would you like to further improve your forensic vigilance knowledge and skills?" The game and debriefing together lasted for about two hours.

In the future, players will receive a card with a take-home message and pointers to Fivoor training activities that they could enrol in as a follow-up to the game session. These cards were not yet available during the experiment.

3.5 Design of the control condition

The control condition was designed as a 1-hour, on-site workshop consisting of a word of welcome/introduction (10 minutes), a video presentation (30 minutes), and a facilitated group discussion about the video (20 minutes).

An introduction emphasising the importance of forensic vigilance in daily practice was given by the manager of the outpatient clinic (also a therapist). The manager and 18 – 28 participants were all present in person in one of the organisation's conference rooms. The video presentation was a pre-recorded lecture by leading Dutch expert in forensic vigilance Maartje Clercx (see Fig. 4). We decided upon using a video presentation, instead of a live presentation, for logistic reasons: a video presentation made the planning of the experiment less dependent on the availability of the expert.

Using slides, the expert addressed the significance of forensic vigilance and explained the process of establishing its definition. She clarified the definition itself and elaborated on characteristics of professionals (such as personality traits and years of working experience in forensic psychiatry) associated with forensic vigilance. After the video presentation, the participants discussed as a group the concept of forensic vigilance and the importance and meaning thereof in their daily work. The discussion was moderated by the manager.

The contents of the presentation differed from those of the game. However, given the purpose of both instruments – motivating participants to enrol in training activities, not the training itself – these differences were not considered problematic.

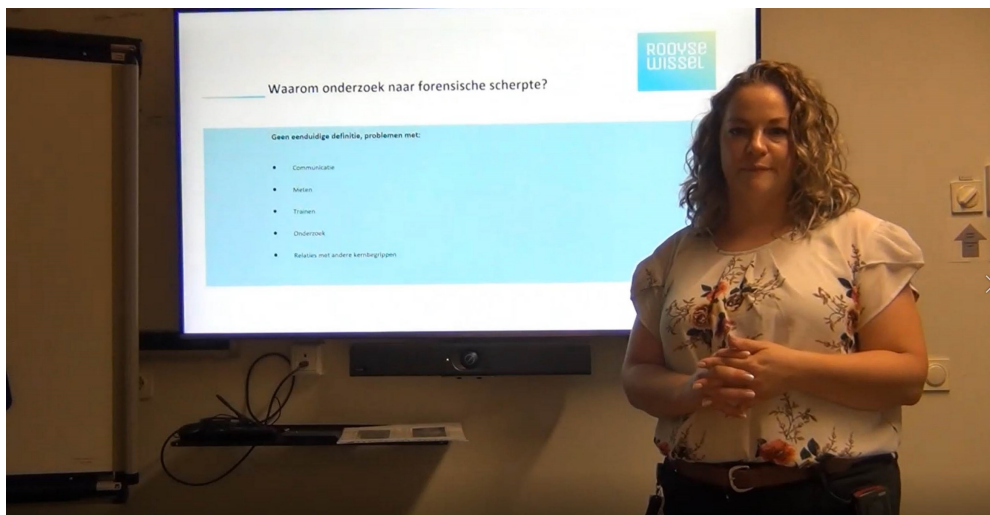


Fig. 4. Still from video presentation by forensic vigilance expert Maartje Clercx

4 Results

A total of 63 respondents completed the pre-questionnaire. The characteristics of the sample are shown in **Table 1**.

Table 1. participant characteristics

Age	Range 21 – 54 years (M=36, SD=7)
Gender	female (71%), male (29%)
Professions	social worker (32%), nurse (34%), psychologist (25%), other (9%)
Work experience	Range 0 – 22 years (M=5.8, SD=4.8)
Frequency of playing games	Seldomly (24%), a few times a year (21%), monthly (33%), weekly (22%)
Enjoyment of playing games	very much (49%), a little (35%), very little (16%)

4.1 Quantitative results

The responses to the pre-questionnaires were merged and so were the responses to the post-game (PG) questionnaires and the responses to the post-presentation (PP) questionnaires.

4.1.1 Participants’ preferred learning styles

Boxplots of the respondents’ scores (N=63) on four learning styles from Kolb’s Learning Style Inventory (LSI; Kolb, 1985) are shown in **Fig. 5**.

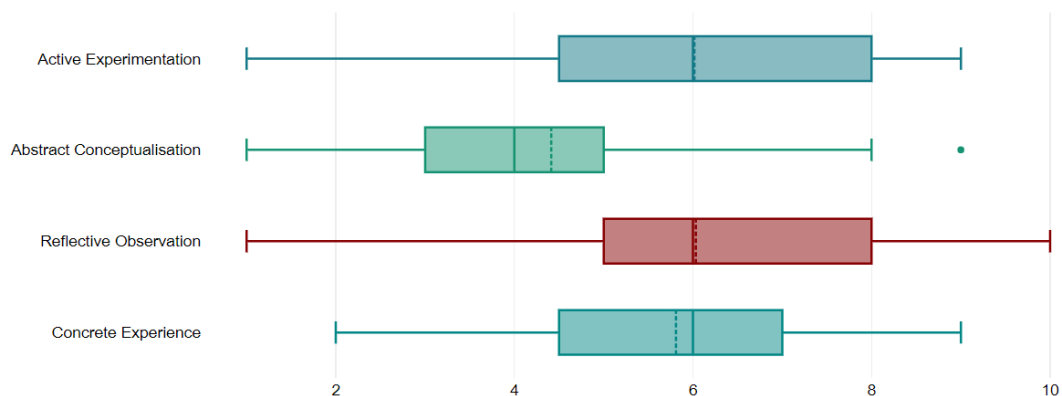


Fig. 5. Boxplots of the respondents’ scores for four learning styles (Kolb’s LSI, N=63) (1985). Each learning style was scored on a 10-point scale.

Paired-samples t-tests with the LSI scores revealed that there are no significant differences between participants’ mean scores for Active Experimentation (AE; M=6.0, SD=2.1), Reflective Observation (RO; M=6.0, SD=2.1), and Concrete Experience (CE; M=5.8, SD=1.8) at the 0.05 level. However, the mean score for Abstract Conceptualisation (AC; M=4.4, SD=1.8) is significantly smaller than AE ($t(62)=-4.607, p<.001$), RO ($t(62)=5.913, p<.001$), and CE ($t(62)=3.615, p=.001$).

Therefore, the results show that the respondents, on average, prefer to learn from personal involvement with people in everyday situations (CE), observing situations from different points of view (RO), and trying out methods and strategies (AE), more than from the use of theories and logic to understand problems or situations (AC).

4.1.2 Quality of the game and game session

A total of 29 participants responded to the items in our post-game questionnaire about the quality of the game and the game session. This number is considerably smaller than the response to the pre-questionnaire, due to the fact that many participants needed to leave immediately after the debriefing. Multiple reminders were sent to complete the post-questionnaire, but the response rate remained low. The responses were visualised as boxplots in Fig. . In the Figure, the dotted lines that represent the mean scores are centred around the value 4. Therefore, the results indicate that on average the participants agree with the propositions about the quality of the game and the game session.



Fig. 6. Boxplots of the quality of the game and game session. Items were scored from 1 (completely disagree) to 5 (completely agree).

4.1.3 Game experience

A total of 29 participants responded to the items in our post-game questionnaire about in-game experience (iGEQ). The responses were visualised as boxplots in Fig. . The iGEQ measures seven dimensions of game experience. The results show that, on average, the respondents scored high on the dimensions Competence, Immersion, and Positive Affect (mean scores in between the values 5 and 6). Moreover, the respondents had intermediate scores on the dimensions Flow and Challenge (mean scores near value 4). Finally, the respondents scored low on the dimensions Tension and Negative Affect (mean scores between 1 and 2). This means the respondents experienced little tension and few negative emotions while playing the game.

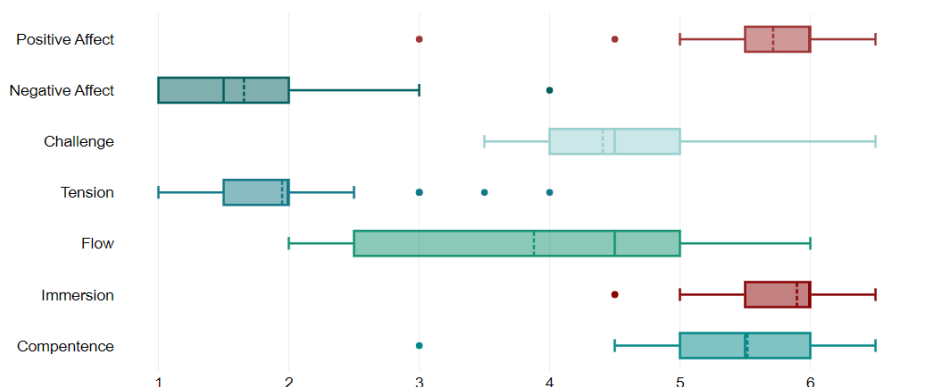


Fig. 7. Boxplots of responses to the in-game experience questionnaire (iGEQ). Items were scored from 1 (completely disagree) to 7 (completely agree).

4.1.4 Effect of background variables on reported quality and experience

A total of 20 participant (13 female, 7 male) responded to both the pre-game and post-game questionnaire. Mann-Whitney U-tests were applied to analyse a gender difference in average scores for quality and experience of the game. The resulting significant differences are shown in **Table 2**.

Table 2. Gender difference in average scores for quality and experience of the game.

	Mean Rank			U	p
	Women	Men			
The game was overall well designed	12.81	6.21	15.50	.01	
The debriefing encouraged me to think	12.92	6.00	14.00	.01	
The game cards were clear	12.85	6.14	76.00	.01	
Positive affect	12.85	6.14	15.00	.01	

The Table above shows that on average women scored significantly higher on three items measuring the quality of the game and game session, and on one dimensions of game experience (positive affect). The differences on the other items and dimensions were not significant at the 0.05 level and were therefore not reported. Consequently, the variable Gender seems modify the reported quality and experience of the game to a certain extent, but this could be due to the relatively low sample size.

No significant differences were found when the sample was divided along other background variables (age, profession number of years of experience, learning style, and the frequency and enjoyment of playing games). Therefore, the results suggest that the reported quality and experience of the game did not depend on the age, profession, etc. of the respondents.

4.1.5 Participants' experience of the game vs the presentation

Of all respondents, 17 respondents both played the game (experimental condition) and attended the presentation (control condition) as well. We applied 1-tailed related-samples Wilcoxon signed rank tests to determine the difference between the reported experience of the game versus the presentation. The alternate hypothesis read: "the experience of the game is more positive than of the presentation". **Table 3** provides the results.

Table 3. Participants' experience of game (experimental condition) and of the presentation (control condition). The five dimensions of experience were measured in the range 1 – 7.

Dimension	Game		Presentation		Wilcoxon (1-tailed)	
	M	SD	M	SD	Z	p
Immersion	5.76	0.73	4.41	1.14	-3.35	.001
Flow	3.44	1.38	2.59	1.12	-1.93	.03
Challenge	4.21	0.69	3.88	0.74	-1.39	.08
Negative affect	1.85	0.63	3.71	1.41	-3.38	.001
Positive affect	5.59	0.81	4.88	1.13	-2.23	.01

We found that participants experienced the game significantly more positively than the video presentation on four out of five dimensions (immersion, flow, negative affect, positive affect). On the remaining dimension (challenge), the game scored more positively than the presentation, but the difference was not significant at the 0.05 level.

4.2 Qualitative results

Semi-structured interviews were conducted with six participants of both the game and video presentation (3 female, 3 male; age: $M=40$, $SD=12$ yrs). The outcomes confirmed the quantitative results shown above: the game was evaluated more positively than the video presentation in terms of 'immersion', 'flow', 'negative affect', and 'positive affect'. For instance, a female participant (age 34) mentioned "the game stimulated me much more than the video presentation" (higher 'immersion'). A male participant (age 64) confirmed that the game helped to stay focused more than the video presentation did (more 'flow').

In addition, the interviewees explained that the interactive and social characteristics of the game were the main reasons for them to evaluate the game more positively than the video presentation. For instance, in the game they enjoyed working as a team in a way that resembled their daily practice, whereas they experienced the video presentation as an individual activity that was less related to their everyday work. All interviewees also viewed the game as a team-building activity.

Some interviewees remarked spontaneously that the presentation (control condition) being a pre-recorded video, instead of a live presentation, did matter to them: they would have evaluated a live presentation more positively than a video recording. Interestingly, other interviewees mentioned that the format of the presentation did not matter to them: they stated that recorded and live presentations are equally difficult for them to maintain focus on.

The observations made during the game sessions and video presentations are also in line with the results presented above. At the start of the video presentations, the participants seemed interested and keen to learn, but this faded when the presentation progressed: participants started talking with each other about other topics than the presentation and some used their phones for non-related activities. During the game, none of these things occurred: participants stayed focused on the activities and actively engaged in the discussions.

5 Discussion and conclusions

The Fivoor management aims to develop innovative instruments for professional development of their staff. The results above state that a sample of 63 of their healthcare professionals prefers instruments that, in the terminology of Kolb's Learning Styles Inventory (1985), provide Concrete Experiences and allow for Reflective Observation, and Active Experimentation with real-world cases, rather than Abstract Conceptualisation based on theoretical knowledge.

The game ROTBEESTEN?! was developed as such an innovative instrument to motivate professionals to enrol in forensic vigilance training. In a controlled experiment, healthcare professionals who participated in this game and debriefing evaluated it more positively than a treatment as usual consisting of a video presentation and group discussion (control condition).

How participants perceived the quality of the game did not depend on the background variables age, profession, work experience or the frequency and enjoyment of playing games. Therefore, the game seems suitable for a wide range of participants. However, some gender differences were found, where female participants evaluated the game significantly more positively than male participants, but this could be due to the relatively small number of 20 respondents who completed both the pre-game questionnaire and the post-game questionnaire.

When compared to the control condition, the user experience in the game scored significantly better on four out of five dimensions: Immersion, Flow, Negative Affect, and Positive Affect. The game scored higher on the dimension Challenge than the control condition did, but the difference was not significant at the 0.05 level. Interestingly, other authors reported an increased experience of challenge among game players when compared to lecture attendants (Grimley et al., 2012). This may be due to different interpretations of the dimension 'challenge'. Some of our interviewees stated that staying focused on the presentation was a big challenge for them, which is different from the regular meaning of 'challenge'.

Qualitative results of the experiment were used to explore explanations of why the game was evaluated more positively than the oral presentation. Most interviewees indicated that they had trouble staying focused on the presentation, while this was not a problem in the game. Also, they experienced a lot more pleasure from the game. These results were confirmed by the authors' observations in both conditions of the experiment. The main reasons, as reported by the interviewees, for these differences are the fact that the game fitted their preferred learning style much more closely than the presentation. The interactive game experience in which players actively collaborated with colleagues on concrete, real-world cases in a fictitious world helped them to stay concentrated on the activities much more than the presentation which appealed to more abstract conceptualisation capabilities of participants. Our analyses showed that abstract conceptualisation was a significantly less preferred learning style among our respondents.

5.1 Limitations and recommendations for future work

In the design of the experiment, certain choices were made that limit the generalisability of the results. For instance, in the control condition it was decided to use a video presentation instead of a live presentation, due to the limited availability of the presenter. Some interviewees indicated that their evaluation of a live presentation could have been better than of the video, although others reported that it would not have made a difference. To study this potential effect, we recommend to compare the game to a live presentation as well.

Also, the response to the post-questionnaires was lower than expected (50% fewer respondents than to the pre-questionnaire). This, and the fact that participants volunteered for being interviewed afterwards, may have caused a bias in the response: participants who did not enjoy the game may have refrained from completing the post-questionnaire or from volunteering for being interviewed. However, observations during the sessions do not point in that direction – the players all seemed equally appreciative of the game session, while they almost unanimously seemed to dislike the control condition. To confirm these observations, we are currently preparing more experiments to increase the response. This will allow for more powerful statistical analyses of the results and enable us to systematically and reliably determine the effectiveness of the game.

Finally, in this exploratory study, no attention was paid to the costs involved in developing the game with respect to developing traditional motivational instruments such as presentations. Follow-up research into the cost-effectiveness of ROTBEESTEN?! would be helpful to understand the feasibility of such games.

5.2 Conclusions

The card game ROTBEESTEN?! was developed to motivate professionals at mental healthcare provider Fivoor to enrol in existing training in forensic vigilance. Players of the game evaluated it more positively than treatment as usual (a presentation). They reported difficulties to stay concentrated on the presentation, where this was not the case for the game. The persuasive elements of the motivator game seemed to match the learning style preferences of our sample of participants better than traditional instruments that focus on the transfer of theoretical knowledge. Also the facts that the game is played in teams and contains many interactions helped to stay focussed on playing the game. From the experimental results we may conclude that games are promising tools to motivate (healthcare) professionals to enrol in training activities – perhaps more promising than oral presentations with the same purpose. We are currently in the process to extend the experiment and improve the response to our surveys to follow-up on this exploratory study and systematically establish the effectiveness of the ROTBEESTEN?! game.

Acknowledgement

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EXTENDED ABSTRACTS

A Story of Landscape Change - Exploring trajectories of Shifting-Cultivation through Games: Lessons from the field...

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Abstract. Some landscapes are contested, even when the rights of the indigenous people managing the land are protected by the constitution. Wildlife does not know where a National Park ends, and indigenous forests start. Those in charge of protecting the wildlife see these forests go up in flames, and want traditional farming methods to stop. They lobby to take the rights of the local farmers away, hoping to extend the park into their lands. This study took place within this conflict, and aimed to understand landscape change, by starting with understanding what motivates farmers to transition away from one system, shifting cultivation, into another, for instance plantation crops.

In the model we explored the resource allocation strategies of farmers of the Karbi tribe in Northeast India. Using Companion Modelling, we co-developed a role-playing game of the local farming system. Within the game, farmers allocated labour and cash to meet family needs, while exploring new opportunities like bamboo, rubber and tea. In the game, farmers embraced new options where investment costs, especially monetary investments, are low. Returns on these investments were not automatically re-invested in the farming system. Instead, most money made is spend on the next generation's education. The gamescape changed profoundly as a result of changing farmers' strategies. Natural ecological succession was replaced by an improved fallow of marketable bamboo species. Plantations of tea and rubber became a bit more prevalent as time progressed, while old practices that ensure family food security were not yet given up.

Keywords: System Transition, Shifting Cultivation, Landscape Change, Assam India, Role Playing Game

1 Shifts in Cultivation

Shifting cultivation is still a widespread farming system throughout the tropics, constituting the main production method for the rural poor living in tropical forest margins. Landscapes shaped by shifting cultivation currently cover roughly 280 million hectares worldwide [1]. There is no clear global trend that describes changes in the use of shifting cultivation. Farmers are still, maintaining, extending or departing from the practise [2–5]. Though shifting cultivation often described as a main cause of both forest degradation and deforestation [6], it is the discontinuation of the practise, and its replacement by intensified land uses, that results in far longer lasting negative environmental impacts [1], including the loss of biodiversity and reduced carbon stocks [7–8]. The patchy landscape, with vegetation of different ages regenerating and maintaining a high conservation value, both for flora and fauna, ends up becoming dominated by annual crops and/or permanent plantations grown in monocultures.

In this study, we focus on the Karbi Anglong hills in central Assam, Northeast India. The hills are predominately used for a shifting cultivation system, locally known as jhum, and have not yet undergone significant changes (e.g., [9–10]), despite efforts by the Indian Government to replace the perceived ecologically harmful practices with more economic beneficial cash crop systems [11–12].

However, not only the Karbi farmers are dependent on this landscape. The wildlife of Kaziranga National Park, uses the forested hillsides for refuge during the monsoon season, as the Brahmaputra floods the park completely.

With rubber, bamboo and tea emerging as alternatives to jhum [12] for small-scale farmers; their decisions have the potential to shape their livelihoods, the landscape and the conservation effort of the Indian Government.

2 Model Construction

To investigate jhum farmers' decision making and livelihood strategies, we adopted a constructivist approach based on participatory modelling [13–17]. We co-developed together with local jhum farmers a haptic model of their landscape in the form of a role-playing game and invited them to play out their livelihood strategies (Fig 1, 2a & 2b). Specifically, we examined how jhum farmers allocated their resources (i.e., labour tokens and money) when having the opportunity to plant rubber and tea and sell bamboo, and how their allocation strategies impacted their income in the game. From this we identified what the farmers' resource allocation revealed about their priorities and values concerning their livelihood. Finally, we recorded the impact of the farmer's decisions on the game board mimicking their landscape.

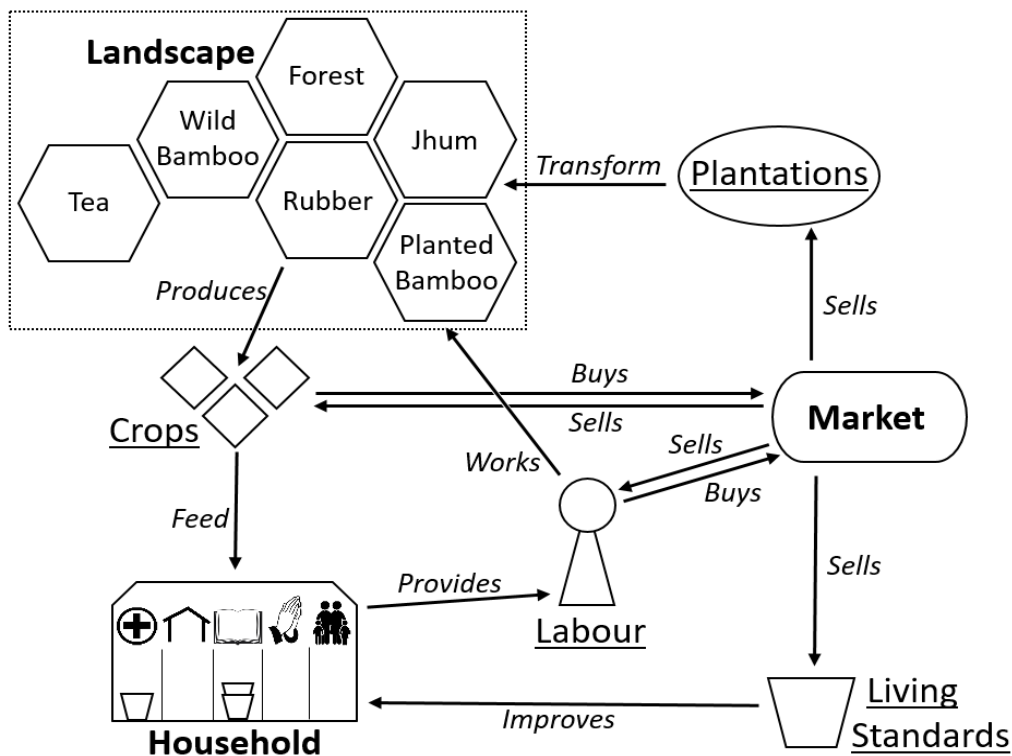


Fig. 1. A schematic representation of the model, and its main components.



Fig. 2a. The landscape of the game at the end of the game session, the result of simulating 18 years of decision making and landscape dynamics.



Fig. 2b. The investment categories that represent living standards, and the investments made by one of the players.

3 Results & Discussion

Over the course of the game, players allocated most of their labour tokens to jhum (Fig. 3a), which also remained their main source of income throughout the game, closely followed by harvesting planted bamboo (Fig. 5). Most of their wealth was invested into improving living standards, in particular education (Fig. 4). Most players, 39 out of the 48 participants, invested money in tea before the end of the game, while 17 of the players chose to invest in rubber. However, the total investment, compared to the other spending categories was small (Fig. 4a & 5). and plantations never represented more than 16.27% of the landscape (Fig 6a).

The maintenance of jhum cultivation alongside the increase in bamboo harvesting suggests that farmers are not aiming to maximize their income per unit of labour. One of the reasons brought forward by the players during the game sessions was that jhum rice is considered to be tastier than food from the market, also attributing higher health benefits to rice and vegetables intercropped and grown on their jhum. The strategies of the farmers impacted the landscape. It transitioned from a forest and wild bamboo dominated system towards a landscape that is dominated by planted bamboo with few rubber and tea plantations in between. The traditional jhum system has only recently seen the introduction of bamboo gardens as an improved fallow [18–20]. As time progressed in the game, these fallows took over, while the first plantations slowly appeared in the game landscape. The planted bamboo was described by some of the players to be a stepping stone that allows for investments in tea and rubber at a later stage. However, only when livelihood costs are sufficiently covered was money invested in plantations. Once local processing infrastructure gets developed and highway access to international markets, especially China and Myanmar is improved, farmers might seek to reap the benefits.

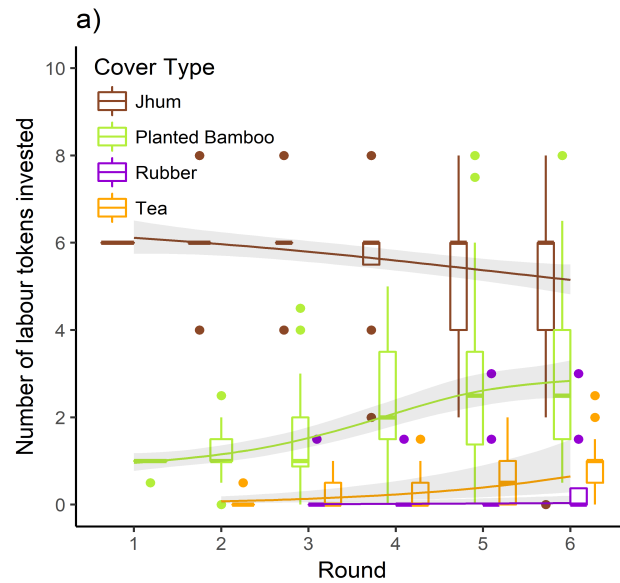


Fig 3. Labour allocated to the different land cover types (a) and crop types (b), per round. The boxplots and the dots represent the dispersion of the observed data. The lines are the predictions from generalised additive models accounting for the nested random effects of the players with village ID. The grey area represents the 95% confidence intervals.

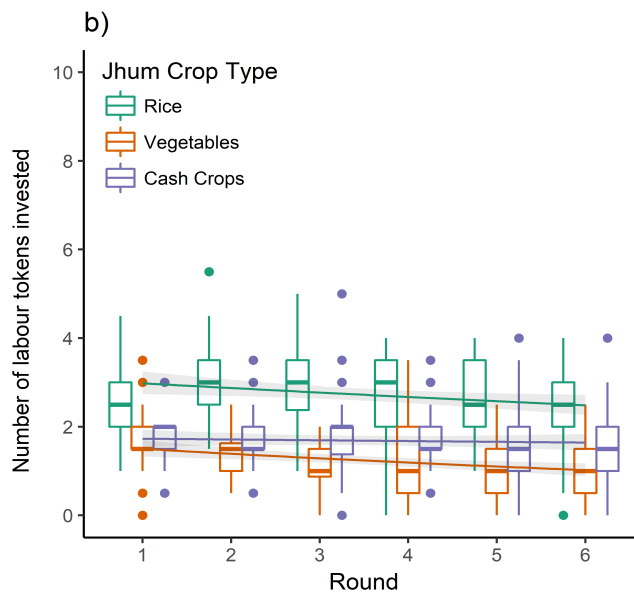


Fig. 4. Monetary investments. Investment in the different categories per round (a) and cumulatively for the different standard of living categories (b). The boxplots and the dots represent the dispersion of the observed data. The trends are the predictions from the models, the grey area the corresponding 95% confidence interval, including the variation from the random effects. Jhum and bamboo are not shown since they require no monetary investment.

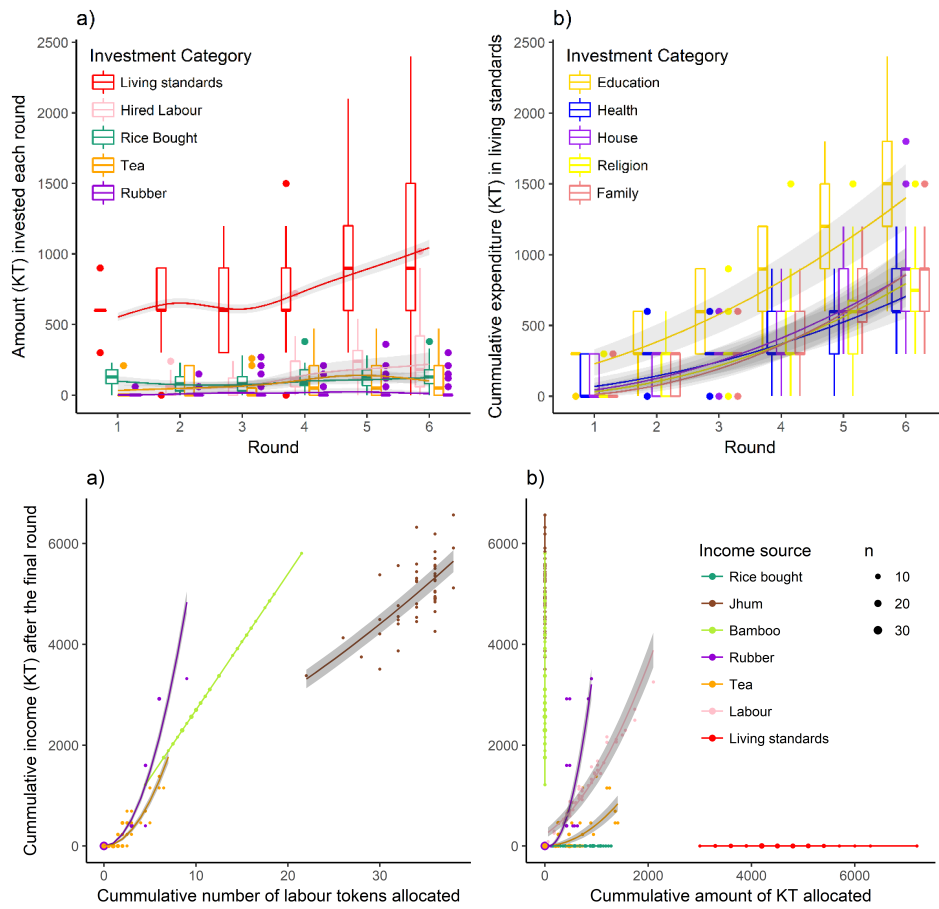


Fig. 5. Total cumulative income generated at the end of the game. (a) Through the cumulative number of allocated labour tokens, and (b) through financial investment in the different categories over the course of the game. The dots represent the observed data, the size of the dot reflects the number of observation at each location. The trends are the predictions from the models, the grey area the corresponding 95% confidence interval, including the variation from the random effects.

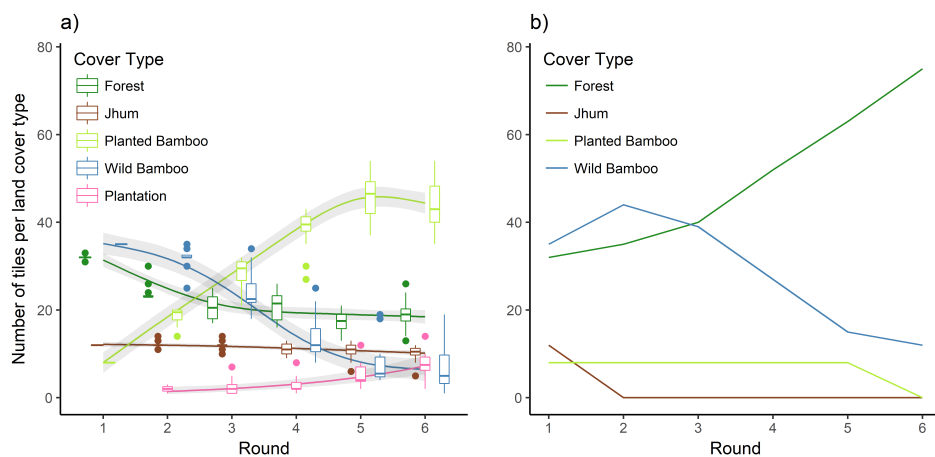


Fig. 6. Trajectory of landscape composition as exploited in the game (a) versus baseline landscape with natural succession only from round 2 onwards (b). The boxplots and the dots represent the dispersion of the observed data, and the lines are the predictions from generalised additive models accounting for the nested random effects of the players with villages; the grey area represents the 95% confidence interval and the variation from the random effects (a).

4 Lessons from the Field

Conducting fieldwork within the context of the case study was quite the challenge. Not only are Karbi militia groups still active in the area [21], preventing the government, environmental NGOs and others from working directly with the farmers, there is also the simmering conflict around the ambition of the park managers to expand into the ancestral lands of the Karbi [22]. The constitution is currently protecting scheduled forest dwelling tribes from expulsion from their land [23]. However, changes to the Indian constitution, that would give the government power of forested areas, have been pending at the supreme court for quite some years. Mass protests have already been taking place all over India [24], and there is a serious risk of (ethnic) violence returning to this part of Assam.

The original goal of the study was to develop different scenarios what would allow for exploring potential political solutions, involving Karbi Jhum farmers, Kaziranga NP and environmental NGOs. However, from the side of the government there were no policy ideas that could be incorporated in the game. There were also no government funds available to compensate farmers for crop losses, to initiate sustainable development initiatives or provide alternative sources of income to Jhum farmers, reducing the pressure on the forests.

Playing once with officials of the forest department yielded a landscape and a system that was far more market oriented, fully focused on producing cash crops, and turning the forests into rubber and tea plantations (Fig. 7a & 7b). This outcome lays bare that those in charge of developing policy don't understand the objectives of the primary landscape managers. Lack of trust, and understanding stood in the way of finding a way out of this simmering conflict at this time, using this game.



Fig. 7a & 7b: Examples of the cash crop planting strategy of an Assam Forest Department official, taking the role of a Jhum farmer, and the impact of investment strategies on the landscape, with rubber and tea plantations emerging quickly in the landscape.

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A millionaire-based game for shared learning on wetland ecosystem services and sustainable management under future socio-economic development and climate change

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Abstract. In Thailand, some wetlands are degraded and people who are living in wetlands are old. So, sustainable management is urgently required. “Communication, education and public awareness (CEPA)” is one of the important activities for conservation and management and could be implemented via gaming and simulation. Therefore, we created a simple gaming and simulation based on a millionaire game feature and tested with old and low formal education farmers at Koh Lat, Chachoengsao province. We integrated a spatial representation of the wetland into the game board for farmers to manage under a scenario of future infrastructure development (bridge construction) and climate change. They have initials, money and water to play for 4 rounds, representing 4 years in reality. The relatively rich, produce low waste and still have enough water will win the game. Ten farmers (5 men, 5 women) were invited to play. We found that both men and women valued the importance of the ecosystem services from the wetland. Men and women have different idea to manage the wetland. Farmers can understand the game and want to learn more about possible businesses for further adaptation. The second workshop will be conducted with more groups of stakeholders with the objectives of identifying the management actions and selecting focal people to implement the plan. We conclude that this game is easy to use for shared learning on wetland ecosystem services and sustainable management. This game was slightly adjusted and used with farmers in a Ramsar wetland in Lao PDR.

Keywords: Climate Change Adaptation, Ramsar Site, SDGs, Ecosystem Management, Wetland

1 Introduction

Wetlands are important ecosystem providing enormous value of ecosystem services to support human well-being. Unfortunately, many wetlands around the world are in crisis due to several factors, from both natural and man-made. It creates negative feedbacks to human and wildlife, such as biodiversity loss, water insecurity, and poverty. In many parts Thailand, economic growth driving by government policies and climate change phenomena stimulate wetland degradation and loss. Therefore, from this social and environmental changes, it is urgently needed for sustainable wetland managements.

Among several techniques to manage wetlands, communication, education and public awareness (CEPA) is one of the important activities [1]. This could be done by using gaming and simulation for shared learning among concerned stakeholders. There are many water management learning games [2, 3, 4, 5], however, in some wetland areas of Thailand, there are aging farmers. They have low formal education with difficulty to understand a complicate game. Therefore, a simple but effective game is required to facilitate shared learning on wetland ecosystem services and improve resilience and adaptive management capacity under future climate change events and high uncertainty.

Koh Lat area in Chachoengsao province is selected as the study site. All farming households were affected by severe flood events in 2010 and 2012. Farmers decided to abandon their farms

because of debt after floods. Some parts of island were sold to capitalist from outside. Young farmers and their kids are moved to the mainland for more convenient transportation. Therefore, only 161 households are settled [6] and many of them are senior citizens. Recently, there is a government plan to construct a bridge [6] to connect the mainland and the island. This may create many changes such as recovery of farming activities and more tourists which require more water consumption and produce more waste to the wetland. Therefore, we created a simple game and use with local farmers as a shared learning tool to learn and understand their views and thinking responses on wetland resources and the future development projects. The game structure, results, and future work are presented.

2 Materials & method

We created a board game based on the millionaire classic game and integrated with a spatial representation (e.g. village map and wetland resource locations) in the center of gameboard under a scenario of future bridge development. The game structure is presented in Fig. 1. The game components included gameboard (A0-size), pictograms of farm and non-farm activities (2x2 cm), event and scenario cards, dice, fake money, players' record sheet and public bulletin board (Fig. 2). In the gameboard, there are 23 boxes containing different activities that players (farmers) have to complete. Different activities require different amounts of water and generate amounts of waste and pollution. We played the game for 4 rounds; each round represents one year in reality. We invited 10 farmers including high, middle, and low incomes, and separate them into 2 groups of 5 men and 5 women in order to compare their idea at the end.

Before the game started, we provided initial land area, money and water (drinking water and water for other activities, they can buy more in the next round of play if needed) to players. They have to manage these assets. Farmers with relatively higher income (compared with the beginning), lower waste and enough water will win the game. The debriefing session was conducted after playing by comparing the two ideas from men and women groups. The importance of the wetland and their future of wetland are discussed. Individual interviews were conducted after the gaming session to assess individual learning and obtain information about how to improve the game.

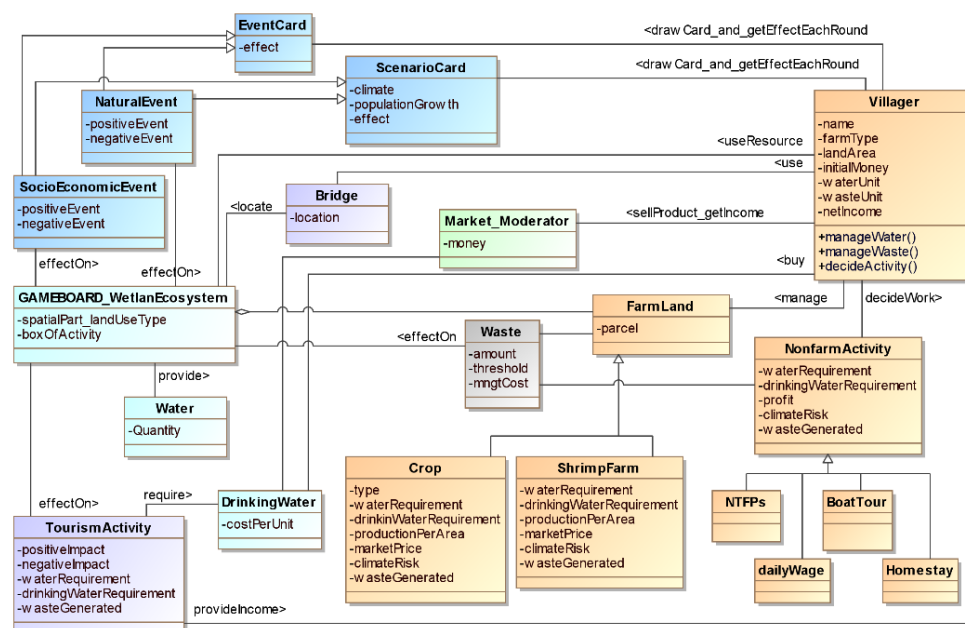


Fig. 1. The game structure.



Fig. 2. Board game and its artifacts.

3 Lesson learned from the field workshop

Although farmers are senior citizens, they can easily understand the gaming features and are able to play the game with their friends (Fig.3). All farmers said the game looks like the millionaire game that they played when they were young, while the farming activities in the spatial landscape is similar to reality and not difficult to understand.

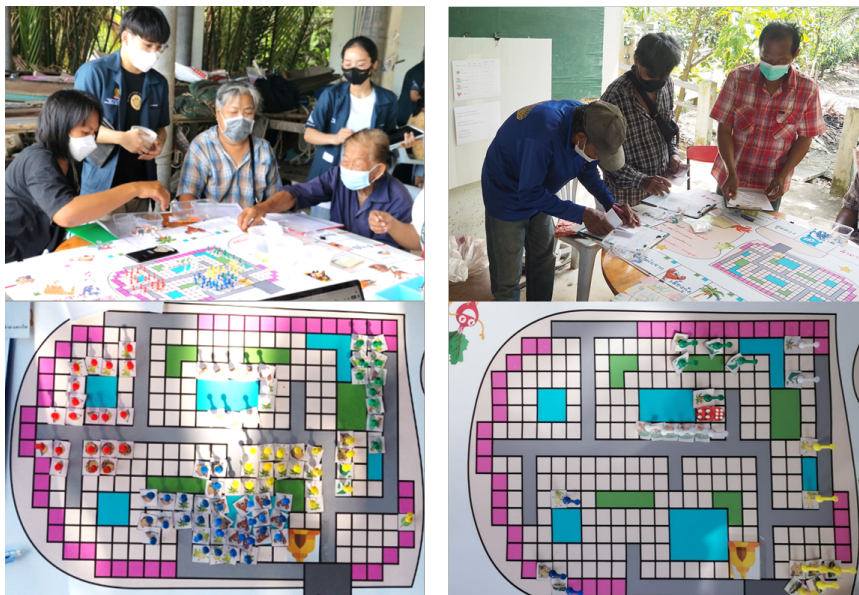


Fig. 3. Atmosphere and decision-making from men and women groups.

It was found that both men and women have the same perspective in that ecosystem services from wetlands (e.g. non-timber forest products, aquatic animals, tourism activities) are valuable and still important for their livelihood and household income. However, predicting negative impacts from bridge development on water security and waste tokens was a little difficult to them because in reality, they are plenty of water to use as well as they usually burn the waste. Appropriate waste management system and sufficient water supply system may be crucial in the future if the population increases. They said that they can understand the logic behind about the need to manage water and waste from future possible activities.

About the wetland management idea, men and women had different visions if the new bridge come. Men tended to grow more crops and sell products outside the island, while women interested in homestay and restaurant businesses. This different may be caused from the different

responsibility in field and home works [7]. From the interview, both groups believe that if the new bridge come, their kids will come back and there will be more vital activities in the island. They also wanted students in nearby schools to play this game to learn important of Koh Lat wetland and manage this wetland in the future.

At the end of gaming session, group of women interested to learn more about new businesses to adapt to climate change as a big challenge and ask researchers to suggest the idea. Regarding this request, researchers inform them that another gaming session with more local stakeholders and government agencies will be conducted to exchange feasible idea.

Finally, based on the result from the workshop, we conclude that this simple gaming and simulation based on the millionaire game feature can be used for shared learning on wetland ecosystem services and provided new wetland management idea to farmers. Moreover, we have adjusted this game to represent a swamp Ramsar site context in Lao PDRs and found that it worked well. Therefore, this tool could be useful for wetland researchers to implement in their own context.

4 Future works

As proposed by players, another gaming session will be conducted with more participants and more type of stakeholders including local administrative organization, tourism authority, monk in the island, teachers, students, and tourists in nearby areas. Moreover, the game will be modified based on the suggestion from players such as add more non-farm activities. The new objectives will be proposed which are to use the new version of the game to collectively identify the feasible wetland management actions and identify the focal people to implement the proposed actions.

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Serious games for sustainable agri-environmental and food transitions in territories. A study in France

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Abstract. Given the significant development of serious games on agriculture, food, environment and territories in recent years, it seems important to better understand their characteristics (objectives, players, duration, scales...). This paper thus proposes to question the way in which serious games cover the issue of sustainable transitions in our societies. It is based on a national exploratory survey conducted in France in 2021. The survey had six parts: a) identification of the games and their creators, b) themes and scale of analysis dealt with, c) positioning within different typologies (G/P/S model, ESAR system and the gameplay bricks model), d) knowledge and skills developed by the game, e) modalities of use and evaluation of the effects of the game (based on the CEPAJe model) and finally f) valorization of the game. Most of the games identified are boardgames and most of the game designers had created only one game in their life. Games are mainly cooperative, freely available, integrate several spatial scales in the game mechanics and can be used for teaching aims. Several are also design to work with farmers and local stakeholders. They can be seen as social innovation tools and they are mainly used as a tool to co-construct a vision of the future and to empower the players more than to persuade them, making us call those game sustainable games.

Keywords: Serious game, Taxonomy, Agriculture, Environment, Territorial development

1 Introduction

To adapt to the current environmental upheavals, transitions in agri-food systems are necessary. But these transitions are systemic because they must take into account the multitude of dimensions impacted (agriculture, environment, food, economy...), the diversity of scales and levels of organization to be articulated and the variety of possible paths (agroecology, bioeconomy, digital, biotechnologies...) and related controversies. Also, empowering devices capable of influencing the behavior of actors and citizens are expected [1, 2]. Serious games, defined as being a game whose utility takes precedence over entertainment [3], seem to be able to meet these expectations thanks to the five characteristics proposed by Brougère to qualify the game: "a second degree activity made up of a series of decisions, endowed with rules, uncertain as to its end and/or its progress and frivolous because limited in its consequences" [4]. These characteristics allow players to be immersed in the game, the flow [5], and create the right conditions for learning, exchange and action.

However, given the significant development of serious games in recent years, it seems important to better understand the objectives of existing games on agriculture, food, environment and territories (AFET), to understand how they contribute to the design of possible futures, to identify who are the players and, more broadly, the stakeholders, and, more globally, to identify their characteristics [6]. This paper thus proposes to question the way in which serious games cover the issue of sustainable transitions in our societies. It is based on a national exploratory survey conducted in France in 2021 among AFET game designers.

2 Material and Methods

The survey was designed to identify and characterize serious games designed in France on AFET themes. It was disseminated within research networks on agriculture as well as in professional networks, particularly in the field of agricultural consulting and education. The online questionnaire was organized around six parts: a) identification of the games and their creators, b) themes and scale of analysis dealt with, c) positioning within different typologies (the G/P/S model to link the game to a serious game family [7], the ESAR system to define game media and game categories [8] and the gameplay bricks model to identify the modalities implemented in the games [9], d) knowledge and skills developed by the game, e) modalities of use and evaluation of the effects of the game (based on the CEPAJe model [10]) and finally f) valorization of the game (game protection, research article, dissemination...).

3 Results

While a few games were created over 20 years ago, the majority of the 105 games identified were designed after 2016 and the vast majority are analog (61%). Only 6 are video games, the others mobilizing digital technology only for certain aspects of the game as described by Martel et al. [11]. Half of the game involves designers from research or higher education, other designers work in education (25%), associations (22%), agricultural counselling (18%)... Students and farmers can also participate to the process, which is often (35% of the games) a vector of collaboration between different professional spheres. Only 12% of the games involved specialists of game design (game designer, specialized graphic designer, editor).

The themes most often addressed in the games are agriculture (72 games) and the environment (60), far ahead of territorial development (24) and food (14). About half of the games (56%) deal with only one theme. Concerning the scales of analysis, no preferred scale is found, but rather to a diversity of organizational levels, often addressed jointly.

The games are more often "game based" than "play based", with the aim of transmitting a message (65% of the games) or simulating a real situation (59%) but rarely made to train a specific technique (18%). The games are mainly cooperative and mobilize the players' knowledge and their reasoning and perspective-taking skills. A triptych of three bricks is often mobilized in the design of AFET game mechanisms: Manage, Choose and Achieve. It covers the idea of choice and objective assigned to the game as well as the question of resources (with manage) often implied in environmental issues.

Training (initial and professional) is the most cited context of use with 55 games. This is followed by mediation with the general public (27 games) and use for action (consultation, transformation of practices, etc.) (23). 70% of the games listed have at least two contexts of use. We note that most of the games initially designed for action can be used in teaching (20), whereas the reverse is not true, since only 6 games designed for teaching are used for action. Finally, it should be noted that more than one game out of four can be mobilized in a perspective of support for action. Evaluation is not central to the creators, since it is only carried out systematically in just over half of the game processes, regardless of the context of use (58 games). When it is carried out, the evaluation is in the vast majority of cases an immediate evaluation. Some games do game design or gameplay evaluations in order to be improved. Finding few games that mobilize debriefing when it is usually a common practice [12] make us conclude that most of the respondent are not involved in game science but created their game as a part side project. In the designers' responses, in-depth evaluations to find out what the game produces in and after the game, in the medium/long term, are rare and are carried out by researchers whose research object is the game.

The games are mainly accessible for free (77%), unlike many other types of innovation products. As a result, designers often offer a "print & play" version of their game, as this solution allows for immediate distribution without investing in the production and management of game boxes.

4 Discussion and Conclusion

The serious games propose concertation and engage the player actors in the exploration and even the construction of a transformation of reality towards more sustainability [13]. The games qualified as collaborative in our analysis thus join the trend aiming at the development of more collaborative and cohesive social relations [14]. More globally, whether they are designed for teaching, mediation, consultation or action, most of the games identified in the survey follow a strategy of social change focused on prefiguration [15]. Most of them aim at anticipating possible futures by empowering professionals, citizens or students, which is the basis of social innovation, especially in the field of territorial development [16]. Adding to these characteristics the free availability of most of them, make us think that games identified don't try to persuade player but give them key element to make their own opinion, leading us to propose a new class in the game taxonomy: the sustainable games, as they are done in present time in order to make the future possible.

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Actor analysis and cognitive mapping to design multi-player games that foster public-private cooperation in urban climate adaptation

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Abstract. The current literature on designing multi-player games to foster cooperation lack structured analytic methods to identify specific multi-actor intervention needs and inform the targeted game design that is needed for effective game interventions. We propose combining actor analysis and conceptual cognitive mapping to improve the initial phases of serious game design focused on problem identification, design specifications, and systems analysis. In an in-depth case study, the key actor (player) roles, resources, action options, goals, and interdependencies along with perceptions of the problem situation were analysed to understand past failure to cooperate in resolving recurrent pluvial flooding in a Dutch residential neighbourhood. Current multi-player cooperative game design does not take these into account (sufficiently). We show how analytical methods available from other research fields can be applied to bridge the gap between systemic analysis of cooperation needs or shortfalls and the design of cooperative multi-player games. Initial results from the serious game intervention will also be presented. We will conclude with recommendations of how our approach can be used to inform more purposeful design of multi-player game interventions and their evaluation.

Keywords: cognitive mapping, serious games, design, cooperation, urban flooding.

1 Introduction

Among other methods, serious games have been used to understand and analyze complex systems with multiple actors (Bekebrede et al., 2015). Serious games provide an environment that can be used to bring different stakeholders together, develop a better system understanding and experiment with cooperation. The design process of a serious game typically consists of 5 phases; *Design Specifications, Systems Analysis, Detailed Game Design, Game construction, Testing and Validation, Game Implementation and Evaluation* (Duke and Geurts, 2004; Peters and Westelaken, 2014). The game design starts with a client problem which is then translated into game requirements. However, often the exact cooperation problem that the game should address is unclear which may lead to a mismatch between the game intervention and the real-world problem.

In multi-actor policy analysis and cooperative strategy development, various problem structuring methods are available to surface the underlying problem and uncover solution options (Eden, 2004). The combination of actor analysis and cognitive mapping have been found particularly powerful in analyzing multi-actor problem situation and understanding cooperative or non-cooperative behavior (Hermans, 2004; Hermans and Thissen, 2009). Cognitive mapping helps represent actor perspectives of a certain situation. Their systematic analysis and comparison can reveal the reasons behind current behaviors of action or inaction – and in this case, shed light on the lack of cooperation, e.g., such as different goals or their prioritization among stakeholders, dilemma's where a perceived action leads to both benefits in achieving one goal and loss in achieving another (i.e. avoidance of trade-offs), or mutual action and resource dependencies (Cunningham and Hermans, 2018).

In this paper, we present a methodology for the initial design of serious games that focus on game requirements and systems analysis. We propose the use of cognitive mapping to identify the problem that a serious game should address and shortlist relevant real-world elements such as stakeholders, solutions, objectives and uncertainties that should be represented in the game.

2 Case Study

Cities across the world are becoming more urbanized, leading to conversion of green spaces into paved areas, also in the Netherlands. As a result, little space is available to infiltrate intense rain showers, thereby leading to flooding in urban areas (Butler and Davies, 2004). To adapt the urban water infrastructure (UWI) for the future, blue, green, and grey solutions can be applied. While grey measures perform well at flood-risk reduction, green-blue measures (also called sustainable urban drainage systems – SuDS or nature-based solutions – NBS) provide co-benefits such as amenity, recreation, improved water quality, biodiversity, and temperature regulation (Alves et al., 2020).

A case study research will be conducted in a local neighborhood in a Dutch mid-size city to execute the aims of this research. The neighborhood consists of 170 households who already experience frequent flooding, approximately twice a year. Multiple stakeholders would need to cooperate to prevent flooding, yet have thus far failed to do so. Implementation of measures on public and private land requires them to work together. A serious gaming intervention is being deployed to overcome this situation.

3 Methodology

The overall research methodology is presented in Figure 1

3.1 Actor analysis

Firstly, an actor analysis will be conducted to identify key stakeholders and to select relevant participants from the case study, using a power-interest matrix. A PI matrix helps identify critical actors – those with a high level of power (they possess important resources) and high level of interest in the problem (Enserink et al., 2010). Further, an actor analysis will help identify the formal roles and interdependencies of the identified key stakeholders in regards to stormwater management in the neighborhood. Any prevailing structural impediments to cooperation will be identified.

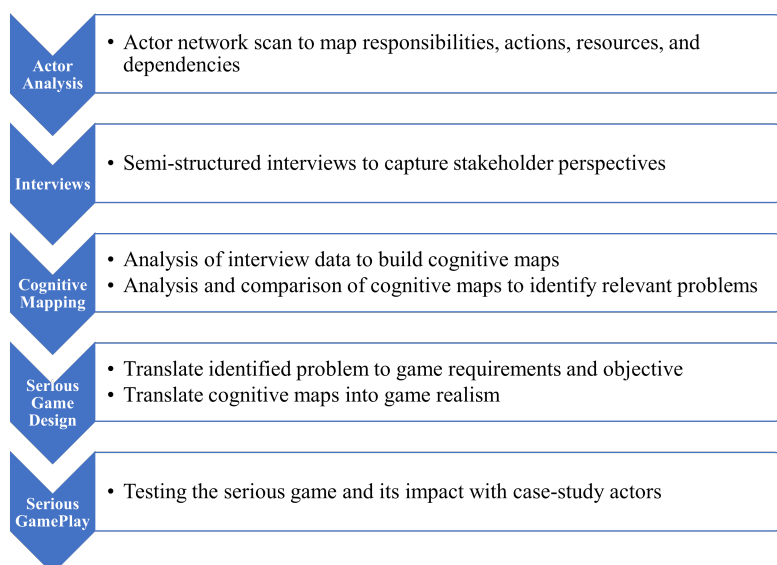


Fig. 1. Overall research methodology

3.2 Semi-structured interviews to explore perceptions / mental models of the current situation

Semi-structured interviews are currently being conducted with the identified key stakeholders to gather information on their perspective about the problem of flooding in the case study area, and more specifically, their objectives, solutions, perceived uncertainties and causal relations. An adapted version of the interview questionnaire provided by Cunningham and Hermans (2018) is used to structure the interview protocol.

3.3 Cognitive mapping

Cognitive maps help make stakeholders' causal assertions more explicit and present them in a structured way. A most basic cognitive map is presented in Figure 2, with actions being the perceived solutions for the problem, goals being the objectives, context being the perceived uncertainties and factors representing the intermediary concepts that link the actions and uncertainties to goals.

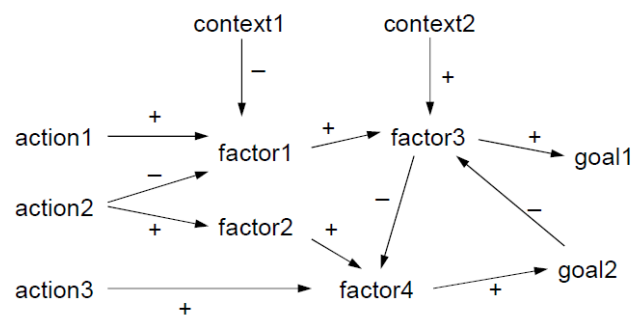


Fig. 2. An abstract representation of a cognitive map (Cunningham and Hermans, 2018)

Once the interviews are concluded, the interview data will be analyzed to extract information required to build a cognitive map for each actor, i.e., actions, system factors, goals and contextual factors. The software DANA (<http://dana.actoranalysis.com/>) will be used to visualize and analyze the cognitive maps and find overlaps and conflicts in actor perceptions. These will highlight possible action conflicts, goal conflicts, resource and action interdependencies, and the dilemmas that stakeholders face.

3.4 Identification of reasons driving non-cooperation and implications for serious game design

The results of the analysis of cognitive maps will be used as a starting point for the serious game design, and translated to a game requirement and specifications document and identifying real-world elements – stakeholders to be involved as players in the game, decision options, player objectives, and uncertainties. For instance, if the reason for non-cooperation is lack of awareness of interdependencies among actors and regulations, then stakeholders can play their real-world roles and responsibilities in the game and go through the process of designing a future-proof plan for UWI of a neighborhood. Rounds with and without cooperation can be played for stakeholders to reflect on the decision outcomes in either cases.

3.5 Serious game intervention and evaluation

A serious game intervention will be designed to address the problem identified in the previous phases. The initial prototypes of the game will be tested with researchers and students at TU Delft and thereafter with stakeholders in the case study area. Depending on the nature of the

problem and the reasons for non-cooperation, the game will be evaluated using participant observation and pre/post testing to understand its impact.

4 Results

We will present the methodology for the analysis of the complex multi-actor situation using cognitive mapping and the main results regarding UWI planning of a neighborhood in the Netherlands.

Thus far, our actor analysis has led to the identification of 9 stakeholders which are presented in the Power-Interest (PI) matrix in Figure 3. Among them, critical actors are the municipality, residents and the “MonumentZorg” (monument care). The municipality (and the departments within) is responsible for upgrading the underground sewer networks in the case study area, implement NBS to tackle flooding on public land and pass policies to incentivize and support residents to adopt NBS on their private plots. At least 80% of the houses in the case study area are heritage sites, so any changes to these structures to implement NBS have to be approved by the MonumentZorg. Currently, we are conducting interviews with these 3 critical actors.

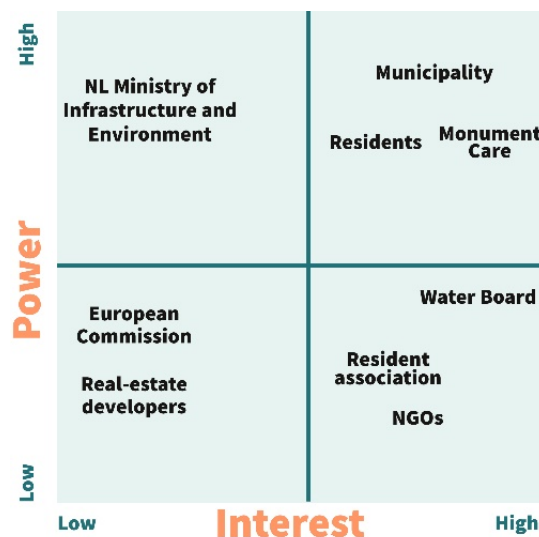


Fig. 3. Power-Interest matrix for the case study

Initial speculations about lack of cooperation hint at the fact that stakeholders have low awareness of interdependencies, their own role, and how their decisions impact each other. For instance, residents are dependent on the municipality to tackle urban flooding with low awareness of their own role in managing rainwater on their private land. Furthermore, it seems that a critical actor, MonumentZorg has not been involved in the discussions on urban water management so far. For houses in the case study area to become more climate adaptive, MonumentZorg will be approached to understand their perspective on urban flooding and how they perceive the adaptation of heritage houses.

We expect that upon completion of the semi-structured interviews, we are able to identify any goal or action conflicts, dilemma's or resource and action dependencies that may hinder cooperation. This will be translated into game specifications, requirements and the real-world elements to be incorporated in the game. Together with practice partners, a serious-game intervention will be designed and evaluated in the case study.

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Moderate Tension Enables an Open Discussion: Text Analysis of Written Comments in Debriefings

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Abstract. In a production management game setting, there are two prospective approaches: provide additional structured instructions, and organize a team in a semi-autonomous manner. In this study, informative questions were used as additional instructions to motivate participants to share their knowledge with others. Organizing a team semi-autonomously is a way of organizing them with a mix of groups of friends. The semi-autonomous grouping procedure would introduce moderate tension and spark an open discussion for a better decision. This study examined the effects of one additional question and semi-autonomous grouping by comparing the data obtained in 2021 with those obtained in 2022. The data in 2021 showed the combinational effect of the additional question and grouping, whereas the 2022 data showed the single effect of grouping. To identify differences between 2021 and 2022, the participants were divided into two groups: experienced and inexperienced members. Experienced members represented those who understood the situation before the game ran. In addition to descriptive statistics, an exploratory text analysis was applied to the written comments of the participants. In 2021, the effects of the semi-autonomous grouping and the additional question canceled each other. One additional question might have misled the teams by narrowing their horizons. In 2022, experienced members and inexperienced members shared common perceptions after the game. By 2022, experienced members seemed to succeed in convincing inexperienced members. A semi-autonomous grouping procedure was better off without the additional question.

Keywords: Moderate Tension, Open Discussion, Semi-Autonomous Grouping Procedure, Text Analysis.

1 Introduction

Making good decisions as a team is an important issue in society. If people can share their knowledge within a team, they can gain better understanding, hold serious discussions, and make higher-quality decisions. However, it is difficult to share knowledge or hold open discussions within a team ([1], [2], [3], [4]). In a production management game setting, there are two prospective approaches: provide additional structured instructions, and organize a team in a semi-autonomous manner. In this study, informative questions were used as additional instructions to motivate participants to share their knowledge with others. Organizing a team semi-autonomously is a way of organizing them with a mix of groups of friends. Previous studies showed that further research is required to determine the impact of grouping and the synergistic effect of the combination of grouping and informative questions ([5], [6]).

2 Method

The OPT SCHEDULING GAME ([7]) simulates a mechanism of optimized production technology. Participants work in ten-person teams, with the goal being to make as much profit as possible by producing airplanes with plain A4 paper. Individual members have eight tasks (see Figure 1), and Table 1 lists the cost and profit.

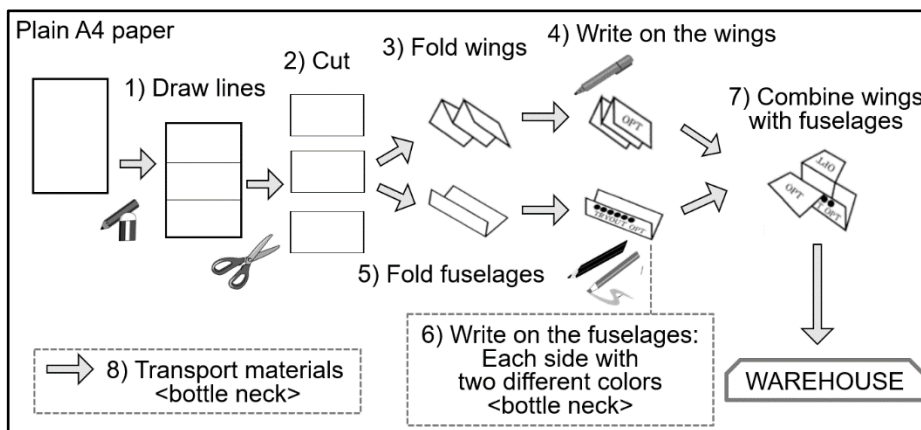


Fig. 1. Operation process of OPT SCHEDULING GAME by Legg (1994)

Table 1. Cost and profit

Items	Cost	Items	Profit
Initial cost	¥200,000	Airplane	¥20,000
A4 plain paper	¥3,000/sheet	A pair of wings	¥5,000
Additional staff assignment	¥500,000/staff	A fuselage	¥10,000
Changing the location	¥200,000/location		
Process improvement	¥50,000/improvement		

Participants completed two different questionnaires before and after the game on the class website (see Appendices 1 and 2). Before the game ran, participants answered five questions for 2021 and four questions for 2022. They were asked whether they understood the initial cost and what was required to recover it, and whether they understood the bottleneck of the overall process. Subsequently, they were required to estimate their teams’ net profit. An additional question asked participants to explain how they calculated their net profit in 2021, the purpose being to encourage them to share their knowledge within a team and hold serious discussion. In the second questionnaire, after the game, participants were asked to choose their level of process understanding, strategy understanding, prediction, and satisfaction on a scale ranging from 1 (never) to 6 (fully), and describe what should have been done better through a free description.

In 2021 and 2022, a semi-autonomous grouping procedure was employed to organize the teams. This procedure organizes a team as an aggregation of small groups of friends. The game required several ten-member teams. I gave the same suit from a deck of playing cards to those who wanted to be on the same team, submitting to their requests as long as I had the same suit remaining in my hand. Thus, most team members had someone in their group with whom they were acquainted.

When I organized teams completely randomly, participants struggled to break the ice before discussions, and when I asked participants to organize teams autonomously, they were distracted by small talk during game sessions. Organizing a team semi-autonomously introduced moderate tension and sparked an open discussion for a better decision ([6]).

This study examined the effects of the additional question and semi-autonomous grouping by comparing the data obtained in 2021 with those obtained in 2022. The data in 2021 showed the combinational effect of the additional question and grouping, whereas the 2022 data showed the single effect of grouping.

The numbers of participants and teams in 2021 were 114 and 12, respectively, and 103 and 11 in 2022, respectively. The number of valid responses was 81 in 2021 and 86 in 2022, after excluding data from those who refused to provide their responses for statistical analysis. All participants were freshmen at college, majoring in social science, and aged 18-20. Moreover, 80% of the participants were male and half of the teams were all-male. The remaining teams comprised a mixture of male and female members.

3 Results

The mean of the teams' final profits is ¥10,417 (in red) in 2021 and ¥107,455 (in black) in 2022. Contrary to expectations, the additional question for 2021 had a negative effect. The means of the four items in the second questionnaire were not significantly different between 2021 and 2022, except for the level of satisfaction. Participants in 2022 were more satisfied than those in 2021.

To identify differences between 2021 and 2022, the participants were divided into two groups: experienced and inexperienced members. Experienced members represented those who understood the situation before the game ran; that is, the initial cost, what was required to recover the initial cost, and the bottleneck (*write on the fuselages* or *transport materials*). Experienced members made up approximately 50% of all participants, both in 2021 and 2022. Experienced members made better estimations than inexperienced members, and this tendency was stronger in 2022 than in 2021 (Table 2).

Table 2. The means of estimations of experienced and inexperienced members (¥)

Year	Experienced members' estimation			Inexperienced members' estimation		
	n	Mean	SD	n	Mean	SD
2021	48	266,631	221,231	33	286,545	288,351
2022	48	132,625	195,944	38	205,459	281,157

Note: The total number of members was less than the number of participants because the data of participants who disagreed with the statistical analysis were excluded.

An exploratory text analysis was used to determine what was on their minds after the game. The question "what should have been done better?" was analyzed, and four categories of related words were derived: planning, writing on the fuselages, transport materials, and materials in the process. Tables 3 and 4 present the cross-tables of the four categories, with experienced and inexperienced members in 2021 and 2022, respectively. The chi-square value is significant in the category of *materials in the process* between experienced and inexperienced members (Table 3). Experienced members in 2021 paid more attention to *materials in the process* than inexperienced members. Figures 2 and 3 illustrate the results of hierarchical cluster analysis for 2021 and 2022, respectively. A noteworthy finding is that *materials in the process* is in the highest hierarchy level in Figure 3. The 2022 participants, both experienced and inexperienced, perceived that *materials in the process* had to be handled sensitively.

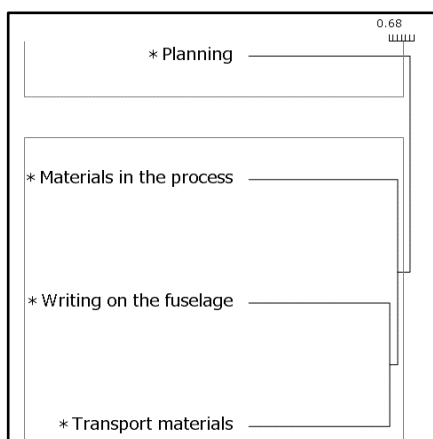


Fig. 2. Dendrogram of four categories in 2021

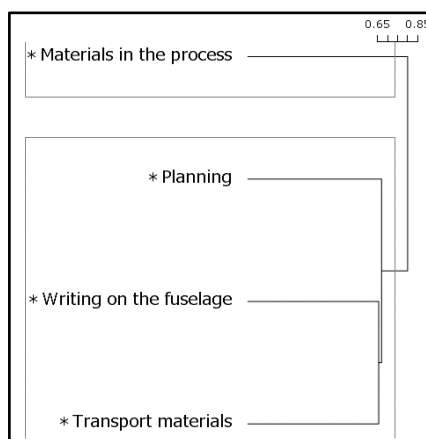


Fig. 3. Dendrogram of four categories in 2022

4 Conclusion

Table 3 reveals the differences between experienced and inexperienced members. In 2021, an additional question might have misled the teams by narrowing their horizons. The effects of the semi-autonomous grouping and the additional question canceled each other. Table 4 shows that experienced members and inexperienced members shared common perceptions after the game in 2022. By 2022, experienced members seemed to succeed in convincing inexperienced members. A semi-autonomous grouping procedure was better off without an additional question.

Table 3. Cross-table of four categories and experienced and inexperienced members in 2021

Planning	Writing on the fuselages	Transport materials	Materials in the process	Number of cases	
Experienced	14	25	22	17	48
Inexperienced	14	16	16	4	33
Total	28	41	38	21	81
Chi-square value	0.990	0.008	0.000	4.380*	

* p < .05

Table 4. Cross-table of four categories and experienced and inexperienced members in 2022

	Planning	Writing on the fuselages	Transport materials	Materials in the process	Number of cases
Experienced	15	26	22	9	48
Inexperienced	18	17	17	14	38
Total	33	43	39	23	86
Chi-square value	1.698	0.424	0.000	2.680	

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Appendix 1. First questionnaire before the game run

- Q1 Do you understand that the initial cost is ¥200,000?
- Q2 Can you correctly estimate the minimum number of airplanes required to recoup the initial cost?
- Q3 Which task do you think is the hardest? Please choose one of the following options:
- Draw
- lines; Cut; Fold wings; Write on the wings; Fold fuselages;
- Write on
- the fuselages; Combine wings with fuselages; or Transport materials
- Q4 Please estimate your team's net profit gain (sales minus costs)
- Q5 Please explain how you calculated the net profit (in 2021)

Appendix 2. Second questionnaire after the game run

- Q1 Please give us your feedback on this game in two lines.
- Q2 How much did you understand the process of producing an airplane?
- Q3 Which task seemed to be the hardest?
- Q4 How well did you understand your team's plan?
- Q5 Did you expect your team to end with this result?
- Q6 How satisfied are you with the result of this game?
- Q7 What do you think should have been done better?

On Simulating Shocks and Stresses in Climate Change Games: A Review of Game Design Strategies

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Abstract. In the last few decades, simulation games have been successfully used around the world in the context of addressing climate change related challenges. A particular game design challenge in these games is simulating both short-term events (shocks) and long-term gradual changes (stresses) and their interplay as a result of climate change. In response to encountering this challenge in the design of a climate change game, the study presented in this paper aimed to identify game design strategies and mechanisms to simulate both shocks and stresses in climate change games. Games included in recent review papers on climate change games were reviewed, resulting in the identification of four game design strategies: (1) time-based simulation with triggered events; (2) shocks as changing probabilities; (3) jump to a future climate scenario; and (4) climate change as a game condition. Each strategy is briefly described with examples of mechanisms used in games. From a research perspective, the presented study serves as a precursor to specify research questions and a review protocol for conducting a systematic review on this topic, thereby addressing this study's limitation of missing relevant games not covered in the review papers. From a game design perspective, the study and identified strategies offer guidance and inspiration for game designers working on climate change games.

Keywords: Game design, Game mechanisms, Climate change, Shocks, Stresses

1 Introduction

Addressing climate change is one, if not the most pressing global challenge of our time. To support finding and initiating transitions in the context of climate change, simulation games have been successfully used to convey its complexity, raise awareness, and facilitate collaboration and dialogue [1-4]. Depending on the aim, a particular design challenge for such games can be how to simulate both short-term extreme events (shocks) and long-term gradual processes (stresses) resulting from climate change and their interplay.

The above described design challenge was encountered while developing the Delta Management Game, a multiplayer climate change game where players explore salt intrusion adaptation and mitigation strategies in the Dutch delta. Salt intrusion of surface water concerns the physical process of salt sea water flowing further in-land in estuaries when the counteracting river discharge is low. The intended game experience aims to show the physical process of salt intrusion in periods of droughts (shock) while also capturing how sea level rise (stress) is likely to affect salt intrusion in the future.

In support of the design challenge, this study reviewed climate change games to identify game design strategies and mechanisms to simulate both shocks and stresses. The presented review and identified strategies serve as guidance and inspiration to game designers, but also as a precursor to specify research questions and a review protocol for conducting a systematic review.

2 Method

To explore the different game designs strategies, games included in recent review papers on climate change games [1-4] were reviewed, focusing specifically on how these games included both stresses and shocks. No inclusion/exclusion criteria or quality assessment were applied. The

games were reviewed based on papers, documentation, or playing them if e.g. a web-based version was available. The games were subsequently categorized into game design strategies.

3 Results & discussion

Below, the identified game strategies are described and illustrated with examples. Climate change games explicitly only focusing on either long-term processes [e.g. 5] or short-term, extreme events [e.g. 6] are not represented in these strategies.

3.1 Time-based simulation with triggered events

Most games identified concern playing a (mostly turn-based) time-bound scenario (e.g. some years) [7-14]. Shock events can occur at any simulation step based on one or a combination of factors like an underlying climate change scenario or player actions. Events may therefore also become more extreme as the game progresses. In *Aqua Republica* for example [7], players take 12 turns that represent around 20 years passing. Events, including climate-related like flooding and droughts, happen as a result of player actions in previous turns and are communicated to players at the start of each turn. Depending on simulated river discharges and prior player actions in the *Sustainable Delta Game* [13, 14], multiple drought or floods can occur during simulated steps covering up to 25 years. Players receive detailed feedback at the start of each turn on the impacts of events, accompanied with newspaper headlines describing past events.

3.2 Shocks as changing probabilities

Some board games include shock events as probabilities that may change during gameplay to simulate climate change impacts [15-17]. Probability changes alter the in-game frequency of event occurrence, but not their extent or intensity. Focusing on communicating changing probabilities of extremes under climate change, *CAULDRON* uses six-sided dice where initially throwing one particular side triggers an extreme event [16]. The dice cannot be inspected by players and are replaced during the game, presenting players with new, unknown, and varying probabilities. *Dissolving Disasters* takes a similar approach [15], though replacing the die after a few turns with a truncated cone to make it difficult for players to assign probabilities to event occurrence.

3.3 Jump to a future climate scenario

Other games immediately present players with a future affected by climate change [18-21]. In this future scenario, players face a climate change related challenge, which may still be time-based on a much finer resolution. In *Forage Rummy* for example [18], players take 13 turns to develop year-round livestock forage production and animal diet regime given future climate conditions in 2050. Extending on *Forage Rummy*, *FARMORE* covers three years with future climate variability [19], where one year can represent extreme weather to evaluate the adaptive capacity of the players' developed system.

3.4 Climate change as a game condition

Some games include the extent of climate change as a game condition that players directly or indirectly influence and that can lead to (delayed) effects [22-24]. The board games *KEEP COOL* [22] and *THE FARMERS* [23] use (global) carbon levels that fluctuate based on player actions. As a result of these levels, events happen at the start or end of turns, some of which can be seen as shocks. Similarly, in *Broken Cities*, players randomly draw event cards when cumulative emissions surpass certain thresholds, shown as highlighted squares on a track [24].

4 Concluding remarks and next steps

The aim of this study was to identify game design strategies and mechanisms to include both climate change induced shocks and stresses. Four strategies were identified: (1) time-based simulation with triggered events; (2) shocks as changing probabilities; (3) jump to a future climate scenario; and (4) Climate change as a game condition. A limitation of this study is that it only looks at games covered in review papers on climate change games. Relevant games may therefore be overlooked if these did not pass the review papers' inclusion criteria or were published after the conducted reviews. These limitations are addressed by conducting a systematic review, informed by this study. As a precursor to such a review, the identified strategies should be seen as preliminary, but already offer guidance for designing climate change games, including the Delta Management Game.

Acknowledgements

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Healthcare Institutions in Flux: A strategy and collaboration game about enabling smart digitalization in healthcare

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Abstract. In this gamified case study, students play one of eleven stakeholder role, with 4-5 students per stakeholder group in the healthcare sector. The sector faces its typical ongoing challenges and conflicts but against a backdrop of increasingly urgent strategic questions about digital transformation. Stakeholders must coordinate and compromise to reach their collective goal – reducing the admission of over 65-year-olds to the ER (which costs the Netherlands € 1.4 billion EUR). Unnecessary hospital admissions can be prevented by attention to social causes, early diagnosis and sending patients home for observation, which are achievable in the game through points related to various actions that can be taken. Each group has its own individual goals, which sometimes conflict with each other, and interact in different ways. The game is played in two rounds of four phases (Strategize, Negotiate, Invest, Results). In Strategize, groups reflect on their individual goals in the context of their collective goal, and make a plan. In Negotiate, students attend meetings with the other stakeholders. The third phase is Invest, in which stakeholders make decisions about resource allocation, which they input into an online portal. The fourth phase is Results, where the lecturer displays the results each stakeholder group has achieved towards their individual goals and the group's collective progress towards achieving their collective goal. In the second round, students strategize and negotiate to make up for unresolved issues, learn from past mistakes, and try to reach their goals by the end of the game.

Keywords: Institutional Theory, Teaching, Healthcare

1 Setting

I present a gamified case strategy and collaboration game about digital transformation in healthcare.

Students take stakeholder roles (Government, doctors, nurses, insurance firms, technology firms, clinics, hospitals, elderly care) with conflicting targets, practices, norms and values. They must analyze digitalization challenges, devise strategies, listen to conflicting perspectives and collaborate.

The game offers an abstracted view of the healthcare system to teach systems thinking, allows students to experience institutional pressures and other concepts from institutional theory, and exposes them to different perspectives. Students also experiment with strategizing and applying concepts of value-driven and integrated-care principles, which are important to healthcare innovation in the Netherlands. Though based on the Dutch system, the game is applicable in management, organization, and strategy courses across levels and contexts for its broad learning goals, and has also been played at the executive level with healthcare management MA students. Different student groups experience learning goals differently, but report positive learning and experiences.

1.1 Empirical setting

Digital transformation involves pervasive change to society, industries and organizations (Vial 2019; Yoo, Boland, Lyytinen & Majchrzak, 2012), their processes, products and services (Hanelt, et al., 2021; Gegenuber, et al., 2022; Schafheitle, et al, 2020; Scott & Orlikowski, 2021).

Organizations are faced with the challenge to react and adapt to potentially disruptive innovations such as artificial intelligence (AI) or Internet of Things, as well as to evolve their businesses to leverage evolving technologies (e.g. Besson & Rowe, 2012; Kreschmer & Khashabi, 2022), such as by including software in products in services where previously it was not needed.

In the healthcare sector, new sensors, devices, AI applications, portals, and platforms are emerging rapidly as potential solutions in the complex, or ‘wicked’ problem of ensuring an effective, affordable and patient-centric healthcare system. However, now more than ever, technology implementation must aggregate to field-, organization- and professional- *transformation* rather than simply *adoption* because as novel and widespread technologies shift roles and responsibilities between patients and providers, call for new workflows and facilitate changes in the location of care from formal facilities to the home. These and other shifts involve new technical and communicative interfaces between digital and human components in the system.

The digital transformation of healthcare can be understood as a wicked problem nested within the larger shift in healthcare. A ‘wicked’ problem involves nested technical (more beds/efficient technologies/nurses, etc.) and relational problems (changing workflows, new professional roles, shifting norms) (Mair & Seelos, 2021; Seelos & Mair, 2017); and multiple actors with conflicting interests (Alford & Head, 2017; Head & Alford, 2015; Head, 2022). The digital transformation of healthcare is an ongoing, necessary and complex process and a crucial step for sustainable care. For example, to re-direct unnecessary but costly ER admits which cost the Netherlands 1.4 billion EUR per year (Vektis, 2018), technologies for diagnostics, home monitoring and telehealth are necessary, but will only be sufficient if deployed amidst workflow change. To reap the benefits of technologized solutions, tech must not only replicate functionality in a more efficient, digital way, but fundamentally reshape the organization of activities such that different people (and technology) take on different tasks, resources and responsibilities - from human to algorithm, from trained professional to home-stay patient.

Digital transformation and its impact on organizational strategy is complex, particularly in the healthcare context (aging populations, rising costs, labor shortages). Master students need to be prepared with analytical, critical thinking and empathetic strategizing skills to work on this challenge of the future, and others.

2 Theoretical underpinning

2.1 Institutional theory

Institutional theory (IT) is a useful academic perspective that can prepare students to consider the ‘human’ barriers and enablers to tackling complex future challenges. Institutional theory (IT), helps students understand how to interpret changes in a firm’s external environment, why and how they matter for organizations (Glynn et al., 2016; Ocasio & Gai, 2020), and how they influence solutions (Thornton & Ocasio, 1999). However, Institutionalists have raised concern that while IT matters, it has not crossed into practice (Glynn et al., 2016). An institutional theory perspective can help to analyze healthcare challenges (e.g. Scott, 2000; Reay & Hinings, 2009; Barbour, 2010). An interactive game is ideal for helping students experience challenging theory, as well as critical thinking and empathizing learning goals (Duke, 1974; Garris, Ahlers & Driskell, 2002; Hofstede, Caluwe & Peters, 2010).

2.2 Theory learning goals

The game is designed to get a deeper understanding of the theoretical concepts of institutional theory and to see them in action. Institutional theory is often perceived as a high-level, abstract

theory and the game should help students to see its practical relevance. The main institutional concepts addressed include:

- Legitimacy
- Diffusion
- Institutions
- Institutional pressures
- Organizational responses to those
- Decoupling

The game also addresses several other learning goals, such as demonstrating a systems perspective whereby students recognize the dynamics between actors, levels and organizations (Grewatsch, Kennedy & Bansal, 2021). Others are left out for space constraints.

3 Game overview

3.1 Stakeholders

The students take roles of different stakeholder groups. A good size of a stakeholder group is around 4 to 5 people. Depending on the amount of students who signed up for the workgroup, the amount of groups needs to be adapted. There are in total 11 different groups. In case there are more or less students, the amount of groups can easiest be adapted by adding or removing another tech company. This needs to be considered in the other documents as well, so it is preferable not to change the amount of groups.

The stakeholder groups are:

- Tech companies:
 - MedTech
 - BigTech
 - NewTech
- Healthcare organizations
 - Health & Medical Center (HMC)
 - General Practitioners (GPs)
 - Elderly Care
- Insurances
 - We-for-you insurance
 - Health Alliance
- Staff
 - Nurses at the Elderly Care
 - ER Doctors at the HMC
- Patient representatives

Every group gets a stakeholder description in the beginning of the game. Subsequently, they receive individual stakeholder round cards for each round (in addition to general information sheets for every stakeholder group). Each group knows about the overall goal and their own goals.

The groups cannot achieve their goal on their own, they need to interact and collaborate with the other groups. This is exemplified by an healthcare organization that wants to buy a new technology from one of the tech companies. To do so, the organization needs to acquire money from the insurance companies, but also the tech company needs to gain legitimacy from other stakeholder groups so that it can actually sell the product.

3.2 Strategize

In the strategize phase, the students have time to read and understand the new information per round. They have time to prepare their internal memos and the action plans that they need for the later negotiation phase. They agree on their goals and plan what needs to be done in order to

achieve this goal. Each round, there is time to adapt the strategy and vision based on new information and the results of the last round.

3.3 Negotiate

In the negotiate phase, the stakeholder groups get the chance to meet other stakeholder groups to discuss with them. They need to convince other groups to e.g. invest money in them or grant legitimacy to their favorite tech supplier. In every round, they have planned and open meetings (in the third round there will only be open meetings).

3.4 Invest

In the invest phase, the students come together with their own group again. Based on the information they gathered and agreements they made in the prior phase, they take the decisions on what they want to invest in (healthcare organizations), how they want to allocate their money (insurances), whether they give their support / legitimacy to the tech companies (patient representatives, insurances, nurses, doctors) and which insurance receives which amount of premium points (patient representatives). The decisions are documented in the investment sheet via a survey.

3.5 Results

The results phase is the shortest one, in which the results from the round are presented. The lecturer reveals which group achieved their goals and which did not, and shows the overall result for the system. The lecturer also engages with the students to discuss what happened, and why.

3.6 End of the game

After the presentation of the results of round 2, the game ends. The lecturer leads a reflection of decisions and actions in the game, and presents some take away points, especially linking the session to theory.

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Bridging video games and ecology through systemic game design

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Abstract. Ecology can be defined as a science that studies the interactions between organisms, as well as with the environment in which they evolve. In order to represent these interactions, researchers turned toward system dynamics, using feedback loops.

A similar trend toward systemic modeling is happening in game design, as the notion of interaction is also central to the study of games. Although the mechanistic view of video games remains dominant, interaction-based approaches are increasingly complementing it, and extensive studies of systemic approaches in game design can be found in at least two-game design books: *Advanced game design: a systems approach* and *Elements of Game Design*.

Through this common theoretical approach, we saw an opportunity to create games on the theme of ecology: how can the use of systemic modeling facilitate the creation of video games related to ecology?

We used de Rosnay's systemic equilibrium loops (1979) to model game systems in a game design course. We present two games and their equilibrium loops, demonstrating how the systemic approach allows pressing ecological issues to be translated into game concepts.

Keywords: Game Design, Ecology, Systemic, Gameplay loop, Research through Design

1 Systemic modelling to facilitate game design

Ecology can be defined as a science that studies the *interactions* between organisms, as well as with the environment in which they evolve (Blandin, Couvet et al. 2023) In order to represent these interactions, researchers turned toward system dynamics, using feedback loops (De Rosnay 1975, Kurz, Dymond et al. 2008, KCVS 2011, Bralower and Bice 2022).

A similar trend toward systemic modeling is happening in game design, as the notion of interaction is also central to the study of games (Stang 2019). Although the mechanistic view of video games remains dominant, interaction-based approaches are increasingly complementing it (Salen and Zimmerman 2003, Sicart 2008, Olsson, Björk et al. 2014), and extensive studies of systemic approaches in game design can be found in at least two-game design books: *Advanced game design: a systems approach* (Sellers 2017) and *Elements of Game Design* (Zubek 2020).

Through this common theoretical approach, we saw an opportunity to create games on the theme of ecology: **how can the use of systemic modeling facilitate the creation of video games related to ecology?**

2 French systemic approach

We used the work of the French systemists (Le Moigne 1977, De Rosnay 1979, Morin 2008). Elaborating on Heinz von Foerster's second-order cybernetics (Breton 2019) those authors developed the complexity paradigm (Morin 2008). In his major book, *The Macroscopic* (1979), De Rosnay specifically worked on the concept of autoregulation, self-organization and autopoiesis. He expanded upon system dynamics (Forrester 1971) to offer a balanced way of visualizing systems. He demonstrated how a system can maintain itself forever in a dynamic equilibrium as shown with mice population (fig. 1).

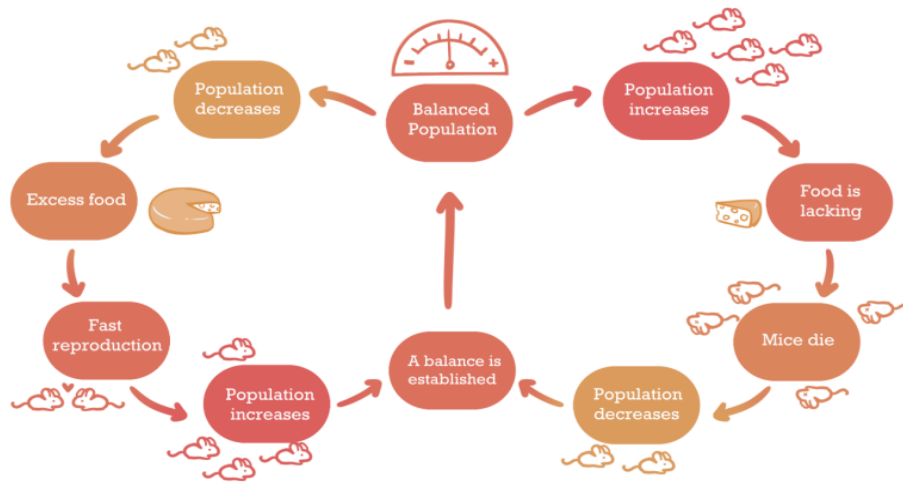


Fig. 1. Systemic loop describing the regulation of mice population, reproduced from De Rosnay (1975, p.17).

We used this approach to model games system during game design projects and courses (Chiapello 2022, Chiapello and Dumitrache 2022). For example, students analysed the game Roller Coaster Tycoon (as seen on fig. 2).

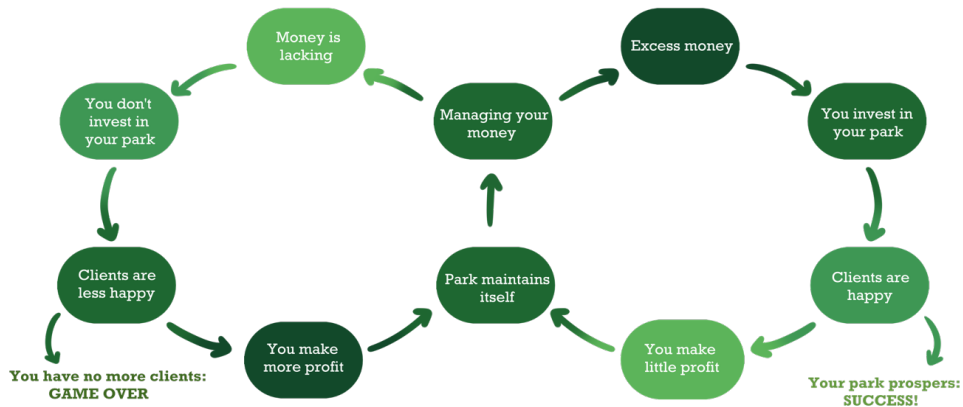


Fig. 2. Roller Coaster Tycoon Systemic Equilibrium Gameplay Loop

For this project, we tried to model game systems and ecological systems as dynamic equilibriums, in order to make games about ecological issues.

3 Methodology

To test this approach to game design, we conducted *project-grounded research*, in an educational context (Findeli and Coste 2007). Project-grounded research is a form of research *through* design (Frayling 1994, Godin and Zahedi 2014) where knowledge is developed through practice, and researchers are integrated into a project as stakeholders. For this study, the researcher was also a professor in a university department of art and design, which has a program in game design. Students became partners and the projects carried out in class become fertile ground for testing and refining systemic modeling for ecological video games.

As part of a game design course, the students created games projects related to ecology. It is important to stress that those were not serious games: no learning outcomes were expected, and each group could choose their target audience. However, as systems convey meaning through procedural rhetoric (Bogost 2010), the intended message of the game had to be clearly enunciated and visible within the system.

Students had to: 1) explore different systemic models of phenomena related to climate change, and 2) inspired by these models, elaborate a video game concept, 3) details their intentions and message. Those concepts and explanations were gathered and analyzed by the professor and discussed in class. This whole process generated different design documents that were all collected for the research.

4 Results: ecosystems and game systems and equilibrium

Four teams worked on this assignment: all produced interesting design documents; for this paper we selected two games that clearly identified a pressing ecological issue while delivering a well-defined message about it.

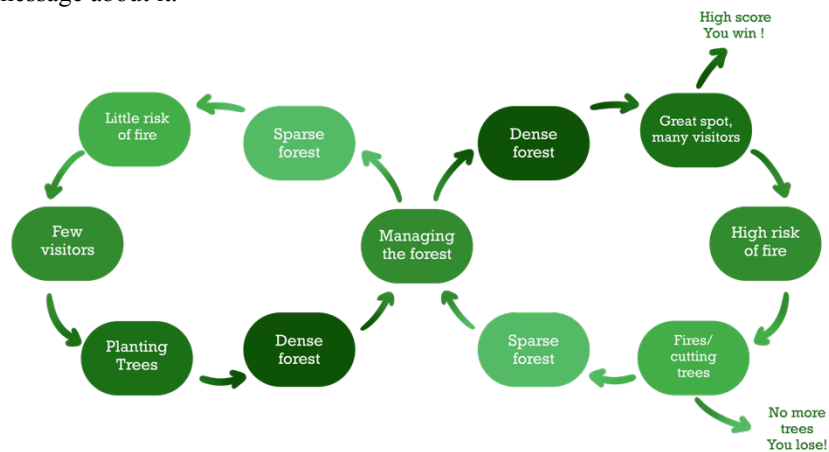


Fig. 3. Forest Fire Systemic Equilibrium Gameplay Loop

The first game concerns forest fires (fig. 3): the goal is to plant a forest, and to open it to pedestrians so they can enjoy nature. However dense forests with high traffic are prone to fire. While the game pushes the players to densify the forest and to allow a maximum of people to visit it in order to make a high score, careful management is needed to prevent the forest from going up in flames.

Another game concept exposes the danger of soil overexploitation (fig. 4). The players must manage a carrot field and a rabbit farm. Once again, the high score system encourages the players toward intensive exploitation of the soil in order to produce a high number of carrots. The player will collect a lot of carrots, allowing rabbits to be well fed and to reproduce faster, thus making high profits. However, if the land is overexploited, it will turn dry and infertile, and the player will no longer be able to cultivate it, losing everything. Once again, players' choices can help to avoid over-exploitation, for example by allowing the land to lie fallow, which reduce the profits but preserve the soil.



Fig. 4. Rabbit Farming Systemic Equilibrium Gameplay Loop

In both examples, players are supposed to try to understand the system and then should be able to manage resources efficiently and win the game, making these experiences relatively short and streamlined in order for the message to be clear. However, these systems are scalable and could be the backbone of experiences with a wider scope if combined with other elements.

With these students' projects, we can see how the systemic approach allowed ecosystemic issues to be translated into game concepts, making ecological concerns tangible through games about the environment. The tension between high scores and resources is a classic problem in video games, and it resonates with our current ecological challenges. The analogy between ecosystems and game systems is thus a fruitful one, that we shall continue to explore.

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Escape Room Design As A Double Impact On Learning

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Abstract. In achieving a sustainable future, an often-neglected pillar is raising awareness and educating youth on the issue of energy transition, a complex topic to understand for students, especially when they have diverse backgrounds. The application of escape rooms to educational purposes has become more popular as a way to encourage experiential learning and engage people in their learning environment. While different types of initiatives are taking place in higher education institutions, these are often led by teachers and focused on sustainability in a very broad sense. In this context, a project has been set up at Hanze University of Applied Sciences in Groningen, where students from the Master Energy for Society created a playful physical escape room experience for others to learn, while learning themselves in the process of designing. In this extended abstract, an overview of the project is provided together with some preliminary findings on the double impact on learning, both on master students acting as designers, and on a group of external students acting as players. Based on group discussions, positive impact on learning is observed on both groups. In the context of this project, we conclude that what seemed to have worked well in terms of the set-up is learning by having a specific and real challenge such as creating an escape room that is going to be played by other, among other factors. We also offer observations and advice for further improvements when implementing such a setup in higher education.

Keywords: Escape Room, Energy Transition, Game-based Learning, Innovation

1 Introduction

Energy transition is key to achieving a sustainable future. In this transition, an often neglected pillar is raising awareness and educating youth on this issue. It is a complex topic to understand for students, especially when they have diverse backgrounds [1]. In the last years we have seen a growing interest in the use of gamification approaches in higher institutions to motivate learning in innovative ways, in part due to the response to an environment of increasing “performativity” and “instrumentalism” in education [2]. A new trend is the use educational escape rooms: “a live-action team-based game where players discover clues, solve puzzles, and solve tasks in one or more rooms to accomplish a specific goal (usually escaping from the room) in a limited amount of time” [3].

In this context, a project was set up at Hanze University of Applied Sciences in Groningen (with the support of a Comenius Teaching Fellowship and the Centre of Expertise Energy), where students from the Master Energy for Society created a playful physical escape room experience for others to learn, while learning themselves in the process of designing. In this extended abstract, an overview of the project is provided together with some preliminary findings on the double impact on learning. We end with some conclusions, offering observations and advices for further improvements when implementing such a setup in higher education.

2 About the project

The project was part of the course “Communication & Behavior” in the master program during the second block. In the first part of the course, they received theoretical lessons on behavioral change, communication strategies and persuasion. In the second part of the course, the class was divided into small teams of four students to work on the development of the escape room, during

which they follow a process of design, creation and testing over a number of weeks. Each small team was in charge of developing a different mission (story and puzzle) focused on a specific theme within the energy transition (and a specific learning outcome for each topic) -consumption, production, storage and transformation-, while at the same time applying the knowledge gathered in the theoretical classes and putting into practice important skills such as creativity, problem-solving, collaboration, and critical thinking. In the process, they had coaching sessions and they were guided by a group of experts in game design, energy, psychology and communication.



Fig. 1. Example of puzzles

At the end, the different missions were put together into a final prototype. The final prototype was played by the whole class first of all, and then by a group of students who represented a sample of their main target group, at a live event where they could analyze the outcomes and impact of their own intervention. A debriefing session between the coaches and students was held at the end to reflect on the experience.

3 Preliminary findings

Due to the project setup, a double impact on learning was made: on the one hand, master students were challenged and supported in learning about energy transition and how to communicate and educate others on this innovatively. The escape room was then opened up to other students to make them more aware and knowledgeable on the energy transition while having fun.

To assess the impact on learning on the master students who designed the escape room, a group discussion was conducted. When asked what was main learning points, the groups mentioned:

- 4) success in energy transition was a collective effort and not individual,
- 5) creativity could be used to trigger a positive change in critical matters,
- 6) how you communicate matters relating to energy transition to youth,
- 7) the added value of playtesting and the 'learning by doing'; learning how to receive feedback and integrate it into improvements and further development,
- 8) everyone in a group has different skills, and is important how to combine them.

On the more critical side, they expressed the challenge of bringing ideas into practice (especially with the more abstract topics of storage and transformation), coordinating with other teams to put all missions together and create a single escape room, and linking behavioral change and communication theories gathered in the first part of the course into their missions. In addition, they felt overwhelmed with the logistics around building the escape room (e.g. constructing boxes, buying materials, etc.). Overall, it was appreciated to work on a specific project / group intervention through an escape room.

The final prototype was played by a group of 8 students with backgrounds in communication and in law, in two different sessions on the same day. To evaluate the impact on their learning, the master students conducted a group discussion after playing. Outcomes showed that players acknowledged to have become more aware on issues such as energy consumption (e.g. which appliances use more energy, different types of energy labels), the importance of hydrogen, and

their individual role in the energy transition. It was perceived as a fun and stressful experience at the same time due to the time pressure.

4 Conclusions

The application of escape rooms to educational purposes have become more popular as a way to encourage experiential learning and engage people in their learning environment [4]. In comparison to serious games, escape rooms involve participants in the heart of a narration: the learner is immersed in a story and is ready to learn through narrative transportation. Escape rooms can offer a more physically engaged version for training, while still working towards mental training as well. In addition, they are seen as a good a tool for communication and team-building.

In higher education institutions, we see a growth of this type of experiences, but not much on the issue of energy transition, which makes this project original. Another aspect to highlight in relation to its originality is that the escape room was designed by students for students, which is still rare since most of the time, teachers are in lead of developing the game [4]. In the context of this project, what seemed to have worked well in terms of the set-up is learning by having an specific and real challenge such as creating an escape room that is going to be played by others. A rented shipping container was available to create the game, making the challenge tangible and more urgent. Also, a makerspace that offers support in crafting was available. It is important to mention that there was also available budget to purchase needed materials such as locks and black lights. On the other hand, having more time available and a better structure of the course, would have made it easier to better align theory classes and the project by having more coaching and reflection sessions organized during the development of the escape room. For future research, we recommend experimentation on larger cohorts to refine and establish further conclusions, and make a comparative study between a “traditional” course versus game-based learning through escape rooms.

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Co-design of FimWaagaSel game as part of a Living lab process towards Sustainable Development Goals in Fimela, Senegal

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Abstract. With a group of local stakeholders in the Fimela district in Senegal, we created a living lab in order to find out robust pathways to reach sustainable development goals (SDGs) in this region, taking in account local constraints and expectations. We worked jointly so that this new emerging institution would have suitable tools for this objective. We built on several approaches for the participatory elaboration and exploration towards transition pathways towards sustainable development goals. As part of this process, we identified the issue of salinization of inland water in this coastal region, as a key issue for several SDGs. We adapted CreaWAG to co-design a serious game, FimWaagaSel, with a subgroup of Living Lab members to handle it. This co-design process was elaborated with a focus on actors and resources as well as soft and hard infrastructures, human, artificial and natural. It paid attention to the potential of local stakeholders involvement so that solutions might emerge. The core team of the living lab tested and validated the game which is now demanded for sessions within the villages of Fimela District.

Keywords: Living Lab, Co-design, Sustainable Development Goals, Salinization.

As the Sustainable Development Goals (SDG) are still to be achieved for 2030, their implementation at local level remains a challenge, especially in sub-Saharan Africa. In this desire to anchor the SDGs at the local level, the SDG pathfinding action research project aims to explore avenues for sustainability through the creation of a living lab using participatory process and tools in Fimela (Senegal).

The living lab has been created by a national level development NGO with stakeholders from local village associations and local representative NGOs (eg. Nature conservation) but also representatives of municipality leadership and representatives of main business sectors (fishing, agriculture). It includes also teachers from the local university. Its main goal is to find out pathways towards SDGs as interpreted to fit local stakes. Main issue for this new agile institution is to find out the tools and the means to work and explore potential pathways.

Among the participatory tools, we co-designed a serious game, FimWaagaSel, with the core members of the Fimela living lab following the Cooplage set of tools [1, 2]. This co-design process started with the identification in each village of the main stakes in relation with SDGs and the stakeholders either active in the evolution of these stakes or affected by them. These included salt intrusion, drinkable water availability, access to health centers, access to energy and development of schools. Then the core team of the living lab, as appointed by the living lab whole assembly, selected the topic of salinization as the first one on which to test the game joint design process.

Consequently, the main question is to generate a serious game on salinization issue that fits representations of stakeholders to make it meaningful and legitimate for working on pathways towards a better local management of salt.

The core team set the goal of preventing and adapting to the salinization of the land of the district. The process then came through two workshops: a first one for conceptual model design and a second one for game elements development leading to a prototype. These two workshops

were completed through dedicated work of two members of the project team to finalize the game prototype development (and make it playable). The conceptual model was designed with members of living lab core groups and at least one villager active in previous living lab workshops. The design followed a CreaWAG process [3] updated with the ARDI approach [4] and the refined robustness framework [5] to identify the components to be added in the game, their dynamics and their interactions, including resources, users and (soft and hard) infrastructures. This stage was supported by a map of the area so that participants to the workshop could localize the stakes and infrastructures. It led to the collaborative elaboration of conceptual maps, including a new diagram dedicated to infrastructures. This diagram maps infrastructures considered in the model with the main stake addressed by the model as presented in the Figure 1 extracted from the results of the participatory process. It also specified, for each user and stakeholder, their potential involvement in the emergence of a solution: agree, manage, oppose, support. Besides, the emerging solution may constrain users' activities or benefit to them. Identifying these relations in an open collaborative mode enables to better understand the dynamics of the social and ecological system as the emergence of a solution may generate new interdependencies. In total, there are seven roles relating to the main economic actors, local authorities, deconcentrated services and Civil Society Organizations. For the sake of realism and limiting the number of players, some endorse both roles of users (farmers, fishermen, breeders ...) and representatives of their municipality. Each round represents a duration of one year, and between two rounds, there are 5 years. The players therefore have to choose between, on one hand individual seasonal activities such as farming or fishing, and on the other hand mid-term management of infrastructures including land and mangrove reforestation and the construction/maintenance of dykes to combat or not the progression of salinity.

Providing ways to compare and combine hard and natural infrastructures as means to prevent salinization is one of the purposes of the game. Actors targeted to play the game are the ones identified as roles in the game (mainly resource users of the different municipalities of the district as well as local environmental NGOs and Mayors), but the game could also be interesting to be played at central government level in order to account for the local issues, and at local communities level to get other points of view from the territory.

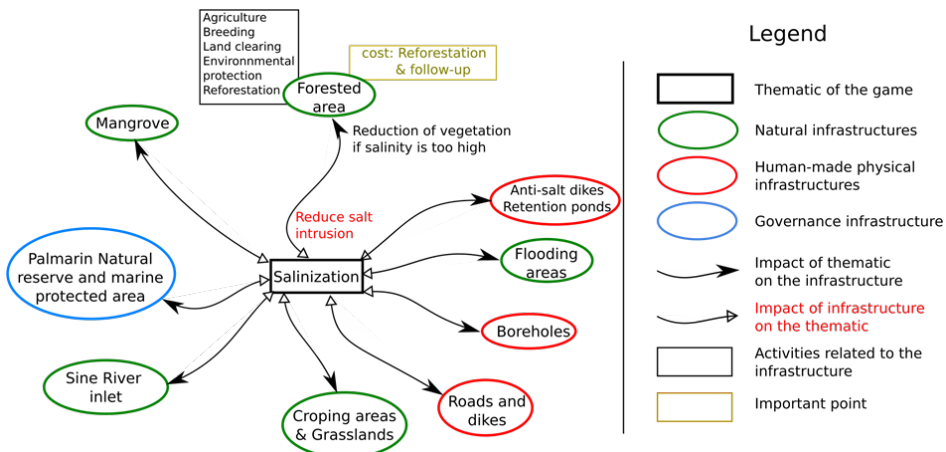


Fig. 1: Conceptual map of infrastructures related to salt intrusion processes (Only the Forested area natural infrastructure is detailed here for readability sake)

Initial session at the living lab level of FimWaagaSel highlighted a number of elements of governance 'resources' needed for transitions. This has been made possible by the explicit and accurate representation of these infrastructure in the game. A resource needed includes a clearly attributed and legitimate coordinating actor or institution to make efficient the reforestation

activities of local civic organizations across the district. It has also been pointed out that over the time, monitoring of the evolution of salt is crucial to motivate action and requires some dedicated funding. In addition, players could identify the risks of increased salinization on economic activities and natural capital, due to climatic uncertainty (irregularity/weakness of rainfall).

As such the game proved to be a useful instrument to support the living lab activity. For the sake of assessing and monitoring such activities, qualitative and quantitative data will be collected.

The actors involved in the living lab are now (1) developing the capacity to use this game in villages by training local facilitators who will run participatory sessions based on the game, and (2) co-designing a second game as a part of the institutionalization of the living lab in the district.

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An adaptable Ludic Game – for teens and grown-ups

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Abstract. The Game has a basic structure that can be complexified, either by the definition of the rules or by the creativity of the participants. The basic structure is a supply chain with three types of companies: suppliers, manufacturers, and retailers. Suppliers sell assembling units to manufacturers. Manufacturers, using assembling units, construct goods, sold to retailers, which in turn sell to an Exporter. The basic rule of the Game simply sets a price bracket for the commercialization of the assembling pieces, for every actor involved in the chain. The Exporter can discretionarily define the price of the pieces he buys according to the number of assembling units and the variety of shapes and colors used in the piece. The Government acts in arbitration and guarantees the legitimacy of transactions. The complexification in the rules can occur, for example, due to the offer of prizes by the government to the company that makes the first sale. The creativity of participants can lead, for example, companies to make investments in other companies, use different forms of sales channels and merchandising using social networks, and consult the internet in search of models. Another important factor is the game evaluation system, composed of 23 subjective items, evaluated by the participants both as actors in the productive chain and as members of society. Six quantitative items, on the financial and physical results of the Game, are also part of the evaluation system. This evaluation system is based on the BEM of the Brazilian National Quality Foundation.

Keywords: Adaptable Game, Companies, MBA, Undergraduate, High School

1 Introduction

This work presents a ludic (Magic Pins) and highly competitive Game whose evaluation system is based on the Brazilian Business Excellence Model (MEG) [1]. The Game has been applied since 1996 until now, in private companies, MBAs, undergraduate courses, high schools, and K-12, totaling 237 classes, and around 7,000 participants. At the finish, we will make an analysis of the Game Components [2].

2 The Brazilian Business Excellence Model (BEM).

The MEG was updated seven times (1994, 1997, 1998, 2001, 2002, 2003, and 2016). The most recent MEG, presented in Figure 1, is based on the Tangram. When using MEG, the organization must adapt it in the best way that defines its management model.



Fig. 1. The MEG.

The eight Fundamentals of MEG are Systemic Thinking, Compromise with Stakeholders, Organizational Learning and Innovation, Adaptability, Transformative Leadership, Sustainable Development, Process Orientation, and Value Generation.

3 The Game Evaluation System

The Game Evaluation System consists of six objective questions: Average Purchase Price, Average Sales Price, Value added to the product (Final sale price of product/cost of the raw material acquired), Physical Participation, Financial Participation, and Profitability on Initial Capital.

3.1 These are calculated by Excel spreadsheets, referencing each company's purchases and sales. In addition, there is a set of subjective questions evaluated by the participants, but due to the constant evolution of the MEG, the questions were being adapted to the reality of the market. Since 2010, there are 23 subjective questions based on the MEG, such as Organizational Climate, Customer-Supplier Relationship. All grades range from 1 to 5 for all questions. Only the question of Profitability can be assigned a zero grade if it is negative. Table 1 shows these questions.

Table 1. The Questions, who is the evaluator, and what the weight of each item.

QUESTIONS	WHO	WEIGHT
1.1 The Vision defined by senior management is clear.	STK	8.0
1.2 The Mission defined by senior management considers the values of the organization, the focus on the customer, mutual respect and trust, ethical behavior, participation of people, and expectations of high performance.	STK	8.0
1.3 The leadership style is focused on results.	STK	6.0
2.1 The company conducts customer satisfaction surveys post sale.	CM	1.5
2.2 Measures are taken regarding customer satisfaction and complaint surveys.	CM	1.5
2.3 The company seeks partnerships with its competitors.	STK	1.5
2.4 The company takes action in accordance with the competitor analysis.	STK	1.5
2.5 The company analyzes the competitive environment in search of new	STK	1.5
2.6 Actions are taken in relation to the analysis of the competitive environment.	STK	1.5
2.7 The company seeks partnerships with Supplier Markets.	SM	1.5
2.8 Measures are taken regarding the search for partnerships with the Supplier Markets	SM	1.5
3.1 The company knows the expectations and the current and future needs of the Consumer Markets presale.	CM	1.5
3.2 The company evaluates and improves its product in accordance with the information from Consumer Markets.	CM	4.0
3.3 The company has a product line differentiated by quality.	CM	4.0
4.1 Are people from the workforce, suppliers, and other stakeholders aware of and involved in issues related to social and environmental responsibility?	STK	3.0
4.2 The company has an established code of conduct.	STK	3.0
4.3 Does the company communicate to society the impacts and corresponding information associated with products, processes, and facilities?	A	3.0
4.4 Has the community's degree of satisfaction with the company been identified and ev	A	3.0
5.1 Information about competitors is used by the company.	STK	2.0
5.2 Information about product quality is used by the company.	STK	2.0
5.3 Information about customers is used by the company.	CM	3.0
5.4 Information about operational performance is used by the company.	STK	2.0
5.5 Information about financial performance is used by the company.	STK	3.0
6.1 People are satisfied with what they do.	STK	4.5
6.2 The Business area has autonomy to act.	STK	4.5
6.3 The Production area has autonomy to act.	STK	4.5
6.4 Communication between the Business and Production areas is clear, objective, and	STK	4.5
7.1 Best average price paid when purchasing raw material Supplier Market.	OG	4.5
7.2 Best average price received when selling raw material in the product Consumer Ma	OG	4.5
7.3 Value added to the product Final sale price of product / cost of the raw material acq	OG	4.5
7.4 Lead time for delivery time elapsed from the moment the buyer confirms the purchas	CM	4.5
7.5 The criteria used to select and train suppliers are clear and well defined.	STK	4.0
8.1 The company satisfied all the expectations and needs of the Consumer Market.	CM	20.0
8.2 Profitability.	OG	22.0
8.3 Physical share physical sales.	OG	8.0
8.4 Financial share financial sales.	OG	8.0
8.5 The Company has an excellent organizational climate.	STK	6.0
8.6 Ranking of the Companies that negotiated best with the Supplier Market.	SM	10.0
8.7 Considering all of the items evaluated, what score would you give the Company?	A	16.0

Excel Simulator

- An Excel simulator was developed to record the information concerning the buying and sales of the companies and the evaluations, it calculates the result of the Game. Each

company has an Excel file with six tabs Financial Information, Simulator, Sells, Buys, Other Expenses & Revenues, Evaluations, and Stakeholders. Figure 2 shows an example.

MFK		RETAILER A		
Nr	Quantity of Toys	Quantity of Pins in Toys	Price	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Total	0	0	R\$ 0,00	

MFK		RETAILER D		
Nr	Quantity of Toys	Quantity of Pins in Toys	Price	
1	1	43	R\$ 40.000,00	
2	1	10	R\$ 8.500,00	
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Total	2	53	R\$ 48.500,00	

Fig. 2. Example Excel Spreadsheet

4 The Game Design

The Game Design is presented in Figure 3, highlighting the supplier-customer chain that begins with the Suppliers and ends with the Final Client.

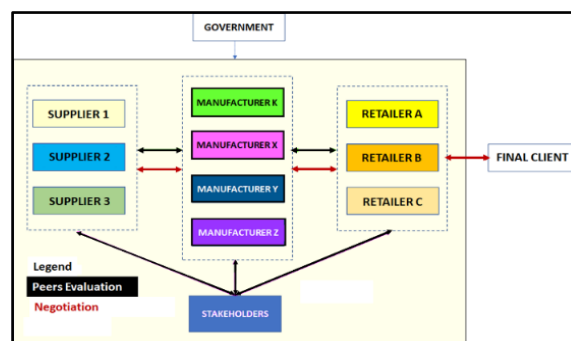


Fig. 3. The Game Design.

- Two to four Suppliers — they receive and pay (consignment or otherwise) for raw material lots that will be sold as interchangeable parts to produce toys. They sell to the Manufacturers and evaluate them. Each Supplier is formed by two students.
- Three to four Manufacturers — they purchase from the Suppliers interchangeable parts to produce toys that are sold to the Retailer. They evaluate both the Suppliers and Retailers in the customer-supplier relationship. The companies typically receive scores from more than one evaluator for each available item. The final score of the evaluation items of a company is the mean of the scores given by the different evaluators. Each Manufacturer is formed by at least three to five students.
- Two to four Retailers — they purchase toys from the Manufacturers according to the demand defined by the Exporter, and they evaluate the Manufacturers in the customer-supplier relationship. Each Retailer is formed by two students.

- Exporter — played by the Teacher. He negotiates high volumes of toys (demand from the Game) with each Retailer without determining the color or design of the toys but only the amount of raw material used to make them. The Exporter first determines the toy lots for the Retailers.

- Government — also played by the Teacher. It takes general measures to ensure that the Game favors each business's production and consequent management.

It's worth pointing out that the rules of the Game support a market economy based on individualism and private property in the means of production.

4.1 The Magic Pins

Magic Pins were used as raw material to be handled in the Game. These pins are produced in five colors and four designs and were chosen because they are affordable national products that are available in the Brazilian market. The colors are white, yellow, red, green, and blue and are also classified in terms of design: 4-hole pins, 3-hole pins, 1-hole pins, and half-wheels.

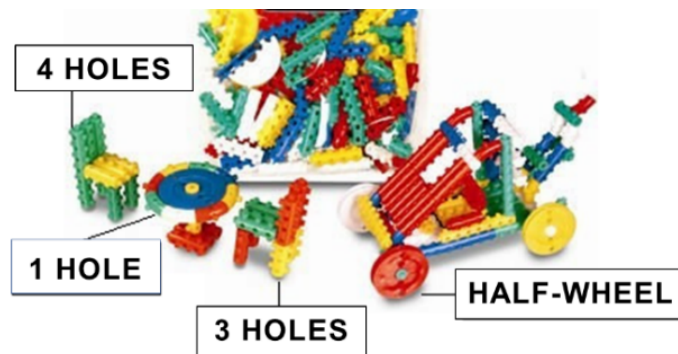


Fig. 4. The Magic Pins.

5 The four Game Meetings

On the first meeting, the Teacher divides the class into small groups and asks them to do the following activity: present a list of three organizations (companies, associations, football teams, etc.) that they consider to be successful and the reasons why. In the end, the Teacher comments that the students "gave him a lesson". They have enough knowledge to "run their business" and "make money". He explains that the Game will help them understand "how to achieve success" because the "reasons" are already known to them.

On the 2nd meeting, the Teacher divides the class into teams, presents the Magic Pins, and shows how to fill in the Excel spreadsheets to make a rehearsal with the class. They buy, sell, and fill in spreadsheets.

On the third meeting, the real match occurs. All the playful activities and their results are consolidated in Excel spreadsheets.

On the fourth meeting, the debriefing takes place. Groups from previous teams are formed with suppliers, manufacturers, and retailers. The results are discussed by the Groups. The Teacher presents three questions:

1. Which Supplier obtained the best performance? What are the reasons for this?
2. Which manufacturer obtained the best performance? What are the reasons for this?
3. Which retailer got the best performance? What are the reasons for this?

In general, the group's outcome coincides with the Game's results.

6 Timeline of the Game

For the first time (1996) the Game was applied at a Brazilian large mining company for the new employee development program. This training aimed to present the BEM and its applicability to trainees in the company. It was applied in 1996, 1998, 2000, and 2001, totaling 20 classes. Each Game was applied for 4 consecutive days and the results were part of a doctoral thesis [3]. This Game was also applied in other private companies operating in the financial market, offshore-onshore, aviation, agribusiness, technology, and armed forces, among others, until 2015.

In 1998, a school of management requested a business game discipline for its courses, lasting 18 hours on 2 consecutive days. The database analyzed consists of outcomes from 47 classes and 1,410 students [4].

In 2007 the Game was introduced into an undergraduate course in Business Administration. The program provided 16 weeks of 2-stroke classes. Another adaptation was made and had full acceptance by the classes [5,6].

In 2015, a tournament was created between high schools, in 4 meetings. The project was transformed into a postdoc project (7). This work collects the students’ opinions about Administration and the profession of Administrator. The tournament was implemented for four consecutive years. In total, nine schools (three public and six private), 736 students, and 41 teachers participated in the tournament. In each school, there was a winning team. The students showed that they already had a previous partial perception of the profession (as defined by the curriculum directives).

In 2018 and 2019, the Game was held in five classes of high schools, one MBA class as well as two 9th-grade classes in junior high school. During the pandemic, activities were suspended. Since February 2022, the Game has been applied as a school subject "Entrepreneurship Game" in a high school. It lasts 20 weeks, 2 classes per week.

7 Why is the Game so adaptable?

- (a) We have not thoroughly studied the reasons for this adaptability, but Table 2 shows some reasons why a Serious Game is so adaptable to different groups of people [2].

Table 4. The Components of a Serious Game X Game Meetings.

		COMPONENTS OF A GAME						
		Symbolic Structure			Game Procedures		Flow and sources of information	Scenary
		Paraphernalia	Visual Aids	Roles	Rules	Mechanics		
Meetings	1 st	Colored pens, PCs, White Frame.	Slides.	Company Partners.	Game Manual.	Group Work.	Presentation of the Game and its rules.	Computer Lab.
	2 nd	Magic Pins, PCs.	Excel, Magic Pins, Internet.	Supplier, Manufacturer, Retailer.	Suppliers' sales price range, Maximum limit of pins per toy, and Maximum amount paid to Retailers.	Random choice, by the Professor, of the doctors of the Companies; Purchasing, Selling, and Production Activities.	Use of excel spreadsheets and exchange of information and negotiation between companies.	Computer Laboratory, Distribution of Pins to Suppliers, Testing.
	3 th	Magic Pins, PCs.	Excel, Magic Pins, Internet.	Suppliers, Manufacturers, Retailers, and Evaluations.	Suppliers' sales price range; Maximum limit of pins per toy.	The teams are the same Companies. Purchase, Sale, Production, and Evaluation by Companies.	Use of excel spreadsheets and exchange of information between companies.	Computer Laboratory, Distribution of Pins to Suppliers. The game is for real.
	4 th	Colored pens, PCs, White Frame.	Slides.	Representatives of the Companies discuss the performance of their companies in intercompany Groups.	Formation of Intercompany Groups.	Discussion in Intercompany Group, Presentation of Results and Feedback.	Teacher, Result Information, students/trainees.	Computer Lab, Students return to their companies, Joy and crying.

In all classes, there has never been a case in which the participants questioned the outcome of the Game since the participants are the protagonists. Either negotiating or evaluating, they are exercising the sovereignty of the market.

There must be other reasons that justify this adaptability. It is worth mentioning that in all classes there was a certain homogeneity in the profile of the participants, either by age, professional experience, or business culture.

It's very important to say that the adaptability of the Game also relies on the fact that although the participants play a role, they act and react in response to real pressures of the market as it happens in real life.

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"Who's playing cards?" an exploration of the role of playing cards in social contexts

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Abstract. A search of articles available on the website for the SAGE Journal Simulation & Gaming returned 350 responses to the search term *cards*. A scan of a representative sample of those articles showed they report on the design of simulations/games using cards. However, the search did not find articles about the history and diversity of forms of 'cards' used for play and learning which we had hoped to find. This article therefore introduces an exploration of that history with an examination of some of the origin stories surrounding playing cards. It then investigates aspects of the diversity of forms that evolved from those origins. The historical interactions and influences of playing cards are mentioned where possible. This work is intended as a beginning and not yet a comprehensive exploration of some of the ways in which different social contexts and cultural influences have affect the design and use of cards and the games they are used to create.

Keywords: Card Games, Adapting/Repurposing Games, Canasta

1 Introduction

This work stemmed from our curiosity about the origins and adaptations of the card game called Canasta, and emerged while we were working on another project. The tantalizing fragments we found prompted further exploration of the issue of development of cards as items for 'play' and the many adaptations through which cards have become invaluable tools to support learning goals across a range of disciplines. A search of articles available on the website for the SAGE Journal Simulation & Gaming returned 350 responses to the search term *cards*, and a representative sample of those articles showed they focus on the design of simulations/games using cards as tools for various earning purposes. We did not find articles about the history and the forms of cards themselves. This article therefore launches an exploration of that history with an examination of some of the origin stories surrounding playing cards. This work is intended as a beginning and not yet a comprehensive survey for their use and introduces what is known about some of the social contexts and related factors influencing their design and use.

2 About Cards Themselves

While there are many special purpose decks for games like *Magic: The Gathering* and *Pokemon*, this inquiry is focused only on the more familiar multipurpose, ranked and possibly suited playing cards. The familiar modern 'deck of cards', in use globally today, consists of 52 stiff paper cards with the 'face' side commonly printed in red and black and the 'back' either blank or printed with the same image on every card. In the modern deck there are four standard suits known as Spades ♠ and Clubs ♣ (both always printed in black), and Hearts ♥ and Diamonds ♦ (both always printed in red). The ranks run A (which can be high or low depending on the game), K, Q, J, 10 through 2. This is known as the international pattern (or occasionally the Anglo-American pattern or English pattern of French-suited cards) and the most common dimensions for these cards are between 90.5± 3.5mm tall by 60±4mm wide depending on the manufacturer. The games known as Bridge and Poker are largely responsible for the ubiquity of the international pattern, but this arrangement is also used for games like Whist, Cribbage, Rummy, Napoleon (Nap), etc [7]. However, there are numerous decks across the world and across time,

which do not fit this 52-card model. Decks may add cards as does the recent Canasta Caliente deck which includes rule changing cards. Decks may also subtract cards, such as Pinochle using two decks but removing 2 through 8. One interesting variant is used in the game of Agram in Mali which uses only 31 cards where the cards in rank order are A, K, 10, Q, 9, 8, J, 7 (with no ace of spades) [4] [6]¹.

In contrast to the international deck, Swiss and German players of the game called Jass only use 36 cards and with suits called Shields, Roses, Bells, Acorns. German players of Skat only require 32 with suits known as hearts, leaves, bells, acorns. To continue this inventory, Spain and Mediterranean Italy use cards with suits of coins cups swords and clubs and French players of Tarot need 78 larger sized cards with an additional rank and 22 trumps in the standard French suits, of course. Adriatic Italy uses images of coins cups swords and batons - which are very archaic in appearance and reflect the earliest cards made in Europe.

The 78-card Tarot Deck, used for trick taking and illegal gambling games, evolved from the 52 card Italian (Acorns Bells, Hearts, and Leaves with King, Knight and Foot Servant) deck which had the Queen inserted between the King and Knight and non-suited trump cards - as added in the 1400s. Variations subtracted and added cards over the years and the meaning of the imagery was eventually lost. The use of the deck for fortune telling was first recorded in Bologna around 1750. When the deck was converted to the French suits, the trump cards were numbered, and more familiar decorative images replaced the archaic ones [4] [5].

3 A Very Abbreviated History -- Origins and Influences

“Out of an apparent void, a cluster of references in early {European} literature (inventories of possessions, edicts, city chronicles and account books) emerges pointing to the sudden arrival of playing cards, principally in Belgium, Germany, Spain and Italy and very soon afterwards we hear of them being banned or controlled by the authorities.” [2] We will return to that troublesome issue of banning and control later. However, our first goal is to uncover more about how and where cards emerged out of that ‘apparent void’.

It turns out that the arrival of cards in human activity was largely contiguous with the invention of paper and then printing in China. In the 600s, books were still prepared as scrolls which were inconvenient especially for reference purposes. However, once printing was available, books with detachable leaves were substituted for scrolls. One early book was about the “dice game”, also known as the “leaf game”. The emperor going on a 25-day drinking binge and playing this game in 969AD is often considered to be the first recorded reference to actual playing cards. Wilkinson suspects that the leaves of these books eventually replaced the dice and became cards. To support this claim, he references the card games of Japan where the cards form the leaves of books of poetry and further states that Japan “obtained all or nearly all its amusements from China” [1 pg64]. Chinese-styled cards may be found wherever Chinese traders were bound to the east, including Japan, Malaysia, Indonesia, Taiwan, Singapore, North Borneo, and Vietnam. The Chinese “money-suited” deck of 38 cards in four suits (coins, strings of coins, myriads of strings, tens of myriads) is believed to be the forefather to the four-suited decks of today by some.

After a period of development and refinements in China, the use of playing cards travelled along the Silk routes of Central Asia, through such modern countries as Kyrgyzstan and Uzbekistan moving from China through these members of various Islamic empires. Along the way ‘cups’ and ‘swords’ were added as suits to the original suits of coins and strings of coins related to what Mah Jong calls circles and bamboos. Non-figurative (i.e., without representations of nature) court cards were added the sets of cards as they were taken up by players in the Islamic empire.

¹ The information in this paragraph and elsewhere is a summary of data in the links included in the references list

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The Polos (Niccolò and Matteo returning from China in 1269) may have brought cards from China to Venice, however writers of the Black Death (Bubonic Plague, 1347-1350) Era, such as Petrarch, Chaucer and Boccaccio, where one-third of the population died, and trade was decimated, do not mention playing cards nor do they appear in other records. Yet, within two decades, the first ban on card games is noted in Switzerland, followed shortly thereafter in many locations. Some authors have suggested that this was a result of the Crusades, but the timing seems off as the last crusade to the Islamic Empire ended in 1272. The Northern Crusades, while still ongoing in 1350-1372, involved the wrong part of the world. But with the loss of much population, there was socioeconomic change. Serfdom ended in much of Europe and with that, the lower classes gained mobility. The Hundred Years' War was ongoing, adding to the intermixing of population. The abstract Islamic court cards were replaced in Europe by the king and his attendants (noting that some decks today do not include the queen e.g., in Italy, Spain, Germany, Switzerland, etc.). The designs were simplified, possibly due to the loss of manpower available for their painting and production.

Playing cards spread throughout the world and adapted readily to local cultures. Japan had "matching" games with painted shells that were adapted to playing cards when Portuguese traders introduced such to the islands prior to the isolationist period in 1543. The "book" concept was also seen in Japan with the 100 Poems playing card game played with two decks of 100 cards each. Another game of Japan is the beautiful hanafuda deck of 12-suits of 4 flower themed cards.

Cards based off of the Spanish decks came to the Americas with Cortes or Columbus in the 1500s, where local production quickly began. One interesting non-paper production of playing cards is, when in 1821 Apaches lost access to printed Spanish playing cards, they replaced them with hand painted stiff rawhide decks.

India has ornate cards known as ganjifa, which may be rectangular or circular with 8 or more suits of 48-120 cards, used for a variety of complex games. The fictional game of Tongo set in the Star Trek universe used highly decorative circular and rectangular cards reminiscent of ganjifa cards.

4 Bans and Controls

Why ban cards? There was a very early belief that evil was associated with cards, as well as the vice of gambling. One recorded example of such a belief in the evil impact of card playing concerns events from a card game in March 969. This note states that "one month after the Tartar prince held the tournament of leaves with his lords, he was murdered". (Wilkinson, pg. 65)

Cards have a long history with drinking and gambling, vices to be avoided. According to Parlett, the Chinese Leaf Game involved much alcoholic drinking as the leaves (cards) were printed with instructions or forfeits for whomever drew them. The association with gambling has been documented in police records since 1294. Wilkinson even posits that the first cards may have even actually been paper currency, but due to the risks involved this got substituted with "money cards", resulting in the suits of coins, strings of coins, myriads of strings, and tens of myriads.

'Foreign cards' (i.e., card sets from other cultures) often had imagery that was considered inappropriate, if not blasphemous. The Mamluk cards of Istanbul in the 15th century are quite striking in their abstract designs. The court cards are named king, viceroy, and under-deputy, however likely due to Sunni Islam restrictions, no depictions of persons are on them. The suits

of coins, polo-sticks (which evolved from sticks which evolved from strings), cups (believed to be derived linguistically from the word for myriad as cards moved from China to Mongolia to the Islamic Empire), and swords.

The Church took a strict, prejudicial view on what it saw as lewd, frivolous, fickle or dishonest behaviour. Members of the clergy would certainly not approve of card playing if it had anything to do with gambling or fortune telling. Moralizing tracts were published expressing disapproval of gambling as a mortal sin which might offend God and destroy lives. In 1423, a preacher in Sienna urged his followers into a pious frenzy where they burnt their playing cards among other items. The preface of Van Rensselaer's book *The Devil's Picture-Books*, written in 1890, states that "The 'Devil's Books' was the name bestowed upon Playing-cards by the Puritans and other pious souls who were probably in hopes that this name would alarm timid persons and so prevent their use. Whether or not his Satanic Majesty originated Playing-cards, we have no means of discovering; but it is more probable that he only inspired their invention, and placed them in the hands of mankind, who have eagerly adopted this simple means of amusing themselves, and have used it according to the good or evil which predominated in their own breasts."

Laws and royal decrees were passed forbidding card games from an early date, most likely directed at gambling and immoral behaviour including card sharpening and swindling. These were also likely motivated by economics, especially after the labor shortages created by the Black Plague of 1347-1350 that lasted for generations; for example, Paris found it necessary to ban card games specifically on workdays in 1377. But these were to no avail as the games were so popular. The authorities began to realize that playing card production had to be controlled by an official bureaucracy, or in many cases playing card monopolies were set up and taxes raised for the treasury.

All of this makes it interesting to note that card games today are usually not associated with evil or Satan, although they are still used for gambling – for large and small stakes.

5 Canasta -- reflecting playing card history

Canasta is a matching game of the rummy family (variant of 500 Rum) invented in 1939 in Uruguay as a time-efficient alternative to Bridge. The players make melds of seven cards of the same rank and go out by playing all cards in their hands. The game spread throughout South America then to the US by 1949 spawning many variations along the way. In 1951 the "Official Canasta Laws" were published in the US and Argentina. But as there is no actual official version of Canasta with no official governing body, the game has continued to spawn a large number of variations involving various numbers of decks (but at least one more than the number of players), players, teams with two players per team, rule changes and scoring plans. It is not uncommon for "house rules" to apply wherever Canasta is played. By the mid-1950s, Canasta was one of the most famous games worldwide, although there was not a common variation globally. Samba was quite popular in the mid-1950s worldwide but has faded since then. The Buraco variation is popular in the Middle East. Hand-and-Foot Canasta, created in the 1970s in which each player is dealt two piles of cards (the hand and the foot), is considered to be more fun for beginners.

6 Conclusions and next steps

There is no one standard version of Canasta, although there are many similar games with common characteristics which have evolved into what might be called a 'Canasta family'. Versions today include "Classic" Canasta, Modern American Canasta, International Canasta, Samba, a plethora of "national" Canastas, Hand-and-Foot Canasta, Ponytail Canasta. There is also an interesting variant called Boat Canasta designed to allow players familiar with different rules to play together optimally. The viral spread of Canasta across the world and the inability to

define an 'official' version, despite multiple attempts by multiple organizations and publishers, is similar to the spread of playing cards into new area - as in Europe after the Black Plague.

This article began as a search for information about Canasta and morphed into a discovery journey about the history of cards and card playing. We were also surprised by the dearth of information about this in the literature on using cards for simulation-based learning activities. In our future exploration of how we might adapt Canasta for our original intention to design learning activities employing Canasta principles, we will keep this history in mind. We may even be able to find ways to incorporate this evolutionary trajectory into the design process. Of perhaps design a game that explores the history itself.

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Climat Tic-Tac, a serious collaborative and educational board and video game on climate change in the 21st century

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Abstract. We present a serious game created in France by the Pierre-Simon Laplace Institute (IPSL) of climate and environmental sciences and by the Science, Technology, and Society Association (ASTS), an association involved in scientific mediation (<https://climatictac.ipsl.fr>, in French). Climat Tic-Tac is now both a successful board game edited by Bioviva for all players from about 10 years old (good reading needed), and an electronic game, adapted by the association Games for Citizens and online on the Ikigai serious games platform dedicated to higher education students (<https://ikigai.games/games/gameDetails/105>). By choosing mitigation or adaptation actions and their collective strategy, two to five players collaborate to fight against recurring CO2 emissions and climate change impacts in order to save the planet inhabitability. Optional fun challenges are proposed to players to improve the results of their actions. Players realize the need to urgently limit greenhouse gas emissions to avoid even more serious impacts, learn ways to adapt the cities to climate change impacts and reduce our greenhouse gas emissions. By realizing that cities are unequally vulnerable, they also find out that only solidarity can save weaker populations. Science animators from IPSL and ASTS carry game sessions for adults and in schools, followed by discussions on the effects of their choices on climate change. Teachers may also be trained to use this educational game. Finally, a social-psychological study is underway in high schools to investigate the short- and long-term effects of play sessions on knowledge acquisition and commitment to action on climate change.

Keywords: Serious Game, Climate Change, Cooperation, Education

1 Introduction

Human-induced climate change and its impacts are a major challenge for the future livability of Earth. The IPCC scientific synthesis stresses that changes in human activities and practices are urgently needed both to limit global warming by mitigating greenhouse gas (GHG) emissions, and to limit its impacts by adapting the society [1]. In this context, a serious board game on climate change named *ClimaTicTac* was created in 2016-2017 in France for educational purpose [2] by the Pierre-Simon Laplace Institute (IPSL) of climate and environmental sciences and by the Association Science, Technologie, Société (ASTS) involved in scientific mediation.

The objective was to simulate the livability of the Earth subject to increasing GHG emissions and climatic hazards, and put the players in a stake holder position to preserve livability throughout the 21st century. Initially targeted to teenagers and used in middle and high schools, the game proved to be of interest also for older students and adults. As of fall 2019, *Bioviva*TM is marketing a version named *Climat Tic-Tac* for the general public (good reading needed) [3]. Rules are detailed by [4]. It has recently been adapted by the association Games for Citizens as a video game for various electronic devices, available since autumn 2021 on the *Ikigai* platform of educative games [5].

2 Game principles

The game content relies on current knowledge and realistic events. To mimic the necessary global cooperation on the climate change issue, a collaborative game was developed. The shared objective of the players (2-5; possible single video player) is to preserve the planet livability along the century. However, the *Bioviva* version offers a semi-cooperative option simulating lobbies: each player draws a specific objective not known by others. To allow ranking of individual players, the competition introduced aside the general interest makes the collective success more difficult.

Table 1 summarizes the processes simulated by the game. The game includes 6 rounds of 15 years each from 2020 to the next century. Winning implies reaching 2 different objectives at the end of the last round: on the CO₂ (i.e. warming) level, and on the adaptation of world cities.

A scale reports the CO₂ atmospheric concentration, beginning at 415 ppm and up to 560. For 450, 500 and 560 ppm, respective warming levels of 2, 2.5 and 3°C are indicated, as reached at equilibrium after 2-3 decades [1]. At each round beginning, man-made CO₂ emissions are initialized as a function of the player number and increase with the game round number to simulate increasing emissions due to the world population and its growth with time. An emission unit corresponds to +5 ppm. At the end of each round, the CO₂ level is updated following remaining emissions, and emissions are reinitialized for the next round. Depending on the difficulty level played, it is necessary to stay below 500 (+2.5°C) or 560 ppm (+3°C). However, reaching the 1st threshold of 450 ppm (+2°C) opens the possibility of (i) several serious hazards due to positive feedbacks of the climatic system and (ii) repetition of already experienced hazards.

Table 1. Processes accounted for by the *Climat Tic-Tac* game.

Climate change-induced limits to planet livability		
Man-made CO ₂ emissions, and their increase with time due to the growing world population		
Increasing CO ₂ atmospheric concentration and related global warming level		
Threshold effect at +2°C warming causing:		
•	- Positive feedbacks on warming	-
Repetition of severe climate events		
Climate hazards and their randomness		
Variable vulnerability of world cities		
Climate damages on:		
- Health	- Food resources	- Infrastructures
Inhabitability of cities following damage accumulation		
Climatic migrations		
Climate change mitigation		
Adaptation to climate change		
Variable scales and leaders of actions (from local to global, by citizens, local authorities, states, and the international community)		
Limitation of action possibilities		
Need for good cooperation and empathy towards the most at-risk populations		
Challenge-dependent action results		
Potentially risky technological solutions		
Lobbies with individual interests (semi-collaborative board game option)		

The game board is a world map divided in three regions (America+Greenland, Europe+Africa, Asia+Oceania), showing 30 coastal or continental cities with various vulnerabilities to climate risks. Ten different damage types are categorized in three main classes (Health, Food, Infrastructures). A starting scenario is drawn where a number of cities are already impacted by 1 or 2 damages. During a round, each player successively implements 1 mitigation or adaptation action and suffers damages from climatic events, all based on cards with informative text intended to be shared.

Hazard cards increase CO₂ emissions or bring new hazards on a given city, or sometimes several cities of a given ecozone (e.g., 3 Mediterranean cities). When a city cumulates 4 damages or 3 of the same class, it becomes permanently uninhabitable. Subsequent migration-induced overpopulation is simulated by adding 2 Infrastructures problems in total to other cities of the region. Depending on the difficulty level played, a maximum of 4 or 6 cities can be lost.

Action cards are played to adapt cities, reducing the damages already accumulated, or to decrease emissions. Because each player has a limited pool of 3 possible actions, the content of Action cards is shared between players (in the collaborative mode), to optimize the collective strategy. Optional fun challenges are offered to players and improve/decrease their action result in case of success/failure. Challenges consist in drawing, mime and word-of-mouth in the board game and in quiz, gap-fill and timeline in the video game. Possible actions include a couple of uncertain technological solutions, but yield damages in case of challenge failure.

3 Conclusion and perspectives

Climat Tic-Tac simulates and teaches essential processes related to climate change, mitigation, and adaptation. Players face with fun the anxiogenic challenge of the livability of Earth during the rest of the century, and realize how important is to quickly control our CO₂ emissions, to collaborate for optimizing action strategies, and to pay attention to the most endangered populations.

The game is presently available in French but can easily be adapted to other languages. *ClimaTicTac* content can already be provided in English, Spanish and Catalan for own printing and limited funding would be needed for implementing various language versions of the video game. Partnership with game editors would also be welcome for marketing *Climat Tic-Tac* in non-French speaking countries.

The development of an oceanic version of the game has been proposed for educational purposes in the sea trades sector, and others could be imagined. Finally, cooperations with experimental psychologists have been initiated to evaluate the impact of playing the board game on the environmental sensitivity of teenager students.

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Harnessing the potential of simulation and speculative games for transdisciplinary collaboration: lessons from experience

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Abstract. Addressing societal challenges requires taking a systems perspective, and establishing a shared understanding and mutual learning. This includes not only learning and gaining a systemic understanding about a system's complexity, but also of the perspectives and values involved in challenges to be addressed. In this study, 'speculative games', games that focus on hypothetical scenarios or experiencing the consequences of technological, social, or environmental changes, are proposed as extensions of simulation games as tools to explore perspectives and values. By reflecting on experiences of the design and use of three games, we provide preliminary insights into the benefits of both simulation and speculative games. We discuss how the speculative games, in contrast to the simulation game, use deliberately open-ended objectives and ambiguous in-game objects and materials to contribute to issue formation. We further discuss how, as a result, the speculative games establish mutual learning through collective sense-making of the games' ambiguous materials and reflecting on how these relate to real-world issues. In the simulation game, learning both about the system's complexity and the perspectives of other players originates from experimenting, discussing and reflecting on actions taken in the game. Our experiences suggest that simulation and speculative games can be complementary tools in addressing societal challenges. As these types of games are not mutually exclusive, future research can focus on exploring the use of speculative elements in simulation games that aim to facilitate transdisciplinary collaborations and addressing societal challenges.

Keywords: simulation games, speculative design, transdisciplinarity, game design, societal transformations

1 Introduction

It is widely acknowledged that addressing societal challenges requires transdisciplinary approaches [1-3]. Among the essential principles of transdisciplinarity are taking a systems perspective, and establishing a shared understanding and mutual learning [1, 4]. Simulation games are proven tools to explore complex systems [5]. By experimenting with actions and system responses, players learn about the system and its behavior, including the views and perspectives of others [6].

In addressing societal challenges, we acknowledge the importance of transdisciplinarity, which calls for a holistic understanding of the diverse perspectives and values involved. To effectively tackle such challenges, it is crucial to incorporate both disciplinary and experiential knowledge. As these are situated with stakeholders, how these affect a challenge may not be easily simulated and incorporated in a game. Extending on simulation games, we have therefore started to explore the use of what we define as 'speculative games'. Inspired by speculative design and design fiction [7, 8], speculative games allow exploring alternative futures, by presenting hypothetical scenarios or experiencing the consequences of technological, social, or environmental changes.

While both simulation games and speculative games aim to explore complex systems and potential future scenarios by offering an interactive environment that offers a sense of safety to

experiment, there are some key differences between them. Simulation games often rely on predictive patterns and attempt to accurately model real-world phenomena. Speculative games, on the contrary, focus on imagining and exploring alternative futures by challenging assumptions. To highlight the potential value of each for transdisciplinary collaboration, we compare our experiences in designing and using three simulation and speculative games. By providing preliminary insights into their benefits, we offer guidance on the design choices necessary for leveraging games to facilitate transdisciplinary collaboration to address societal challenges.

2 Games

This section provides an impression (Figure 1) and description of the three games that each focus on transdisciplinary collaboration to explore a societal challenge. The selected games take a systemic perspective, prioritize mutual learning, and integrate stakeholder values. We selected these games based on our experience with using them, given that the games include different degrees of simulation and speculation. The presented descriptions of the games are brief, but illustrative of the simulation and speculative elements they provide.

2.1 Simulation game: Virtual River Game

The Virtual River Game (VRG) facilitates players’ learning about the complexity of managing river systems and the perspectives of other players on possible suitable interventions [9]. To increase the scores on three indicators; flood safety, biodiversity, and costs, players implement interventions common in Dutch river management practice by changing tiles on a grid-based physical game board that represents a typical stretch of a Dutch river. Players receive feedback on their actions through spatial visualizations projected on the board and graphs, tables, and scores on the indicators. Besides this feedback, the collective objective and role-specific objectives, representing real-world stakeholders and their interests, guide in-game player choices.



Fig. 1. An impression of the Virtual River Game (a), Future-Frictions (b) and NewEarth (c), including their setting and game materials.

2.2 Speculative game: Future-Frictions

Future-Frictions [10] stimulates players (individually or collaboratively) to discuss and reflect on the impacts of urban technology. As a speculative game, it immerses players in a fictive yet relatable urban context to interact with residents and walk around a neighborhood. On three occasions, the players encounter speculative technologies (i.e. ‘guardian angel drone’, AI cat to help people in need, and a crew of sensing pigeons for waste management) and decide how these

technologies will use data. The choices are provocative, non-desirable, and cumulative. After making them, the players observe how both the neighborhood and the attitude and perspectives of the neighbors have changed.

2.3 Simulation/Speculative game: NewEarth

NewEarth supports a collaborative process to design a fictional smart city informed by the values and worldviews that players bring into the game [11]. Players adopt roles like policy maker or citizen, and supplement these with their worldviews by reflecting on and choosing from different statements. Collectively, players set a course for another planet to build a city where they want to live and that addresses an earthbound environmental urban challenge. Players discover, give meaning to, and negotiate over resources and technologies in four game phases. The game concludes by building a new smart city and collectively voting whether or not to move to it.

2.4 Results and discussion

We discuss the results regarding the aforementioned principles of transdisciplinarity based on experiences from sessions in educational and project settings.

2.5 Systemic perspective

As speculative games, Future-Frictions and NewEarth contribute to taking a systemic perspective [1] by what we call ‘issue formation’. To do so, they offer open-ended objectives for players to recognize and express their concerns. In-game materials help to attribute meaning to components and events (e.g. the cubes with multi-interpretable icons in NewEarth). Player decisions’ outcomes are ambiguous, encouraging reflection and discussion of personal values. The VRG, however, provides clear in-game objectives that match real-world challenges to discuss the interactions between interventions and the system. This encourages taking an integrative view by considering the multiple indicators, and collaboratively experimenting to achieve objectives. Rooted in principles of tangible interaction [12], game materials like the board are designed as explicit representations of the system.

2.6 Shared understanding and mutual learning

Similarities and differences in establishing a shared understanding follow from the games’ approaches towards taking a systemic perspective. By providing explicit representations of reality and future outcomes, the VRG allows observing the direct impacts of player actions on the system being simulated. By experimenting, discussing, and reflecting together, players learn about the system and the perspectives of other players on the challenge. Furthermore, the board and projected visualization support experts in exchanging knowledge with players with less expertise. On the other hand, speculative games, like NewEarth and Future-Frictions, are more open-ended which encourages players to attribute meaning to various components and scenarios based on their individual perspectives. Learning originates from interpreting the games’ ambiguous materials and reflecting on how they relate to real-world issues, facilitating collective sense-making.

3 Conclusion

Our experiences suggest that simulation and speculative games may be complementary in facilitating transdisciplinary collaboration and addressing societal challenges. Simulation games support stakeholders in understanding challenges, taking an integrative perspective and exploring solutions, whereas speculative games enable generating ideas and issues for consideration. Although we present this as a sharp comparison here, simulation and speculative games are not mutually exclusive; the inclusion of speculative elements in simulation games warrants further

research to understand game design considerations. We plan to further elaborate on the insights we can gain from exploring simulation and speculation games for transdisciplinary collaboration to inform the design choices of game designers. Doing so will also contribute to positioning the role of speculative games in relation to simulation games, and other well-established approaches that focus on systemic thinking, shared understanding and mutual learning (e.g. ComMod [13]).

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How can serious games foster the debate?

Lessons from the case of a public debate about wind turbines at sea in Nouvelle Aquitaine

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Abstract. Serious games have been used for the first time in a French public debate for a project of wind turbines at sea in the Nouvelle Aquitaine region in 2021 and 2022. Three figures of the debate, consultative, deliberative, and protest are used to understand in which way serious games can foster the debate, as the specific French procedure and as exchanges in the democratic sphere at large. We analyze not only the games themselves but also the way they are arranged in arenas - meaning the rules arranging the entrance of different actors and their interactions. Our methodology includes quantitative and qualitative methods (interviews and questionnaires with players), both for the online game and the two board games specifically developed for this debate. The results show an overall positive appreciation of serious games by the debate's participants in every setting. Advertisement through social media proves to be an interesting way to attract younger players. The games helped to clarify and circulate the arguments among the public. Planning interactions between players and the debate commission members appears essential though to foster deliberation. The co-construction of serious games with stakeholders, which has not been done, could be an original way to integrate oppositions in the debate, and to facilitate the serious games' appropriation by various interested parties outside the formal procedure.

Keywords: Debate; Serious games; Arena; Co-construction; Wind turbines at sea

In France, public debate can refer both to exchanges in the democratic sphere at large, and to a specific procedure, aiming at exploring the variety and quality of arguments supported by the public before a decision – regarding a project, plan or policy – is taken [1]. Since it has been demonstrated that French environmental governance focuses more on involving citizens in the implementation of decisions rather than in the decision-making process itself [2], it seems of crucial importance to foster public debate – in both senses of the word – so that citizens can effectively contribute to define the future they desire and the path they want to take. Serious games have been used for the first time in a French public debate procedure concerning wind turbines at sea in the Nouvelle Aquitaine region in 2021 and 2022. We took this opportunity to explore how serious games can foster a public debate. It is our hypothesis that serious games constitute a relevant media to this end, given that they have been used since the 1970 as a form of simulation of complex issues to enhance social learning and exchange. Since the beginning of the discipline, Simulation/game is presented as a multilogue mode of communication that can be used in a process that encourages debate and consensus [3, 4 & 5]. Subsequently, studies in the field of participatory modeling have shown that game workshops are privileged spaces for dialogue and interaction between participants, which promote communicative learning and learning from others [6]. As an example, the recent “Maladaptation Game” was designed to support dialogue on Adaptation to Climate change, by introducing game mechanics that provoke disagreement and debates between players [7].

Badouard et al. [8] contend that each arena arranges its own culture of the debate. An arena is not only comprised of material tools, but also of the rules arranging the entrance of different actors and their interactions. As such, we will analyze both how the serious games themselves,

and the way they are arranged in arenas, affect their ability to foster the debate. The three debate's figures identified by Fourniau [9], consultative, deliberative and protest, will help us to understand how. Each figure indeed assumes its own definition of a "good" debate. The consultative figure considers that the debate is produced by informing and collecting feedbacks and opinions from a representative public. The deliberative figure considers that a debate must be inclusive and pluralistic, based on the exchange of arguments. The last one, the contest figure, considers that the debate is successful when criticism can be expressed about the project at stake, as well as about the debate itself.

We studied three serious games used in different settings during the wind turbines debate: an online game at the end of which players could send their choices to the public debate particular commission; two board games played in workshops hosted by members of the commission, aiming at discussing the national energy mix, and debating a location for the regional wind turbines project. Our methodology includes observations of four workshops, interviews with players, questionnaires for the players (online and in the workshops) as well as a debriefing with online players. We will first ascertain the contribution of serious games to the debate, before analyzing specific characteristics of the online and workshops' serious games arenas.

The serious games were appreciated by the debate's participants. In every setting, whether in person or online, a large majority of the players (between 79% and 91% depending on the setting) have indeed answered that they found serious games to be useful for the debate. The games have attracted new participants in the debate, and facilitated pacified discussions between participants and with the commission. Our analysis shows that those achievements, as well as the possibility to foster exchanges outside of the procedure, depend not only on the games themselves but also on the way they are promoted, facilitated, debriefed and developed.

Communication appears to be of prime importance for public consultation in particular. The online game has attracted more, and younger, participants than the board games workshops. But the online game has been advertised widely on social media, and with the help of youtubers, while communication for the workshops exclusively went through the official website of the commission. Participants of the workshops admitted they did not know what to expect when they registered, and have asked for a better coverage of the different events of the debate in general.

Interactions between players and with the organizers is another feature that was praised by the workshop participants who played the two board games. Some people who did not dare speaking in big meetings were able to share their comments with members of the commissions, and asked questions. The workshops participants also started during the second board game to discuss possible locations for the wind turbines, and almost half of them found a collective solution. The serious game workshops thus allowed to foster both consultative and deliberative visions of the debate as they provided a space for people to question and express their arguments, and to start formulating a collective position towards the project. Albeit different technical possibilities, this last feature was lacking in the online game.

The possibility to participate in the development of the games, and in their distribution, constitutes a last feature that was asked for by players. Some players, whose real-life jobs and positions towards wind turbines were featured within the games, felt uncomfortable with the way they were depicted, and indicated they would have been happy to contribute to the development of the games – both online and board games were concerned. One organized group of local opponents to the project rejected the games, calling them a "caricature" of their real-life struggles. Co-construction could thus have helped with the understanding and integration of some protests, which constitutes the third figure of the debate for Fourniau. Some players have also asked for the possibility to use the games themselves, with inhabitants of their neighborhood and association members. It would seem to be an interesting way to displace the debate from the procedure to the democratic sphere and back.

Serious games have thus been well accepted by participants in the public debate in general, as a new democratic tool that can help clarify values and arguments or build compromise and consensus. Co-construction of the games could have been a way of expressing, and integrating,

concerns by local stakeholders and opponents to the project who have felt uncomfortable with or rejected the games. Our analysis shows that the use of serious games has the potential to contribute in parallel to the consultative, deliberative and protest figures of the debate. It also reveals different ways in which they can foster the debate, both as a procedure and as exchanges in the democratic sphere. In order to do so, lessons from this case include calls for attention not only to the games themselves, but also to their advertisement, facilitation and development. While each of those characteristics have been hereby discussed in relation to one or two figures of the debate, it is the combined attention to all of them which seems to foster the debate, whatever figure it takes.

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Role Reversal between farmer-facilitators and researchers: first lessons from a serious game on collective management of crop diversity where the role of farmers is played by researchers

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Abstract. In the face of global change, access to quality seeds is a major issue for the sustainability of agricultural production systems in West Africa, as in the rest of the world. This article describes the mutual learning between farmer-facilitators and researchers in Senegal as a result of the latter's participation in a role-playing game as farmers collectively managing crop diversity and the farmer-facilitators observing them play. To this end, following a companion modelling approach, we co-constructed with farmer-facilitators from two farmers' organizations a role-playing game involving farmers who manage seed storage and supply in a context of climate change, soil erosion and rural exodus. By playing the role of a farmer, geneticists and socio-economists gained a better understanding of the complexity of the problems that farmers must face to survive. This experimental design brought out radically different strategies between these researchers from different disciplines. Moreover, the role reversal allowed by this configuration with the researcher-players "observed" on the one hand, and the farmer-facilitators "observers" in the other hand, allowed the latter to notice these contrasting strategies and to realize how much the researchers' way of thinking depends on their field of specialization. This device showed that the participation of researchers from different domain in a role-playing game facilitated by farmer-facilitators improved mutual learning between these actors. This configuration should be renewed once the game is stabilized. It should facilitate future collaborations between these researchers and farmers.

Keywords: Companion modelling, ComMod, seed management, multi-actor approaches, transdisciplinarity.

1 Introduction

In all contexts, farmers depend on access to quality seed to ensure the sustainability and resilience of agricultural production systems (Neate & Guei 2010). In recent decades, climate change has put severe strain on seed systems, particularly in West Africa where the climate is unstable with more frequent rainfall breaks at the beginning of the winter season and shorter rainy seasons (Callo-Concha 2018, Faye et al 2015). In north-central Senegal, Meckhé is an area particularly affected by global changes with low and irregular rainfall, poor soils and a massive exodus of young people. The combination of these factors has a negative impact on the seed and food autonomy of village communities. The farmers in this area are thus faced with a very complex situation, with no simple solution, which calls for changes in practices. To help them in this agricultural transition, they are supported by local farmers organizations such as the Union of farmers groups of Meckhe (UGPM) and national organizations such as the Senegalese association of producers of peasant seeds (ASPSP), which specialize in promoting agroecological

practices and seed autonomy. Although participatory approaches are promoted for these complex situations (Gurung et al 2006; Kornevs 2019; Gurung et al 2006; Perrotton et al 2017) and these farmers' organisations have experience of collaboration with research, their expectations and needs have rarely been taken into account in research projects.

2 Methods

This work is part of the SeedAttach multi-stakeholder project, which studies investigate the conditions under which social justice and agrobiodiversity conservation are achievable and compatible in the context of community seed banks (CSBs). We mobilized companion modelling to represent and bring out solutions to the complexity of situations experienced by farmers in the Meckhe area in terms of seed storage and supply in a context of climate change, soil erosion and rural exodus.

Following the ComMod approach (Etienne 2014), we initiated a co-design process between researchers specialized in the collective management of natural and cultivated resources, in companion modelling and farmer-facilitators of farmers organizations (UGPM and ASPSP). We designed a role-playing game on the collective management of crop diversity to be played by farmers who are members of these two farmers organizations.

Players represent farmers who have to manage seed access, crop rotation, fertility in their field in one hand and individual or collective seed storage, pest management of seed and food subsistence in their household in other hand.

The role of facilitator of the game and of observer during the games was entrusted to the farmer-facilitators involved in the design of the game. This choice was justified by the interest of the partner organizations in appropriating this type of approach in order to mobilize them as a modality of animation in the training courses they offer to their members. The final stage of the game; co-construction consisted in organizing several tests. We asked researchers from two units of the Senegalese institute of agricultural research (ISRA), partners in the project, to play the role of farmers. This test took the form of two game sessions on 25 January 2023 at ISRA-CERAAS with the geneticists and on 31 January 2023 at ISRA-BAME with the socio-economists. Each game simulates the succession of contrasting climatic years and the two tests represented the equivalent of five and four cropping seasons respectively. During the games, the observers collected strategies and interactions through verbatim. This material was used to debrief with participants at the end of the game to discuss individual and collective strategies. A questionnaire was sent to the two moderators, four observers and six players equally divided between the geneticists and socio-economists to review their experience of the game.

This test phase was approached in the form of an experimental device aimed at answering the following three questions

1. To what extent does having researchers play the role of a farmer allow them to understand the complexity of situations they are used to studying from a disciplinary perspective?
2. To what extent does having geneticists and socio-economists play the role of farmers in the same game allow contrasting management strategies to emerge?
3. To what extent does placing farmer-facilitators in the situation of animator or observer of this game allow them to take the measure of the differences in conception, attitude and behaviour between these researchers?

3 Results

The experience of the geneticists and socio-economists playing the role of a farmer enabled them to better understand the multiplicity and complexity of problems they have to face in order to survive climatic hazards, seed pests, rural exodus, soil impoverishment, etc. This setup revealed differences in strategies between geneticists and socio-economists. For example, the geneticists paid a lot of attention to the choice of varieties according to the climatic characteristics represented in the game, whereas the socio-economist were more interested in the economic value of agricultural production

and the financial support mechanisms to get out of difficult situations. The reversal of roles through this device with farmer-facilitators "observers" and researcher-players "observed" allowed the farmer-facilitators to identify these contrasting strategies and to realize that the researchers' way of thinking is very dependent on their field of specialization. Such findings are consistent with socio-cognitive conflicts firstly coined by Mugny and Doise (1978). Indeed, the role-playing game is the common object that revealed different strategies among researchers from different fields. Debriefing sessions helped both farmers-facilitators and researchers from each discipline to reveal cognitive conflicts through verbal exchanges and argumentation. The alternative views were discussed and transformed both actors thanks to the safe social interactions allowed by the "thinking place" composed by the game playing and the reflexive time taken just after the end of the game used to learn from each other.

4 Conclusion

This device showed that the participation of researchers in a role-playing game led by farmer-facilitators improved mutual understanding between these actors. Furthermore, this work was carried out as part of a process of stabilization of our role-play. It opened up avenues and reflections that led us to formulate hypotheses. It would therefore be interesting to repeat this game by renewing this configuration with these actors with a stabilized version of the game in order to confirm the "socio-cognitive conflicts" hypothesis. Such a device will allow us to move from the explicitation of disciplinary points of view to an interdisciplinary approach and should facilitate future collaboration between research and farmers.

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A game to understand changing commons in the Bolivian Altiplano: what future for communities?

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Abstract. In this study, we seek to analyze the reconfiguration of traditional common property natural resources management in the Bolivian Altiplano. We focus on two intertwined commons, water and land. The modification of a role-playing game set up during the first phase of the project, by integrating these two new dimensions, allows us to understand the current state of these commons and their evolution.

This participatory approach aims at validating the results of the previous diagnosis through the improvement and re-appropriation of the game model by the inhabitants of the communities. A qualitative analysis of the exchanges during the game sessions also enables a better understanding of the discourse around the collective management of water and land, the evolution of the community identity and the changes in the governance system.

Through the use of the game, we hope to open an intergenerational dialogue on the future of the communities and the territory.

Keywords: Role-playing game, participatory process, commons, territorial diagnosis, prospective

1 Commons in the Bolivian Altiplano

Since Ostrom's publication [1] in response to the tragedy of the commons predicted by Hardin [2], the concept has experienced an effervescence that goes beyond the scientific field. Whereas Hardin announced that the common management of natural resources could only lead to catastrophe, Ostrom proposed a third way between state management and private property to think about collective action and the self-organization of societies around their resources [3].

Bolivia is a country rich in case studies dealing with commons issues. Apart from the emblematic case of the birth of a common during the Water War in Cochabamba [4] the common management of natural resources, mainly land and water, is traditional in indigenous Andean peasant communities. These fit perfectly into the Ostromian framework of governance unit [5]. There are little researches on the central Altiplano and the literature on the commons in the Andean valleys cannot be applied to this study area due to the difference in relief.

In a context of globalization and population growth, the Bolivian countryside of the Altiplano is experiencing a rural exodus and an ageing population [6,7]. The unit of production and management is shifting from the community to the family. Young people who go to the city to study or work rarely return [8]. As rural communities seem gradually abandoned, what happens to the water commons for irrigation and livestock and the land commons?

2 Objective and issues of the study

The objective of this paper is to understand:

How to design a serious game for an integrated approach of two intertwined commons: the water commons for irrigation and livestock and the land commons.

To what extent would such a game allow us to discuss the current state of these commons and their evolution, related to the future of the community, in order to think about a territory project?

3 Methodology

3.1 Background of the research

This work is a continuation of a ComMod approach [9] carried out within the framework of the Wasaca project, funded by Agropolis Fondation. A role-playing game, Sumak Kawsay, was co-designed with farmers and herders from the two communities studied: Realenga in the municipality of Machacamarca and Santa Maria in the municipality of El Choro. The co-design process was based on the proposal of a martyr version of the game, intended to be improved, thanks to the reactions and recommendations of the players. Minor modifications were made during the game session, and major ones were made from one session to another.

This game allowed us to support a participatory diagnosis of the intervention situation and to understand the main issues experienced as such by the farmers and breeders of the Altiplano [10]. It allowed us to refocus the project on 1) the commons and the will to live together in the community, 2) water for irrigation and livestock and 3) land tenure.

3.2 A game on the commons

First, we clarified the diagnosis of the collective management of water and land through participant observation and semi-structured interviews with institutions (governmental, union and indigenous), farmers and breeders, comuneros¹ and residentes².

In a second phase, we adapted Sumak Kawsay to new questions about the commons. We complexified the board and focused the game on the access to water and land in a context of water scarcity and population growth.

The game prototype was tested with local partners: the Center of Ecology and Andean People and the Technical University of Oruro. We then organized game sessions in the two communities, following the same co-design process as the previous game. Both sessions and debriefing have been recorded, filmed, transcribed, and then qualitatively analyzed using the Nvivo® software.

The ComMod approach was initiated with local partners from the irrigators' network. These irrigator leaders helped us in the organization of the sessions, which constitutes a bias in the selection of participants. To limit this usual bias in participatory approaches, we have conducted complementary interviews with comuneros and residentes excluded from the commons, who are therefore not part of the irrigators' association or who have a limited access to land, but are considered as part of the community.

4 Expected results

During the game sessions, our understanding of the system and our diagnosis are confronted with the views of the inhabitants of the communities. Their feedback allows us to correct and improve the game model and to complete the diagnosis.

Faced with a discourse of loss of reciprocity, the game provides an opportunity to discuss the future evolution of the management of the commons, but also of community identity and interdependence networks.

This work also helps to understand the polycentricity of governance and the entanglement of levels of collective action. We therefore expect to highlight the existing tensions between family and community strategies.

Finally, we expect that the game, used as a support for the comparative case study, allows for the discussion of differences in customs and conceptions of justice in access to land and water. It

¹ Permanent residents of the community.

² Community members migrants or dual residents.

should also enhance what can be considered as common and what cannot, and how these commons could evolve.

5 Discussion: Social impact and perspectives

The first version of Sumak Kawsay highlighted the interest of the participants in this game and their desire to disseminate it in the community in order to discuss the issues surrounding water and livestock farming but also to train young people and encourage them to stay. This new version of the game would thus be an opportunity to open an intergenerational dialogue on the future of the territory.

In the next phase of the project, we will develop an agent-based model from the game to further develop the prospective dimension of the ComMod approach.

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Putting video game practices to work: an overview of gaming integration to working environments

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Abstract. Lockdowns during the 2020-2022 Covid pandemic period popularized new video games and trivialized remote working. We hypothesize it has since then fostered video game practices during working hours, gaming at the office as well as remotely from residence. For many years, researchers have been studying video game skills profitable for professional activities.

Our exploratory research focuses on a slightly different scope: an investigation of the video game practices occurring in typical working environments and during working times. Its sociological purpose is to sketch the main determinant of those emerging gaming practices. To this end, we present a mapping of the integration of video games in five non-exclusive modalities which highlight smartphone uses during slack times at the office and the use of home gaming devices during remote work.

Our methodology is based on a survey of 33 interviews sampled as follow: the interviewees' age ranged from 21 to 42, they play for at least one year on video games, and they are employees working in France, representative of the main socioprofessional categories.

Data collection and processing were conducted in two phases, during the spring 2022 (n=20) and the late winter 2023 (n=13). The first one dealt with the gaming habits of employees with a special emphasis on their practices during the 2020-2022 period, including lockdowns and massive remote work sessions. The second is extending our investigation to the second half of 2022 and to early 2023, where remote work has known a slight reduction in frequency.

Keywords: video game, remote work, slack time, smartphone, gaming console

1 Scope of the research

1.1 Video game skills and professional activities : a literature review

For many years, researchers of various disciplines, mainly sociology, education sciences, media studies, game studies and management, have been working on video games practices for skills development. Those researches on so called "positive effects" of gaming are often promoted as a counter reaction to previous media coverage and researches. This previous studies were often limited to "negative effects" of gaming, such as moral panics dealing with violence and addiction.

Some identified "positive effects" point at skills directly profitable for professional activities. These researches investigate daily video game entertainment contexts experienced at home, looking for social skills (Auray, 2007; Berry, 2012; Chollet, 2020) and psychological skills and resources (Wilkinson et al., 2008; Gaon & Stora, 2008; Stora, 2009; Tisseron, 2009; Granic et al., 2014; Barr & Copeland-Stewart, 2022).

Other researchers focus on video games voluntarily used for specific field of skill development. Schools (Gee, 2007; Simões et al., 2013; Dezuanni et al., 2015; Kahila et al., 2020), museums (Jutant, 2011; Gentès & Jutant, 2012; Lelièvre, 2012; Coville, 2015, 2016) and universities (Coville et al., 2022) have used them to transmit knowledge or develop learning skills among their publics.

In professional context, video game is used for simulation trainings, for instance in contexts such as military ones (Zyda & Sheehan, 1997; Sparrow et al., 2018), or mental healthcare ones (Kato, 2010). Several investigations also focus on cognitive and information processing skills for professionals (Powel, 2005; Lisk et al., 2012; Nuyens et al., 2019; Reynaldo et al., 2021). And finally, the literature on serious games emphasize on fundamental education processes (Lavigne, 2013, 2016b), or on management and recruiting skills in corporate contexts (Michaud & Alvarez, 2008; Allal-Chérif et al., 2014; Chollet, 2015).

Finally, some contributions tackle the frontier between working and gaming by investigating serious gaming (Lavigne, 2016a), computer web based social gaming practices at work (Boutet, 2011), the social skills used for online gaming servers management (Vétel, 2017) and the socioeconomical organization of player's game assets (Vétel, 2018, 2020).

1.2 An exploratory study of video game integration in the working environment

Lockdowns during the covid pandemic popularized new online video games practices and trivialized remote working. We hypothesize it has since then fostered video game practices during working hours. Thus, we propose to focus our research on a neglected subject of investigation: an overview of the main contexts of video game practices occurring during working hours.

Our study aims at identifying video game practices' integration during employees' working hours. To this end, we propose to test a mapping of the integration of video games in five non-exclusive modalities:

- No integration : employees use video game outside of working hours (e.g. during transportation, in the morning or evening, during weekend or vacations)
- Legal work break integration: employees use video games during legal work breaks (e.g. lunch, coffee break)
- Multi-activities integration: employees use video games during their working time (e.g. simultaneously during a remote meeting, or discretely between two professional tasks)
- Promoted company integration: the management encourages employees video gaming (e.g. serious games, coworker team play to promote team building)
- Business integration: video game is an integral part of the company's business and employees have to use them for some core working tasks (e.g. video game programming and testing)

2 Research methodology

For this study, we are carrying out a survey based on thirty three semi structured interviews, sampled as follow: 21 to 42 years old gamers-employees working in France and representative of the main socioprofessional categories.

Our sample was selected according to two requirements: the interviewees had gaming habits during working hours for at least one year, and they had currently a work contract, with one to ten years of professional experience.

Recruitments were performed for 50% by public demands on the gaming social network like Discord and for 50% in private circles. Data collection and processing were conducted in two phases, during the spring 2022 and the late winter 2023.

The first one conducted during a master thesis under the supervision of Bruno Vétel dealt with the gaming habits of employees, with a special emphasis on their practices during the 2020-2022 period, including lockdowns and massive remote work sessions. It aimed in particular at circumventing variations of practices when teleworking take place on more than 2 days per week. Due to the pandemic context, 10 interviews were conducted as video conferences, and 10 consisted of prolonged text exchanges initiated on Discord and followed by emails with each interviewee during 2 to 3 months.

The second investigation is extending our testimonies to the second half of 2022 and to the early 2023, where remote work has known a slight regulation and a reduction in frequency. 5 interviews were conducted in copresence, 7 in video conferences.

3 Analysis and results

Our data analysis reveals distributions of worker profiles according to the following modalities. In work break integration, after mid-2022 we find an overrepresentation of people performing professional activities with faster pace jobs that are less compatible with simultaneous gaming, like hairdressers or nurses. Those people play mainly on smartphone, during short periods of time, typically 5 to 30 minutes, scattered during working and transportation hours. Gendered biases are also noticed with an overrepresentation of women in heterosexual pairs and women in charge of children.

In multi-activities integration, we find three different profiles. The first one matches with gaming activities on smartphone during slack time. The second one corresponds to personal computer or console gamers, practicing exclusively during their teleworking hours. The third one illustrates people who dynamically select a diversity of games and gaming devices, depending on the actual organization of their work.

This survey highlights two important results. Firstly, the gaming device used by workers on their workplace is mainly their smartphone, reducing the variety of available games, especially for women above 29. Secondly, due to the ease of hiding home gaming activities from remote work colleagues, remote work at the residence emphasizes the use of static gaming devices, like gaming consoles and personal computers that can be used to play games designed for longer gaming sessions.

4 Conclusion and perspectives

This exploratory study is a first step towards a refined knowledge of video game practices during working hours, showing in the background how quality of work life is evolving in a post-covid era. Our mapping was successfully tested to highlight gaming practices that depend mainly on gaming devices, working contexts and gendered positions. Further research perspectives would consist of focuses on a particularly popular video game, or widespread professional activities.

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Land-use decisions in challenging contexts: Simulating local realities of small-scale farmers in forest frontiers of the Peruvian Amazon

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Abstract. Interventions aimed at reducing environmental degradation and promoting sustainable development in tropical forest frontiers generally fail to match the realities that smallholder farmers in disadvantaged contexts face when making land-use decisions. To transform frontiers into resilient landscapes, the integration of all stakeholders and a common understanding of diverse perspectives is crucial. To bridge the knowledge and perspective gap between decision-makers, practitioners, and rural communities in tropical forest frontiers, we developed an innovative tool based on serious games. Our game is based on a case study of smallholder farmers in the Peruvian Amazon and simulates local socio-ecological dynamics allowing for reflection and collective learning among participants. By testing our tool in academic settings, we observed that it facilitates extensive reflections and dialogues, allowing players to better understand and reflect on the difficulties of making sustainable land use decisions in challenging contexts. It also highlights the need to consider collective decision-making processes, in addition to the opportunities offered by adopting an agroecological transition approach. Future developments of our tool include the systematization of game sessions through data collection, the analysis of the outcomes of the different player's choices and adaptation to different contexts and settings while maintaining a balance between levels of playability and the simulation of complex realities.

Keywords: Forest frontiers, small-scale farmers, land use decision-making, serious games, social learning

1 Introduction

Small-scale farmers make important contributions to food security, local employment, and the sustainable management of natural resources [1,2,3]. Despite that, many of them continue to live in challenging conditions in increasingly degraded landscapes [4,5]. A downward spiral of deforestation and environmental degradation is evident in tropical forest frontiers where resources are rapidly appropriated due to a shortage of alternative livelihoods [6]. Indeed, an important share of intact forest is lost through fragmentation from smallholder farms [7] who react to interrelated drivers of change such as global market demands or national land policies. Thereby, mosaic landscapes can also offer multiple ecosystem services for human well-being [8]. Transforming frontiers into resilient landscapes is a key challenge of today that requires involving all interested parties in the process and a common understanding of diverse and complex perspectives.

While development interventions in the rural tropics have generated important economic benefits, they also commonly incur social and environmental drawbacks. One of the assumed reasons is that presumptions of development interventions fail to match local realities and contextual constraints faced by rural communities in forest frontiers [9,10]. Considering that smallholders respond to the different changes around their contexts by standing at the center of land-use decisions, new methodologies to better understand their reality, motives and responses to contextual barriers are needed to effectively facilitate and scale sustainable trajectories. Under

this perspective, innovative approaches based on serious games have emerged as valid social learning tools [11,12] that help bridge different perceptions, and share diverging world views of locally managed agroecosystems between decision-makers, practitioners and rural communities [13]. Despite an increase in the number of serious games in the last decade, ones addressing agroecosystems and ecological transition are still rare [14].

Making use of these tools, our objective was to develop a serious game that facilitates social learning and critical thinking among students, researchers, and practitioners across different intervention settings and realities.

2 Methodology

We designed a serious game based on empirical data collected through an in-depth case study of smallholder farmers in a tropical forest frontier. Our case study and conceptual background were developed as part of a research project exploring development opportunities in the Peruvian Amazon through contextual intervention approaches. We developed a serious game that seeks to simulate local socio-ecological land-use dynamics of smallholders while maintaining a certain balance between levels of complexity and playability (Table 1).

Table 1. Overview of the elements of the game.

Elements of the game		Description	
Complexity	Context	Game board	Landscape (village, farms, water bodies, road infrastructure)
		Events	Changes in contextual factors (e.g. infrastructure, climate, institutional and legal frameworks, biophysical factors)
	Agency	Land-use cards	Land uses (forest, coffee, pasture, subsistence crops) with annual production costs and harvest values
	Assets	Beans	Food security (social dimension)
		Coins	Income (economic dimension)
		Ecosystem functions	Resilience (environmental dimension)
Playability	Participants	Player	Small-scale farmer's household
		Facilitator	Transaction counterpart and guide of the session
	Operationalization	Rules	Game steps and transaction values (land-uses, bank loans, living costs)
		Rounds	Village's year and game steps

The complexity of the game relates to the diverse local dynamics we aim to simulate. Players take the role of smallholders in a forest frontier context and make decisions on different land-use changes. All players start with the same amount of assets and aim to maximize them, ideally in a balanced way. Each land-use card represents one of the four main land uses observed in the case study and respective production costs and harvest values, thereby following local ecological principles of production and land degradation. Based on the game rounds, the full game session seeks to simulate between eight and sixteen years of the village's history.

Playability defines the game dynamic, where the interaction between players and the facilitator plays an important role. The facilitator guides each step of the rounds during the game session, based on the game rules.

The game is played in a block of one to four hours, depending on the number of rounds played. The block is structured in three sections: (i) the presentation of the case study and the simulation game, (ii) the playing session, and (iii) reflections, discussions and comments from participants based on their experiences and learning.

3 Preliminary findings and discussion

Initial results derive from observations and feedback during six-game sessions, carried out mainly in educational and academic settings (Table 2). As of February 2023, a total of 93 participants have played the game, mainly researchers and students, and a few practitioners.

Table 2. Summary of game sessions and participants between September 2022 and February 2023.

Event	Date	Place	Target	Participants (number)	Facilitators (number)	Rounds (number)	Duration (hrs.)
Pre-test	08.09.2022	University of Freiburg	Researchers	10	3	5	2.5
Tropentag 2022 Workshop	16.09.2022	Czech University of Life Sciences	Researchers and practitioners	10	3	5	2.5
BSc. Module	02.11.2022	University of Freiburg	Students	18	4	12	4
BSc. Module	09.11.2022	University of Freiburg	Students	14	4	8	1.5
MSc. Module	02.12.2022	University of Freiburg	Students	30	6	10	4
BSc. Module	16.02.2023	University of Freiburg	Students	11	3	12	4

We observed that our game is well balanced between complexity and playability, facilitates extensive reflections and dialogue between participants, and allows players to build knowledge and empathize with the difficulties of making sustainable land use decisions in challenging contexts.

Firstly, participants reported that complexity and playability are well balanced, despite the need for two to three rounds for players to learn the game logic. Feeding into our iterative game development process, they also recommended including new rules for using accumulated ecosystem functions (e.g. payments for ecosystem services), collective local land-use decision-making, and farmer-to-farmer loans.

Secondly, participants indeed reflected on their land-use decisions and outcomes consistently throughout the game. Most participants contemplated environmental issues and believed that their “decisions were not sustainable” after observing the dynamics of deforestation. Other participants “tried to conserve forests for many years but ultimately had to convert to agriculture to maintain livelihoods”. They perceived that contextual changes (events) strongly affected their farms and decision-making in the long term. Overall, financial constraints commonly led to cycles of indebtedness. As social stability and food security go hand in hand, players soon perceived the importance of keeping subsistence crops. Finally, they highlighted that a transition to agroforestry with coffee and pastures would offer a promising solution to balance the three assets.

Thirdly, major learnings emerged from the knowledge co-creation process. Players shared the challenges of making sustainable land-use decisions in unfavourable contexts and their common

feeling of “constantly losing” during the game, which was associated with what they believe is the reality of most smallholders in developing contexts. In this regard, “collective decisions and interactions were considered crucial to deal with the feeling of marginalization”. To foster this collaboration, we let them make community decisions after 6 years, which not only improved their livelihood situation and ecosystem functions but also made them feel “more resilient in the face of uncertainties”.



Fig. 1. Photos from different game sessions.

Overall, we experienced great success with our game in facilitating collaborative learning in the educational context with promising potential to adapt for policy-making, research or practice settings by letting players not only experience hardship but actually coming up with and testing solutions through community initiatives. Simulating land-use decisions in a forest frontier context enables to experience an important element of smallholder’s realities, supports critical reflections on land-use transitions in challenging contexts, and enables players to share their different perceptions of reasons for or against deforestation and strategies for resilient socio-ecological systems (Figure 1).

Our game contributes to other experiences simulating decision-making processes for agroecosystem management in the Amazon region [13] and seeking to understand livelihood strategies in shifting agriculture contexts [15]. It also introduces a unique feature to simulate collective decision-making of development interventions between the players, providing diverse and promising bottom-up approaches that improve the situation of smallholders and entire villages in the game.

4 Next steps

The process of creating the game involved testing and adjustments with the participants, resulting in a functional and playable game that successfully achieved its initial purpose of being an innovative learning tool.

As next steps, we plan to further adjust the rules to better account for land degradation, systematize data collection and observation [16], and adapt the game to different contexts and player settings, including for rural advisory services.

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Interactive simulation of inertia created by mobility habits¹

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Abstract. Recent years have seen an increase of public awareness of global warming, and their expressed concern about ecology. A well-known field of action for reducing one's carbon impact is mobility, where the impact of individual cars is wellknown. In line with public concern, institutions at the national or local level have been trying to encourage bicycle commuting to reduce traffic and pollution, via financial incitations or new infrastructures. These public policies result in increasing difficulties for car drivers (low emissions zones, urban tolls, petrol price, pedestrian areas, car parking difficulties, traffic jams, etc) and increasing comfort and safety for cyclists thanks to dedicated facilities. But despite these changes, mobilities evolve very slowly, for instance in France a large proportion of commuting is still done by car, even for very short journeys under 3km. The role of habits was already shown: individuals routinely reproduce their usual decision when they are in a similar context, which can save decision time but might also lead to misadapted decisions when the environment evolves. Changes in individuals' life cycles are thus the best opportunity to change their habits (new job, moving home, childbirth...). The COVID-19 pandemics also showed an unusual reset of our habits and encouraged cycling, at least for a limited time. We here propose a simulator of the dynamics of mobility in an evolving urban context, under the influence of habits. It is implemented in Netlogo and playable online.

Keywords: Mobility, habits, agent-based modelling

1 Introduction

Recent years have seen an increase of public awareness of global warming, and their expressed concern about ecology. A well-known field of action for reducing one's carbon impact is mobility, where the impact of individual cars is wellknown [8]. In line with public concern, institutions at the national or local level have been trying to encourage bicycle commuting to reduce traffic and pollution, via financial incitations or new infrastructures. These public policies result in increasing difficulties for car drivers (low emissions zones, urban tolls, petrol price, pedestrian areas, car parking difficulties, traffic jams, etc) and increasing comfort and safety for cyclists thanks to dedicated facilities [9]. Despite these changes, mobilities evolve very slowly, for instance in France a large proportion of commuting is still done by car, even for very short journeys [5]. The role of habits was already shown [4,7]: individuals routinely reproduce their usual decision when they are in a similar context, which can save decision time but might also lead to misadapted decisions when the environment evolves. Changes in individuals' life cycles are thus the best opportunity to change their habits. For instance [2] have done an experiment where they tried to incite usual car drivers to adopt public transport, by giving them a free ticket when they moved to a new residence. The COVID-19 pandemics also showed an unusual reset of our habits and encouraged cycling, at least for a limited time [3]. We propose here a simulator of the dynamics of mobility in an evolving urban context, under the influence of habits. It is implemented in Netlogo and playable online.

¹ Supported by the French National Research Agency (ANR), project SWITCH.

2 Simulating habits

2.1 Conceptual model

Our model² is based on a previous agent-based model of rational mobility choice [6] but is very simplified, considering only 2 mobility modes (bicycle and car) and one choice criterion: how favourable the town infrastructure is to this mode. It is considered here that space is limited so favouring one mode is necessarily at the expense of the other: dedicating more space to bicycles necessarily takes this space away from cars, and vice-versa. As a result we represent the town infrastructure as a continuous value between 0 (entirely favourable to cars) and 100 (entirely favourable to bicycles).

Citizens are modelled as agents with a very simple behaviour: at each step (one day), they choose a mobility mode and move around with it. They store a history of the mobility mode used each day over their past 20 trips (this value is configurable in the code). This sliding window will be used to compute their habits, once it has reached the minimal length; before that it is considered that the citizen has no habit yet. Citizens can choose their mobility in 2 ways. Rational decision consists in using the rational mark (urban setting) as a probability, which ensures that the most favoured mode is chosen more often but still with some inter-individual variability; initially citizens can only choose rationally until they build habits. Routine decision consists in using the frequency of each mode in past history (once long enough) as a probability to reuse this mode. Over time, the agent's habits might strengthen, giving them more probability to decide routinely than rationally. Citizens also have a level of satisfaction equal to the rational evaluation of their current mobility mode. We expect that rational deciders switch mode when needed so stay mostly satisfied, while routine deciders might keep their usual mode even if not optimal anymore, so could grow very dissatisfied before they manage to reset their habit.

2.2 Simulator interface

The simulator³ allows the user to modify urban planning at runtime, toggle habits on or off, and reset them. The interface (see Figure 1) provides feedbacks for these actions. Citizens move around in a window, their shape (bicycle or car) indicates their mobility mode, and their colour indicates their satisfaction (gradient from red - dissatisfied, to green - satisfied). Three plots allow to visualise the evolution over time of the modal distribution of citizens, their mean happiness, and the proportion of happy and unhappy citizens among users of each mode. Monitors also display the average strength of bike habit and car habit among their users, and the number of routine vs rational deciders.

2.3 Example scenario

If we start the simulation in a town initially very favourable to cars, without habits, most agents use the car and are very satisfied with it. If gradually making urban planning more favourable to bicycles, the percentage of car users drops subsequently, and the average population satisfaction stays high, since unhappy citizens will rationally switch mode.

If we now start over with the same urban setting but enabling habits, and let citizens build a strong habit, things are different. When gradually turning the habits in mobility town more favourable to bikes, citizens do not adapt: they follow their habits and keep using their car, despite their satisfaction dropping.

² A more detailed description can be found in [1].

³ <https://nausikaa.net/wp-content/uploads/habits-mobility.html>

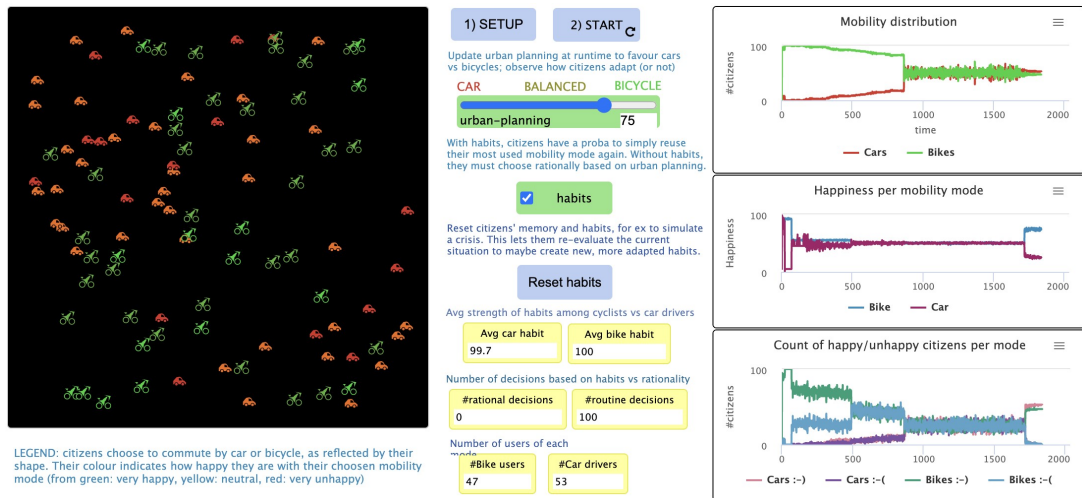


Fig. 1. Habits simulator interface: world (left), actions (middle) and plots (right)

Finally, from that point in time, we can use the button to simulate a crisis and reset all habits. As a result, citizens immediately reassess their mobility rationally, *i.e.* based on urban setting. They subsequently switch to the most favoured mode, which is now bicycle, and turn satisfied again.

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Developing a Companion modeling approach to support sustainability in Marine social-ecological systems – application to the red lobster fishery in Iroise Sea

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Abstract. Marine socio-ecosystems are complex systems characterized by strong interactions between natural resources exploited, human activities and governance. Many human activities rely on the resources that the ecosystem can provide. However, natural resources are common and variable and thus require particular management and adaptation from human activities. In addition, marine environments and activities are difficult to observe, assess or control. Supporting management of marine SES therefore requires the use of participatory integrated approaches such as the ComMod (Companion Modeling) approach. This approach builds simulations and gaming with the stakeholders of the territory to help sharing a common vision of the SES and its future and thus empowering stakeholders towards sustainable trajectories. Within the framework of the HOPOP project, a ComMod approach has been developed in the Iroise Sea red lobster fishery which is characterized by a biomass increase providing incentives to target this species in a context of a decrease observed in a number of other fish stocks. In a first step, the co-construction of a conceptual model with the stakeholders of the fishery will be built through interviews and workshops. This model will be used, in a second step, to create an agent-based simulation model which combines classical biological and socio-economic simulations of scenarios and role playing in order to help stakeholders explore consequences of decisions on the management of their activity. Stakeholders will be able to make virtual decisions and see how they impact the different elements of the socio-ecosystem.

Keywords: Companion Modeling, fisheries management, Iroise Sea

Complex systems are systems composed of a large number of entities and interactions which create emerging properties. A complex system is characterized by a high difficulty to anticipate how the system will evolve (Ottino, 2004). Socio-ecological systems (SES) are complex systems (Berkes et al., 1998). A SES is composed of an ecological part where several species share the same space and interact between them and with the other components of the ecosystem. In addition, a SES includes human activities which depend on or exploit some of these common resources and are often characterized by distinct temporal and spatial dimensions.

In a marine SES, understanding interactions between exploited living resources, maritime uses, governance and science support are particularly challenging to disentangle, thus hampering the emergence of effective management strategies and adaptations to local and global changes (Cheung, 2018). Given the particular complexity of coastal regions, the sustainability of marine living resources and human activities should thus rely on integrated approaches considering the entire SES (Weatherdon et al., 2016). Managing marine SES towards sustainability in a changing world would require to (i) integrate diverse sources of knowledge, (ii) account for interactions between resources, users and governance (iii) explore future options, and (iv) support social learning and development of sustainable options with stakeholders and society (Mackinson et al. 2010, Macher et al., 2018, 2021).

The COMpanion MODELing (ComMod) approach is an integrated approach combining various sources of knowledge from and outside academia while taking into account the interactions between resources, users and governance through modeling and simulation processes

(ComMod, 2003, 2005, Etienne et al. 2011). It aims at providing a better understanding of interactions in a SES (Etienne et al. 2011) and promote a shared knowledge to collectively explore future options, support social learning and identify sustainable management methods with stakeholders. To this end ComMod approach uses participatory and collaborative methodologies based on gaming and computer simulations (Becu, 2021). This approach has been mainly used in terrestrial SES, and there are a few applications to support fisheries management (Becu et al., 2016, Worrapiumphong et al., 2010).

We aim at implementing a ComMod approach in a marine environment with strong sustainable management issues, where there is a tension between actors and resources. We chose Iroise Sea (Figure 1) to explore the efficiency of this type of approach to tackle sustainability challenges in Marine SES. It is characterized by a diversity of habitats supporting the activity of various emblematic commercial fishing fleets as well as other small scale fishery units. In addition, the Iroise Sea is home of the Iroise Marine Natural Park, the first French marine natural park created in 2007. This park adds a new administrative layer to the area in addition to the traditional governance of French coastlines (Iroise sea park).

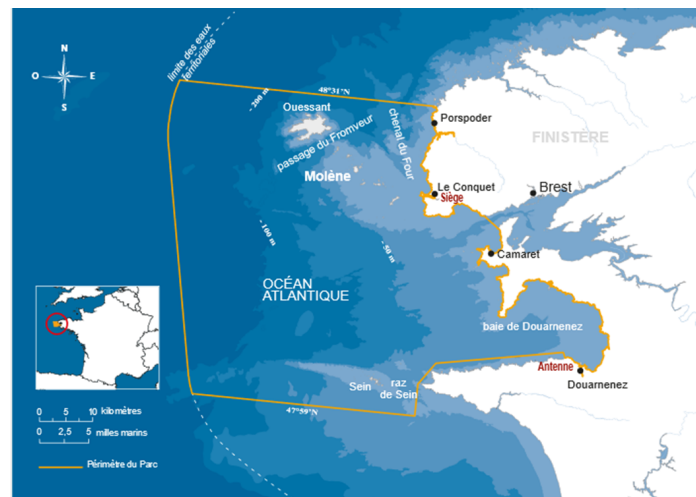


Fig. 1. Map of the Iroise Sea and the Natural Marine Park. Sources: Office Français de la biodiversité

The application of this approach is being implemented as part of the HOPOPoP project (2022-2026). To support the exploration of sustainable futures in the Iroise Sea, the project combines various integrated and innovative approaches based on simulation, gaming and virtual or augmented reality. We decided to implement a ComMod approach in 3 steps: (i) scoping of the case study, (ii) create a conceptual model of the SES and (iii) implement an agent-based model combining simulation and gaming.

The first step is to select the case study. We conducted preliminary interviews and workshops with the park and a fishermen's representative to scope the stakes in Iroise. The case study was chosen for the stake, the interest of the stakeholders (fishermen, manager of the Iroise park, fishmonger), the spatial scale (Iroise sea) and the available data and experts. On this basis, we selected the red lobster fishery. The red lobster case is an important issue because after several years with a small population size, the lobster stock is increasing while other fish populations are decreasing in Iroise. The fishery is mainly managed by conservation measures while access regulation is based on uses and habits. Expected changes in strategies towards red lobster can also have consequences on other species in Iroise depending on which gear is used (Figure 2).

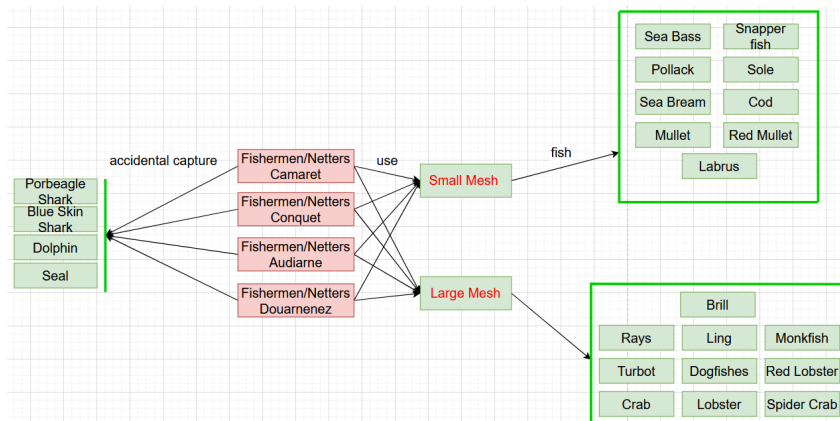


Fig. 2. Conceptual diagram of the netters in the Iroise Sea and the species impacted. Sources: Elaborated from the first scientific focus group workshop of HOPOPoP Project

The second step is to create a conceptual model of the red lobster fishery in the Iroise Sea. We decided to use the ARDI method (Etienne, 2011). The ARDI method stands for Actor, Resources, Dynamics and Interaction. It is one of the main methods used in ComMod approaches to create a shared conceptual model of an SES. This method aims to list all the actors and resources of the SES linked to an issue (here: how the red lobster fishery works in the Iroise Sea? Figure 2). We will then explicit the dynamics (e.g. biology of the red lobster, fishery activity) of the SES linked to this issue. Eventually, we will further construct with stakeholders a diagram representing the interaction between the actors and the resources which govern the SES.

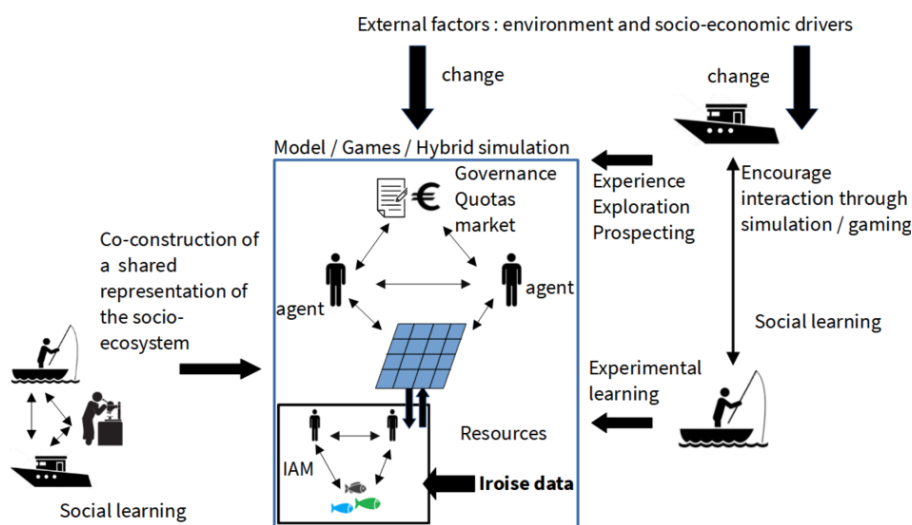


Fig. 3. Representation of the conceptual framework based on a hybrid game/simulation model. Sources: diagram presented during the kick-off of the HOPOPoP project.

In a third step, we aim at implementing a hybrid simulator which combines a role playing game with computer simulation (see conceptual framework proposed in Figure 3). The objective is to integrate several components of the SES into an agent-based model (using the conceptual model created during step 2) including interactions between harvesting strategies of fishermen, resource dynamics, biophysical evolution and management. To help realism, the model will also use other existing models which prove to be efficient such as the IAM model (Merzéréaud et al, 2022; Macher et al, 2018). The IAM model aims to simulate the dynamics and interactions between fish

stocks, the vessels or fleets which exploit them, fisheries governance and the market. This will give stakeholders an opportunity to explore potential ecological, economic or social impacts of alternative choices encouraging experimental and social learning. On this basis, the stakeholders will take virtual decisions which will be integrated into the simulator in hybrid game sessions. Lessons learned will allow to explore and debate the possible futures of the Iroise Sea.

We are currently completing the second step of the project.

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Exp'Eau, a serious game for exploring pathways to improve water quality in agricultural catchments

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Abstract. Water quality depends on agricultural practices, but also on the land cover and the distance between the pollutant sources and the hydrosystem. Consequently, water quality and agriculture are regularly in tension in catchments. Solving this issue requires actions by farmers and other stakeholders (local authorities and catchment manager) that can act through economic instruments and rules.

Although serious games have gained interest in environmental research and management, only a few examples are targeting water quality in agricultural areas, and these poorly include the diversity of interactions.

We develop the game simulator "Exp'Eau" to evaluate and to compare different pathways by facilitating the debate on possible collective actions at the scale of an agricultural catchment.

The game is structured spatially (cell, communal territory, catchment) and socially (farmer, elected official, catchment area manager). The basin is divided into three independent boards to create an effect of distance that enables to focus on interactions between players around the same table. Some time is dedicated to collective discussions.

At farm scale, land uses are characterized by crop practices that are more or less intensive in terms of pollution. Non-farming actions include investments in agroecological infrastructures, land use changes, and training to improve practices.

A purely analog version has proved to facilitate the interactions among players around the game boards and during the collective setting. The split of the catchment into three tables is successful to embody the need for communication between players coming from different subbasins and the interdependencies at the catchment level.

Keywords: Water Quality, Agricultural Practices, Territorial Public Policy, Multiple Scale Interactions, Collective Action

1 Introduction

Water quality depends on agricultural practices, but also on the nature, the state of the land cover and the distance between the pollutant emission sources and the hydrographic network. Consequently, water quality and agriculture are regularly in tension in rural catchments. Solving this issue requires actions by farmers. This may also involve other stakeholders, such as the local authorities and the catchment management, that can act through economic instruments and rules.

Over the last twenty years, serious games gain interest in environmental research and management. Such tools are used for simulating the dynamics of social and ecological systems for which a physical experimentation is not relevant due to questions of scale and potential

consequences [1]. However, only a few examples are targeting water quality in agricultural areas as the central issue, and these do not focus on the diversity of interactions within the catchment.

To work on this issue, we develop the game simulator "Exp'Eau" in order to evaluate and to compare different pathways by facilitating the debate on possible collective actions at the scale of an agricultural catchment. Our main focus was to enable virtual social ecological experimentation through simulation, in a first step to generate new knowledge on water quality in agricultural catchment, and in a second step to facilitate discussions among stakeholders within catchments. We designed the game through ARDI workshop [2] with scientists from seven French Long Term Social Ecological Research (LTSER) platforms, completed by a few interviews of experts and the help of game designers.

2 Requisites

On the one hand, the diversity of processes draining pollutants from the plots to the hydrosystem allowing for their slowing down and/or their degradation, the territorial aspect and the diversity of actors, and possible levers to limit these processes are to be accounted. On the other hand, multiple constraints hinder the transformation of agricultural catchments allowing a better water quality while preserving the agricultural land use.

In such context, a serious game-type tool is appropriate to experiment with different combinations of individual and collective actions on water quality, to monitor the impacts and analyze the results.

Exp'Eau first targets a student audience to be able to repeat experiments and compare possible pathways. In a second phase, an audience of local stakeholders will be relevant to raise awareness about the collective dimension of the water quality issue, and secondly to explore possible courses of action at an actual catchment scale.

3 Implementation

The virtual catchment we consider is designed on the basis of the Moderbach catchment (North East of France) simplified and discretized with hexagonal tiles [3]. The hydrographic network is reorganized into an explicit flow network oriented towards a single outlet. Each tile corresponds to a land use (Agriculture, Nature, Urban), assigned according to the dominant land cover.

The game is structured according to three levels of organization, spatially (cell, communal territory, catchment area) and socially (farmer, elected official, catchment area manager). The basin is divided into three independent boards located on different tables in order to create an effect of distance that enables to focus the interactions between the players around the same table, at the exception of the times dedicated to collective interactions, as featured by the spatial layout presented in figure 1.. Each board corresponds to the territory of a municipality. Exp'Eau features three types of actions related to (1) agricultural practices, (2) the control of pollutants, and (3) a better valorization of agriculture.

Only cells with agricultural occupation are likely to generate an amount of pollution which depends on the type of crop and the agricultural practice, as well as on the presence of some agro-ecological infrastructures on the plot allowing to limit the spread of pollutants.

The farm practice action cards have the same structure. Each crop is described with two to three levels of practice that are more or less intensive in terms of use of chemicals and generation of pollutants. Practice parameters are a minimum level of technicality, levels of effort (measured in work time) and of investment (measured in units of goods), and levels of production (measured in units of goods) and of pollutant emission. All these parameters are valued on a scale ranging from 1 to 5. Cards include bonuses/maluses defined as deviations from a standard weather and as a pest outbreak occurrence. Non-farming action modalities include investments in agroecological infrastructures or land use changes, and training to improve farming practices.

They are also characterized by a cost in time and in unit of goods, as well as a possible effect on the production level of the plot and the emission of pollutants.



Fig. 1. Spatial organization of a game session.

4 Experimentation

On a first prototype, we also developed a computerized version based on an Application Programming Interface (API server/smartphones) to facilitate the collection of the player's choices and the computation of their practice's outcomes. However, as mentioned in [4], this API was capturing the attention of the players, what was limiting the interactions between players. We could not build discussions on the interactions and interpret pathways that these simulations had generated. Therefore we simplified the setting so that players could focus on interactions.

This second prototype is a purely analog version and has proved to facilitate the interactions among players around the three game boards and during the collective setting. In this second version, the split of the game board/catchment into three tables was successful to embody the need to move so as to communicate with players coming from other geographical areas and to understand the interdependencies among farmers and municipal development at the level of the catchment.

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Evaluating the effectiveness of a simulation-based learning approach for developing skills for change management for sustainability among Vietnamese educators

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Abstract. The challenge of educating the next generation of citizens for sustainable development necessitates the development and implementation of innovative and dynamic active learning approaches by educators. These approaches should be designed to influence learners' skills for change management for sustainability positively. This study evaluates the effectiveness of the Leading Change for Sustainability in Schools (Vietnamese) online computer simulation (LCSS-V) in promoting skills for managing change for sustainability among Vietnamese educators. The research employed a quasi-experimental research design to assess the change in learners' skills resulting from a four-week learning module. Quantitative data were collected to evaluate the learning outcomes of 32 Vietnamese educators studying in a Master's degree program. Using One-way Repeated ANOVA analysis, results showed a significant difference in scores achieved each week, indicating skill development for change management for sustainability. On average, learners achieved the highest scores for their skill in change management for sustainability in the final test, reflecting the students' progress during the simulation learning process. The study's findings have significant implications for both academic research and practical applications, as they contribute to a knowledge base that can identify effective educational methods for education for sustainable development, paving the way for a sustainable future.

Keywords: simulation, simulation-based learning, education for sustainable development, skill for change management for sustainability, Vietnam.

To achieve sustainable development, innovative teaching approaches are necessary to empower students to contribute to sustainability, as traditional teaching methods may not fully address the complexity of sustainability-related problems [1,2]. UNESCO's Education for Sustainable Development framework highlights the need to build educators' capacities and encourage them to use innovative and participatory teaching methods to develop students' values and life skills [3]. The current training programs for educators in Vietnam continue to rely heavily on traditional lecture and discussion methods [4,5]. There is a demand for tools that can be used in training educators in Vietnam so that they can both manage their schools more sustainably and pass that sustainability knowledge to future generations of students.

This study addresses the gaps in the literature on educating for sustainability by evaluating the effectiveness of the Leading Change for Sustainability in Schools (Vietnamese) online computer simulation (LCSS-V) in promoting skills for managing change for sustainability among Vietnamese educators.

The LCSS-V simulation is a web-based program designed to promote sustainability implementation in schools by transforming educational organizations over three years. The research employed a quasi-experimental research design to assess the change in learners' skills resulting from a four-week learning module centered around the LCSS-V simulation. Quantitative data were collected to evaluate the learning outcomes of 32 Vietnamese

educators studying in a Master's degree program. The study contributes to the development of innovative teaching methods for promoting sustainability in education, which is crucial in achieving the United Nations' Sustainable Development Goal 4 of providing quality education for all learners.

The instructor introduced the simulation and course objectives before participants played the simulation independently to establish their baseline Bennis result, which measures their strategic and principle skills for change management for sustainability. The course included mini-lectures, peer discussions, and individual and team simulation play. Simulation data on strategy records, time tracking, level of management achieved, stakeholders in the sustainability stage, and Bennis score were collected weekly through a simulation portal to evaluate and adjust the simulation's efficacy. Participants took a final test by playing the simulation once within 30 minutes to determine their learning progress.

Descriptive statistics were used to analyze the weekly extracted simulation data, and repeated-measures ANOVA was conducted to determine differences in strategy moves. Results showed a significant difference between the time and the last playing time, indicating skill development for change management for sustainability.

In the final simulation test, 28 of 32 participants achieved the highest level of 'Change Mastery,' operating a strategic plan yielding more than 7000 Bennis and moving at least 80% of stakeholders to the Sustainability Stage of Change. Three participants achieved the Expert level, and one reached the Manager level, demonstrating overall success in the simulation.

On average, learners achieved the highest scores for their skill in change management for sustainability in the final test (M = 10525; SD = 2962.263), followed by week 3 (M = 9304.69; SD = 2581.521), and the lowest scores were obtained in week 1 (M = 2139.06; SD = 2014.533), and week 2 (M = 5740.63; SD = 3174.379). The baseline score was 0, indicating that learners had no skill in change management for sustainability at the start of the simulation course. This reflects the student's progress during the simulation learning process.

A repeated measures ANOVA was conducted after four weeks to compare the effect of simulation-based learning on the skill for change management for sustainability. None of the students obtained any Bennis (score) on the first attempt. The assumption of sphericity was not violated. The results of Table 1 indicate significant differences in the mean scores of the skill for change management for sustainability among base time, after weeks 1,2,3, and the final test with $F(4,124) = 159.537, p = .000, \eta^2 = .837$.

Table 1. Test of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
simulation	Sphericity Assumed	2602281781.250	4	650570445.313	159.537	.000	.837
	Greenhouse-Geisser	2602281781.250	3.311	786006651.323	159.537	.000	.837
	Huynh-Feldt	2602281781.250	3.754	693208913.196	159.537	.000	.837
	Lower-bound	2602281781.250	1.000	2602281781.250	159.537	.000	.837
Error simulation	Sphericity Assumed	505654218.750	124	4077856.603			
	Greenhouse-Geisser	505654218.750	102.634	4926787.615			
	Huynh-Feldt	505654218.750	116.373	4345119.832			
	Lower-bound	505654218.750	31.000	16311426.411			

Although standard deviations were high because of individual score differences, post hoc tests within-subject analysis revealed a significant condition main effect. The Pairwise Comparisons using the Bonferroni correction showed that the mean differences between baseline, test scores after weeks 1,2,3, and the final test were statistically significant.

Only scores between after week 3 and the final test in week 4 were insignificant, as can be predicted because in the last week, students usually played, and the final test had similar results. The lack of significance between Week 3 and Week 4 is explained by the fact that the measures were taken on consecutive days (i.e., the last day in Week 3 and from the post-test given on the first day of Week 4). Thus, the insufficient time elapsed between these data points generates further changes in student results. It implies that the final test score truly reflected the students' scores.

The boxplot in Figure 1 describes the scores students achieved through the weeks. Note that the outliers showed the results of students' scores. In week 3, three students left behind were numbers 1,5, and 2. However, in the final test, most of them can get medium scores, except student number 1 failed. Those outliers were not eliminated as they reflected the characteristics of educational data.

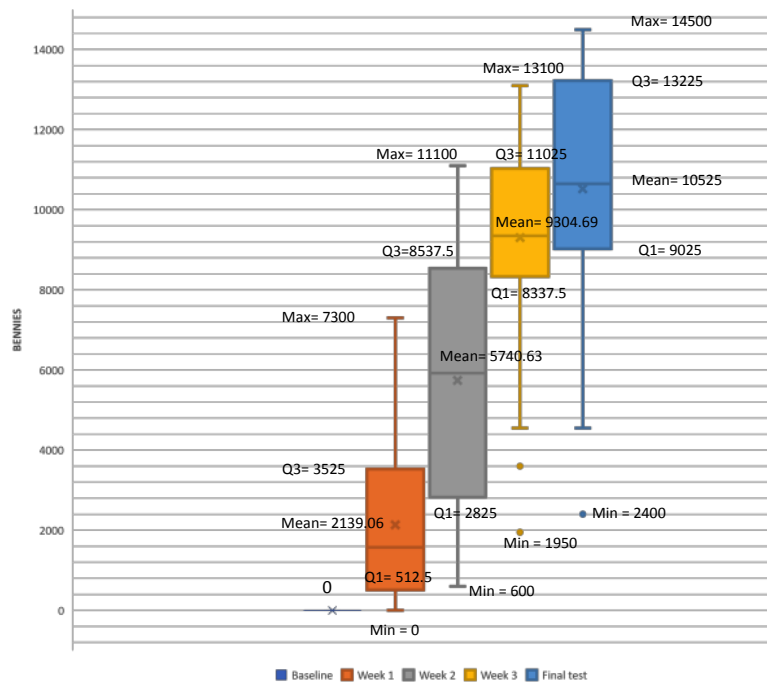


Fig 1. Boxplots for Scores Achieved Through Four Weeks

While the small sample size (i.e., 32 educators) represents a significant limitation, the validation study yielded useful data on the future potential of the LCSS-V simulation. The researcher could collect data from a larger sample of students in multiple classes for further research. It would enable a more valid assessment of the learning outcomes of the LCSS-V simulation.

In conclusion, the study's findings have significant implications for both academic research and practical applications. Firstly, it adds to the body of knowledge on simulation-based learning for ESD by providing empirical evidence, a lacking point of criticism in the field [6]. Then, the LCSS-V simulation is a promising tool for promoting skills for change management for

sustainability among Vietnamese educators. These findings contribute to a knowledge base that can identify effective educational methods for sustainability education, paving the way for a sustainable future.

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«Dukunú Mólé, zogô cúnxença»: a serious game to reconcile biodiversity conservation and economic development in isolated tropical islands. The case of São Tomé and Príncipe

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Abstract. The republic of São Tomé and Príncipe (STP), a small island developing state (SIDS) is at a crossroads. The island faces major environmental and economic challenges posing threats to its unique biodiversity and primary forests. The island's fast-growing population, combined with poor environmental governance, has led to huge pressure on natural resources. Demand for timber, charcoal and firewood for cooking and overexploitation of non-timber forest products are leading to forest loss and fragmentation and habitat degradation of endemic species. A consortium led by an environmental NGO started a participatory process using a serious game approach to explore alternative land use trajectories and reconcile economic opportunities with conservation measures. The tabletop role-playing game was co-designed, co-constructed, tested and implemented over one year (dec 2021 – jan 2023). Nine game sessions were played, gathering a total of 130 participants from various economic sectors (e.g. agriculture, tourism, forestry) and background (e.g. students, farmers, policymakers). Despite its apparent simplicity and compact layout, the game successfully allows for the exploration of diverse trajectories and pathways within a limited time of 3 hours. It fostered exchanges on alternative scenarios, policy implications, and highlighted a general lack of understanding on environmental rules and regulations and on interdependencies and feedback loop in the system.

Keywords: São Tomé and Príncipe, Companion Modelling, Biodiversity, Livelihood Strategies, Landscape Approach

1 Introduction

São Tomé and Príncipe (STP) is an African small island developing state (SIDS) with lower-middle-income. At a crossroads, this hidden gem faces many sustainable development challenges: resource erosion, dependence on foreign aids and trade, growing population, lack of infrastructures and energy sovereignty, poverty and unemployment, weak land planning governance, etc [1]. As a biodiversity hotspot [2], STP promotes itself as a paradise archipelago and has committed to preserve its natural heritage. In 2006, two national protected areas were officially designated, covering more than two thirds of the territory if considering their buffer zones [3]. However, the boundaries, laws, regulations and rules in the buffer zones were never clearly defined and seem to fail in minimizing human impacts [2]. Moreover, since 1970 the fast-growing population, combined with poor environmental governance, has led to huge pressure on natural resources and threats for biodiversity [4]. Demand for wood for construction, charcoal for cooking and overexploitation of non-timber forest products (NTFP) leads to forest loss and fragmentation and habitat degradation of endemic species.

This abstract presents a one-year consultancy work (dec 2020 - jan 2023) between a conservation NGO (BirdLife International), a start-up specialized in serious games (LEAF) and two academic partners (ETH, CIRAD). BirdLife requested the development of a serious game to: (i) raise

awareness on the pressing environmental challenges, (ii) explore alternative development pathways for land use management, (iii) identify barriers and levers to reconcile economic growth and biodiversity conservation. This paper presents the game development process and the first results of 9 playthroughs. The paper also reflects on the challenges, pitfalls, and successes of transferring knowledge and capacity on serious games from academia to a novice NGO.

2 Materials and Methods

2.1 A complex demand, a useful tool

The objectives of the game, as defined by BirdLife, were to: (1) understand stakeholders views on the spatial planning in the island, (ii) develop scenarios that model various land use, biodiversity and ecosystem functioning trajectories that can be used to identify landscape positive investment solutions for biodiversity conservation pilot activities, and (iii) produce recommendations to inform the formulation and implementation of land use policies. Additionally, the broad range of needs from the local partners and the local context in the island translated into methodological challenging criteria. The game ought to be: (i) simple enough to be played with communities with various levels of formal education, (ii) precise and realistic enough to be played with the highest levels of decision-makers, (iii) tailored for the specific case of São Tomé but generic enough to fit the contrasted reality of other small tropical islands, (iv) short enough to be unrolled in 2 hours, (v) long enough to unveil very diverse long-term landscape trajectories. In short, they asked for a model that would work as a viable metaphor [6] for the social and environmental problems it is designed to tackle.

To reconcile these apparent contradictions, we advocated for an intermediary level of stylized but empirical model [7] whose foremost objective was to foster social learning. We implemented a Companion Modelling approach [7] structured around 4 field missions (30 days in total): (1) scoping mission to identify burning issues and co-develop the conceptual model; (2) training on the serious game approach and game development; (3) testing the game and (4) playing the game with broader and mixed audiences.

2.2 Game description

The tabletop role-playing game revolves around a 26-tile board representing an imaginary island with 4 land covers: primary forests, degraded forests, agricultural areas, urban areas. Its name “Dukunú Môle” was collectively selected through a participatory process. It literally means: “if we overexploit, we die”. Players embody the role of community heads in charge of 3 families (representing labour forces/working capacity). The game starts in 1980 and runs for 5 rounds, each round representing one decade. Players’ imposed objectives are to provide food and wood/charcoal for their family members. They can also decide, on a voluntary basis, to pay for the health and education of their family members. Food can be produced in agricultural areas or directly sourced from the forest through hunting or collecting NTFP. Wood/charcoal can be obtained from the primary or degraded forest areas for personal uses or can be sold for commercial uses. Cocoa/coffee can be grown as cash crops and sold at the market.

The game encompasses most of the on-going economic and environmental drivers of change: demographic growth (more families per round), urban expansion (opportunities for well-paid jobs in the urban areas), forest protection (through the creation of a protected area on round 3), new livelihood opportunities through ecotourism, among others. As an add-on to the haptic version, we created an agent-based model that incorporates all the game dynamics. It was initially used to record players’ decisions to replay and revisit the game session during the debriefing.

2.3 Game sessions

Between July 2021 and January 2022, 9 sessions were organized, involving a total of around 130 people, including cocoa and coffee producers, college and university students, members of

parliament, ministry representatives and NGO & Civil Society Organisations representatives. Sessions lasted around 3 hours, with introduction (5'), briefing (10'), 5 rounds (2h) and debriefing (45').

3 Results

Despite the game's apparent simplicity, small-size layout, and limited roles and decisions, a large spectrum of landscape trajectories emerged across the 9 game sessions. The game allowed us to explore contrasted livelihood strategies (self-sufficiency for food vs cash crop) and human capital priorities (health and education). Players revealed diverse strategies with regards to forest conservation and timber extraction, as well as attraction for alternative job opportunities (eco-tourism, well-paid jobs in cities). While being played for only 5 rounds, the game highlighted the effects of short-term, purely capital-accumulation based strategies and their consequences on the overall depletion of the island (reduction of forests and biodiversity, decrease in hunting and gathering, erosion and dry soil, loss of eco-tourism, decrease in community income). The debriefings systematically confirmed a general lack of understanding on the buffer zone rules and regulations, poor knowledge on threatened species and limited overview on the interdependencies in the system. The game is also generic enough to support dialogue in other small island states facing similar drivers of change. The game also helped reflect on key factors to successfully transfer an academic approach to a novice NGO: trust building, experiential learning, adaptability, clarifying expectations and deliverables, overcoming semantic barriers to communication. In a context where participatory approaches are much wanted, this experience could serve as a stepping stone for developing a practical guide to transfer the ComMod approach from the academic realm to NGO and private organizations.

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Collective action for tropical peatland restoration through the H₂Ours game

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Abstract. Unsustainable peatland management with massive artificial drainage constructions causes peatlands to become drier and easier to burn. One of the most frequently burned peatlands in Indonesia is the peatland between Pawan River and Kepulu River (64,000 ha), located in Ketapang district, West Kalimantan. To rewet that area, a hydrological restoration needs to be carried out by planting more trees suitable for wetlands and closing artificial drainages with canal blocking in all areas. However, the sustainable restoration activities need to be accompanied by knowledge improvement through knowledge sharing between stakeholders to achieve mutual understanding, which is difficult to do due to the complexity of the socio-hydrological system. H₂Ours (Water: use, resources and sustainability) game presented here aims to facilitate the sharing of knowledge, support negotiations and enhance coordination among various stakeholders. H₂Ours game was built using the Driver, Pressure, State, Impact and Response (DPSIR) and Actor, Resource, Dynamic and Interaction (ARDI) frameworks to describe the interactions between components in a socio-hydrological system. In the game simulation, players were asked to explore various combinations of land uses in their landscape which brought to costs and benefits of their peatland management. In the debriefing and evaluation session with the players, Most of the participants felt that they enjoyed the game. They also mentioned gaining new knowledge, i.e., seeing peatlands as a single hydrological unit so the hydrological restoration should be carried out together regardless of administrative boundaries. However, they will need higher-level supports to implement that strategy, i.e., regulations and incentives.

Keywords: Tropical peatland, hydrological restoration, serious game, H₂Ours game, collective action

1 Introduction

Indonesia's peat areas which have the thickest peat (domes) combine biomass production and nutrient cycling of rainforest ecosystems, with the carbon storage and water reservoir functions of peatlands. Unsustainable management with massive artificial drainage, has brought many environmental problems, with fires not only detrimental at the local level but also to the regional level as haze and carbon dioxide emissions at global levels [1] [2] [3].

Restoration of the hydrological functions of over-drained, degraded peatlands depends on knowledge, incentives, regulations and motivation [4] [5]. Unfortunately, sharing knowledge among stakeholders become constraints in these socio-hydrological systems. Therefore, active learning in a social context that integrates technical system knowledge and allows for sharing knowledge and perceptions is needed to encourage collective actions. Research shows that people will learn more quickly through experiences so-called experiential learning [6]–[8].

Serious gaming allows integrating technical and socio-political issues involving various stakeholders [9], and provides a safe space to explore and reflect on options through basic elements of gaming (e.g. challenges, rewards, experiences, strategies, emotions) [10]–[12].

We designed the H₂Ours (Water: use, resources and sustainability) game presented here, to facilitate the sharing of knowledge, support negotiations and enhance coordination among various stakeholders of the restoration of peatland hydrological functions.

2 Study area

This study focused on the peatland area in the Ketapang district of West Kalimantan Province, Indonesia. This area has the highest frequency of fires in West Kalimantan, which caused various problems such as health, social, economic and environmental. One of the most frequently burned peatlands in Ketapang is the peatland between Pawan River and Kepulu River (64,000 ha). That area consists of the dome as the core which has the thickest peat, then it is surrounded by dome buffering area with a thinner peat and shallow peat areas. The dominant land-use in this area is oil-palm and seasonal crops. To increase production, people built canals to drain the peatlands. As a consequence, during the dry season, the groundwater level decreased, peatland becomes dry and vulnerable to fire. Peatland restoration is carried out by planting more wetland trees so we can close the existing canal using canal blocking and prevent opening new canals.

3 Methodologies and game participants

We used Driver, Pressure, State, Impact and Response (DPSIR) and Actor, Resource, Dynamic and Interaction (ARDI) framework to describe the interactions between components in a socio-hydrological system, then transformed it into H₂Ours rules. Every round, after the players determined the land-use composition in their peatland, in which each land-use type has economic component (production cost and income) and environmental component (water balance), we calculated the economic and environmental condition using a simple profit equation and water balance equation. To resemble the actual peatland socio-hydrological system, we arranged the game components adopting the current and plausible land-use and solution options (Fig. 1)

To find out the differences in patterns of management of peatlands by communities, the game was played four times with four different groups of participants that consisted of 12 people in each group. Those four groups varied based on their exposure to peatland management activities: Group 1 consisted of Village Forest Management Unit (VFMU) members, Group 2 consisted of Farmer Field School (FFS) members and Group 3 and 4 as the control group were consisted of farmers outside of VFMU and FFS.

After the game, players were requested to fill out an evaluation-questionnaire evaluating and reflecting on their experience while playing the game including enjoyment, learning, and link it to real life.

4 Results

From the four game sessions, the most significant difference to land-use decision-making was in the dome area (Fig. 2, above). Although all participant groups allocated a portion of the peat dome for wetland forest, but member of FVMU (Group 1) planted more forests compared to other participant groups. Member of FVMU (Group 1) planted the dome areas with 60% forest and 40% oil-palm agroforestry with wetland trees, member of FFS (Group 2) planted with 50% oil-palm agroforestry with trees, 25% forest and 25% oil-palm monoculture, while the other participants (Group 3 and 4) planted with 42% oil-palm monoculture, 27% oil-palm agroforestry with trees, and 24% forest. During the discussion, all participants mentioned that they understood the relationship between peat domes and forests but they had to consider their economic conditions. In the buffering and shallow peat areas, all groups tended to select similar land-use patterns. They dominated the buffering area with oil-palm (monoculture and agroforestry), and the shallow peat with crop and oil-palm.

As a result, the dome area had higher groundwater level than buffering and shallow peat area, especially by participants Group 1 (Fig. 2, below). This situation made the dome area by Group 1 was wetter and safer from fire hazards during the dry season compare to other groups.

Based on the evaluation results, 90% of the participants enjoyed the game, 80% understood the purpose of the game, 94% felt they had gained new knowledge, and 92% said that the results of this simulation could be applied in real life. The new knowledge they gained, i.e., seeing peatlands as a hydrological unit, so the land use management and canal blocking construction work optimally to reduce the groundwater outflow from peatland if all villages in the landscape agree to do it together.

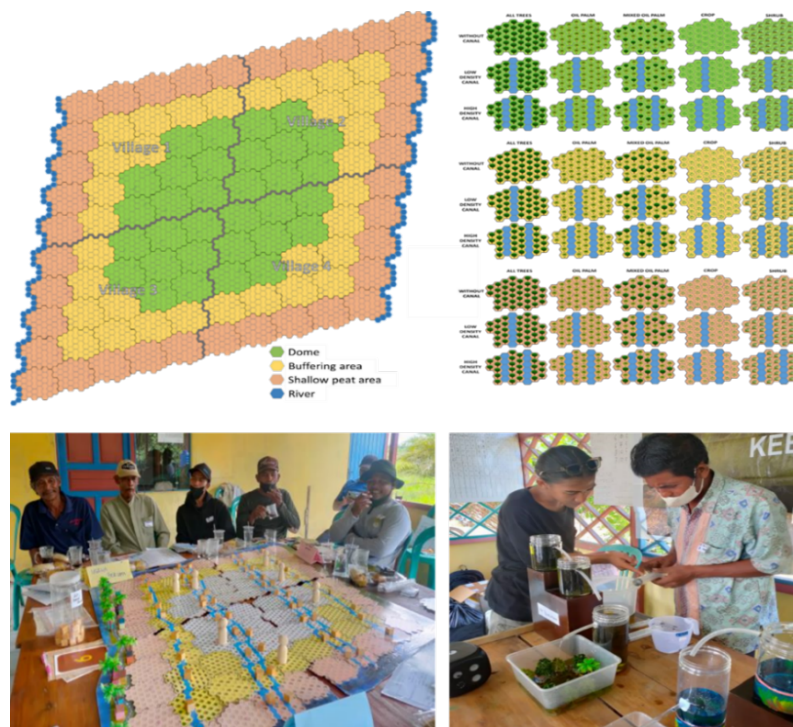


Fig. 1. Board of H2Ours game for peatland version that consist of dome area (area with peat depth > 6m), buffering dome area (area with peat depth 3-6 m) and shallow peat area (area with peat depth < 3 m) (above, left); land-use option (all trees/forest, all oil palm, oil-palm + trees, all crop and shrub) with various canal density (without canal low canal density and high canal density) which affects the drying rate and production income (above, right); game participants managed their peatland (below, left) and a participants poured surface water and groundwater to the water balance model to determine their environmental impacts (below, right)

5 Conclusion

Based on a comparison of the game results of all groups, we concluded that community groups who are more exposed to information on peatland management either through training or their role as forest managers have a better understanding of peatland management.

In the debriefing after each session, participants mentioned that the H₂Ours game allowed them to experience and explore the costs and benefits of peatland management. As this game shows the entire system as a single hydrological unit where villages influence each other, it became evidentially clear to participants that cooperation among stakeholders is needed regardless of administrative boundaries. They also said that to implement this strategy, they will need supports from higher-level stakeholders, especially regarding the economic impact they receive in exchange for conservation activities.

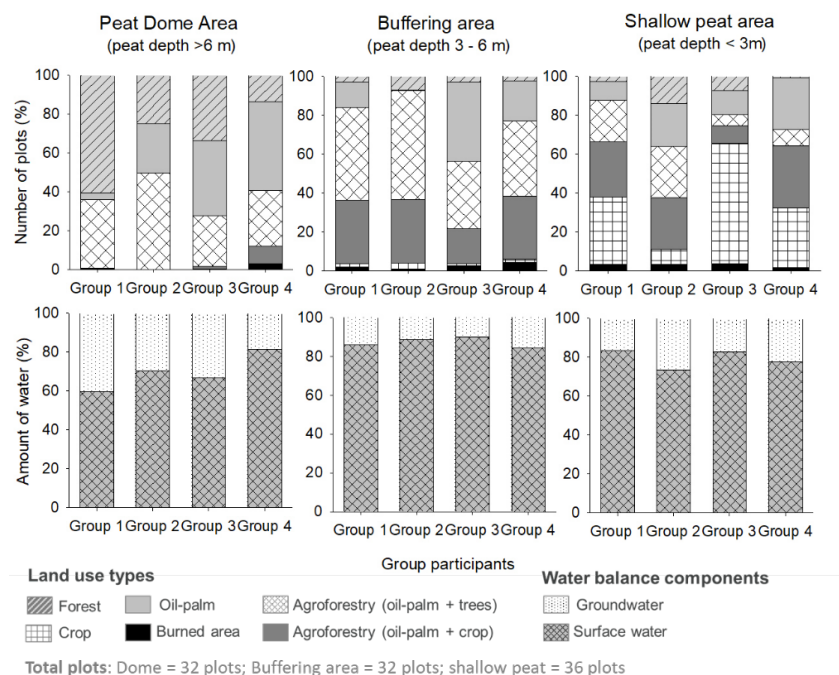


Fig. 2. Average number of land-use plots for eight rounds of H₂Ours game simulation (above) by group participants (Group 1: Member FVMU, Group 2: Member of FFS, Group 3 and 4: Non-FVMU and Non-FFS) and its environmental impacts as ratio between groundwater level and surface water level (below) as the result of their land-use management, more groundwater made the peatland wetter so it did not burn easily

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Insights from the use of participatory simulations in Vietnamese irrigation systems: a case study on waste management

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Abstract. The use of participatory simulations on the matter of public participation in water management has been little explored in Vietnam. Their use take place in a context where individual opinions are difficult to access and participatory approaches, although they exist, are most of the time limited to the time of the development projects and to information-centered meetings. We proposed, through the building and the use of the participatory simulation RÁC ("waste" in Vietnamese language"), to explore how such a tool could be used to foster dialogue in a Vietnamese context. This serious game focuses on the issue of waste management in the rural commune of Phạm Trấn, which is part of the Bắc Hưng Hải irrigation system. The use of RÁC in multiple workshops allowed to consider specificities of the Vietnamese context, both in the expression of opinions and the facilitation of debriefings. Our research found that the statement of personal opinions was less important for the participants than finding leadership, reach common agreements and cultivate cohesion between participants. This first experience for our team also leads to deeper reflections on modalities of organization of participatory workshops when working with Vietnamese local authorities.

Keywords: Participatory Simulation, Irrigation Management, Waste Management, Agent Based Modeling, Public Participation

1 Research project's goal

Public participation in Vietnam takes place in the context of a "negotiated authoritarianism" [1], meaning that while the State's institutions are very productive in terms of legal prescriptions (guidelines, objectives, decisions), they are systematically re-negotiated at the local scale between individuals and the agents of the State. This cultural context creates the situations where opinions are (or maybe) shared publicly but constrained with difficulty. Official events based on participatory approaches are handled by the State representatives. They often are an end in themselves, limiting most participatory events to technical presentations followed by a show of hands [2].

Taking the example of the water resources sector, previous research shows that public participation is limited to the time of the project [3]. Public participation is also necessary to encourage the participation of funders, and finance projects [4]. Although Participatory Irrigation Management has been mandatory since 2004 in Vietnam [5], actual practices show public participation is limited to informative elements.

We wanted to explore participatory approaches in a given territory in Vietnam, i.e. an irrigation system, to apply the use of participatory simulations (that is to say, giving opportunities to participants to interact with an evolutive model) to foster the population's involvement in water management, as well as freedom of speech.

2 Simulation choices & objectives

We conducted forty-one semi-structured interviews with authorities, irrigation technicians, farmers and inhabitants of the communes of Phạm Trấn and Thạch Khố (district of Gia Lộc, province of Hải Dương), which are part of the Bắc Hưng Hải irrigation system in the Red River delta. The results of the interview campaign showed that waste management in irrigation canals constitutes a shared issue among the stakeholders. We then designed RÁC (meaning “waste” in Vietnamese), a participatory simulation designed to foster social dialogue and expression of opinions on the matter of irrigation canals pollution.

RÁC presents an irrigation system based on a modeled environment using the GAMA platform software [6]. The choice was made to represent a fictive irrigation system based on the interviewees’ representation of space and practices, to offer a simulated environment the closest to the participants’ reality without leading them directly to think that they were interacting with a copy of their territory, allowing to avoid direct political deadlocks.

We decided on the use of an Agent Based Model (ABM) in order to better control interactions between the different agents (canals, fields, urban areas, waste) as well as to make it easier to present to participants. Splitting into agents also allowed us to easily follow the system’s evolution through participant’s choices of actions.

RÁC represents a rural commune spanned by irrigation canals and divided into four villages. The goal of the simulation is to lead participants to communicate on local issues emerging throughout the game. They had to continuously communicate to coordinate their actions on the territory, in order to reach a common goal at the scale of the commune. This goal is to keep an agricultural label based on a lower limit of agricultural production and an upper limit on waste production. During the simulation, participants were proposed with nine action cards and a yearly budget to frame their range of choice. The simulation is turn-based (one turn equals one year on the model), allowing participants to take actions and see their yearly impacts after computation.

3 Context and participants

RÁC was used in four participatory workshops in the commune of Phạm Trấn. This commune is located in a rural context, where agriculture and small industries are the main source of economic activities.

Each simulation session regrouped twelve participants. Most participants were farmers, and every session included at least one chief of hamlet from the commune. The chief of hamlet is most of the time a practicing or retired farmer, whose role is to ensure smooth communication between the communal authorities and the inhabitants.

The workshops were led inside the Peoples’ Committee’s premises of Phạm Trấn in June and July 2022.

4 Workshop activities

RÁC workshops typically have a duration of approximately two hours. First, the participants filled a first questionnaire on their views of current waste management and on their expectations related to the workshop. Vietnamese facilitators then take control of the presentation of the rules, split participants into four groups of three (one group handles the management of one village of the simulated commune), and initiate a few mock turns. After that, the simulation is initiated, lasting 10 turns.

During a typical turn (figure 1), the facilitator handling the model runs it, and participants can see on a screen how the simulated territory evolves considering agricultural and waste production. They then have 1'30" to talk with their group partners and coordinate with other groups to choose their actions according to the situation of their village as well as considering global indicators to reach the agricultural label’s criteria. The remaining amount of money from each village is then put in a common pool, and villages have 1' to negotiate which village should

use the remaining money for a single extra action. Once the second countdown reaches its end, groups are called in a random order to give the actions they chose to the modeling facilitator, who then computes the results and runs the model. This process takes place ten times during a simulation session.

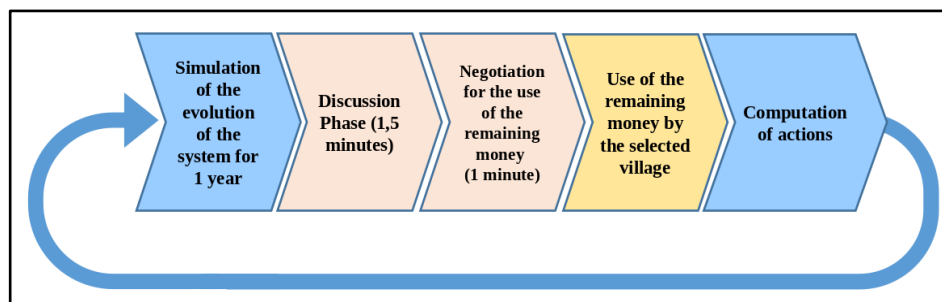


Fig. 1. Unfolding flowchart of one turn in RÁC

A first debriefing phase was proposed under the form of a second questionnaire where participants can express their views on several aspects of the game and regarding communicational aspects. Participants are conveyed to a second debriefing at the end of the day, to share their simulation experience with another group as well as confront opinions on the current waste management processes in Phạm Trấn.

5 Lessons learned

The dataset we analyzed was composed of : 1) quantitative data from the evolution of the RÁC model regarding its evolution through the participants' actions ; 2) quantitative data from the two questionnaires submitted to the participants ; 3) qualitative data from the participants' communicational behavior during the workshops and debriefings.

We proposed the game to foster social dialogue with the idea to create an event during which participants could express their opinion on the matter of waste management in irrigation canals. On their side, participants came to the mutual agreement that they sought clear leadership as well as group cohesion to assist social dialogue. To them, cohesion was more important than having the possibility to state what they thought and confront it with other participants.

Moreover, participants could easily understand the simulation and how space was represented. During debriefings, participants started to think of ways on how it could be inspiring to start sensibilization campaigns on domestic pollution inside their hamlets. Participatory simulations can then lead to the appearance of new individual engagements, or resonate with engagements participants already have – for example farmers associations, women associations, as both these groups were represented during RÁC workshops. There is a need to go back on the field to assess how this willingness to commit took – or didn't take – form in everyday life.

We found that it is difficult to communicate directly with the public in organizing participatory events. This task of communication, requires the participation of local authorities especially in identifying and inviting stakeholder-participants to the said events. As a result, organizing participatory workshops made us rely on local authorities to invite farmers, making it difficult for us to have a clear idea of how and why authorities recruited them specifically. There is a need to work closer with local authorities, who are crucial in our capacity to reach local populations, in order to take a greater part in how participatory workshops are materially organized, from beginning to end.

Further work will be conducted on the field, in the near future, in the form of more workshops. The previous workshop received a warm welcome from participants, and this gives us confidence in its future use in a comparable context.

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Farmers' conundrum: Sustaining a family when resources are limiting in southern Togo

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Abstract. Agriculture is intimately related to the sustainable development goal of Zero Hunger (SDG2). Research institutions and non-governmental organizations have been promoting sustainable production, providing training and education, and facilitating market access to farmers. However, it is key to understand how farmers interact with development agencies and change their strategies because of this interaction. Therefore, this study aims to use a role-playing game to understand how farmers' strategies are impacted by interacting with development agencies. The game simulates the reality of marginalized rural households in Togo. It involves six people playing the role of a farmer and one in the role of a development agency player. Farmers must make decisions about crop and animal production, labor distribution, input investment, family food, school fees, and household improvements. A total of 10 game sessions were conducted between February 26 and March 16. Data analysis will involve Q-methodology, Factor Analysis, Correspondence Analysis, Cluster Analysis, and Logistic Regressions to group players based on their behavior. Preliminary results of the study show that farmers do not tend to prioritize their food production systems. Instead, they prefer to invest in improving the quality of their households. Although they were open to adopt new cropping systems, they mentioned that factors like lack of resources often impede them to implement new systems. These results provide insights into the potential implications of proposed sustainable practices on smallholder farmers and might help to design policies and interventions tailored to the needs and capabilities of vulnerable or marginalized households.

Keywords: Household Strategy, Food Security, Sustainable Development Goals, Farming Systems

1 Introduction

Food and agricultural systems are intrinsically connected to the Sustainable Development Goal to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (SDG2). Agriculture is a multi-purpose activity in southern Togo, which provides food and income. Although a few farmers have access to off-farm activities, agriculture remains the sole alternative for many. Unfortunately, high land pressure, large families, and low crop performance keep agriculture from meeting households' needs for food and income [1].

The agricultural performance depends on a series of resources such as arable land size, family composition, technical knowledge of cropping and animal production, input access and availability, etc. Farmers will consider their resources at the household level as the basis for their decision-making and strategic process [2]. Farmers can better cope with uncertainties such as climate variation, erratic weather patterns, and market instability by adopting various strategies. In turn, adopting new strategies can pose financial [3] and knowledge [4] barriers to farmers. Research institutions and non-governmental organizations (NGOs) have committed to promoting sustainable practices by providing training and education or improving access to resources and markets. However, it is important to evaluate the potential implications such proposed practices can have on smallholder farmers.

This study aims to understand how interactions between development agencies and households can affect strategies when resources are limited, opportunities for off-farm income

are scarce, and food insecurity is high. As such, we designed a strategic game that simulates the reality of marginalized rural households in sub-Saharan Africa to understand how farmers manage their resources to provide their families with food and money while improving their overall quality of life. Understanding household strategies can be helpful in designing policies and interventions that are tailored to the needs and capabilities of households, particularly those who are vulnerable or marginalized.

2 Materials and Methods

2.1 Study area

We are currently carrying out this research in Donomadé, an isolated rural community in southern Togo. Rainfed agriculture is the main activity in Donomadé, and around 600 people depend directly or indirectly on it. Given the village's remoteness, off-farm income is not an alternative to most farmers. As consequence of marginalization and low crop performance, most households in Donomadé are food insecure.

2.2 Game development and structure

We used the ComMod approach [5] to develop our strategic game. The approach relies on the participation of locally relevant actors in the development process. The game design occurs in three broad phases: 1) understanding and agreeing upon the main issues at stake, 2) building of a conceptual model, and 3) developing and validating a role-playing game. Three field trips between 2021 and 2022 were done to complete phases 1 to 3. During these visits, we surveyed 81 household heads, interviewed 28 household heads, and conducted eight workshops.

The game consists of 6 participants to play the role of a farmer. For 6 rounds, farmer players will have to decide how to: manage their crop and animal production, distribute the available labor to several activities, invest in input, feed their family, pay for school, and buy improvements for their household (e.g., motorized vehicle, t-shirts, school books, etc.). In the beginning of each round, farmer players will decide what to plant. Based on their decision, additional labor and/or seeds must be bought. Then the round moves to the harvest phase. After harvesting, players decide what they will conserve as seed for the next season, what will be given to feed their families, and what will be sold in the market. In the beginning of each season, the development agency player must convince farmers to adopt cropping systems innovations and invest in a farmers' cooperative.

2.3 Game sessions and follow-up activities

A final field visit occurred between February 24 and March 16, 2023. During our visit, a total of 10 game sessions were played to assess household strategies and resource management. We measured decisions such as crops species planted, crops and animals sold, crops consumed, money invested (e.g., labor, education, and cooperative), and purchase of household improvement items (clothes, books, vehicle, cell phone, etc.).

A Q-methodology was developed concomitantly to the game sessions. We asked players to sort pre-defined statements around the topic of livelihood strategies. We waited a minimum of one week between the game session and the q-methodology activity to give players enough time to "cool down" from the game session.

2.4 Data analysis

For analyzing the Q-methodology results, we will run a factor analysis. In addition, we will use a combination of statistical tools such as Correspondence Analysis, Cluster Analysis, and Logistic Regressions. By combining the Correspondence and Cluster analysis to analyze the game data,

we will be able to group players based on their behavior during the game. The Logistic Regressions will permit us to calculate the probability of different players' actions.

3 Expected results

Results from our game sessions are being currently analyzed, and formal results will be ready for presentation before the 54th ISAGA. However, first impressions show that players' objectives displayed during the game do not go in the direction of improving farming systems. Instead, they show clear preferences to invest in household improvements and education. Players tended to start the game with ambitious goals (e.g., buying a house in the city). However, most players changed goals mid-way the game when they realized their initial goal was hard to attain. Another glaring observation is that several players decidedly avoided providing enough food for their families during the game (even when they had enough) as a strategy to deal with unforeseeable events (unfavorable weather conditions, unexpected sickness, etc.). During the debriefing session, players commented that they adopted these strategies based on real life experiences. Female players tended to prioritize education and food security while male players prioritized money. Most players were open to adopt new cropping systems promoted by foreign organizations. When contrasting with real life, they expressed that sometimes they cannot adopt a new system due to lack of resources to implement it (e.g., plot ownership, available labor, and access to input). They also showed propensity to collectively invest in expensive crop transformation machinery when they perceived financial benefits. Serious games has been proven to be an effective tool to understand farmers' strategies [6]. Our preliminary results show that, to improve farming systems, first certain needs must be attained. For instance, a farmer might not want to prioritize investing in a new farming system if they have different preferences such as improving their household. The fact that they hold off resources such as available food and money indicate little leeway for investments. On a public policy level, developments should be done to improve basic households' need such as access to food, school, and market. On a cropping innovation level, agencies should consider not only farmers' goals but also the available resources to better promote more efficient and sustainable production systems.

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Exploring the effect of external interventions on smallholder farmers decision-making with serious games in the Peruvian Amazon

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Abstract. In the Peruvian Amazon, agriculture is one of the main drivers of deforestation. The department of Madre de Dios, Peru, is currently in a phase of social and environmental transition, with an exponential growth of farming activities due to the recent paving of the Interoceanic Highway, allowing for improved access to national markets. Various actors, such as the regional governmental and non-governmental institutions, are therefore intervening in the farming system, aiming to boost production, foster economic development and/ or forest conservation. However, it remains unclear how such interventions are perceived by farmers and how they affect farmers decision-making processes in general. Serious games are increasingly recognized for their potential to explore decision-making processes among stakeholders of complex social-ecological systems. In this study, we explore the social-ecological farming system of Madre de Dios through n=57 surveys with smallholder farmers and develop a serious game to represent the system. The serious game is played with various groups of farmers to reflect on the impact that interventions can have on their decision-making and on the rates of deforestation at farm and landscape-level. Initial results suggest that games are useful tools to simulate the effect of various intervention strategies on the farming system.

Keywords: Serious games, Social-ecological Systems, Participatory, Farmer Outreach, Interventions

1 Introduction

In the Peruvian Amazon, agriculture is one of the main drivers of deforestation [1]. The department of Madre de Dios, Peru, is currently in a phase of social and environmental transition, with an exponential growth of farming activities due to the recent paving of the Interoceanic Highway, allowing for improved access to national markets [2]. This recent agricultural boom is generating interest from a variety of actors, i.e., the regional governmental and non-governmental institutions, who are aiming to boost production, foster economic development and/ or forest conservation. While such interventions influence the farming system, it remains unclear how they are perceived by farmers and how they affect farmers decision-making processes in general. This study aims to use serious games to explore farmers' decision-making about land-use, to simulate the effect of existing external intervention on such decisions and to generate discussions about desirable and undesirable interventions.

2 Method

Serious games are participatory research tools increasingly recognized for their potential to explore decision-making processes among stakeholders of complex social-ecological systems [3]. In order to create a game representative of the Madre de Dios farming system, previous household surveys were carried out with n=57 farmers located along the Interoceanic Highway

(Fig. 1). The main components of the farming system, as perceived by farmers, are extracted through the Fuzzy-Cognitive Maps method and used as a base for the game design. These system components include: the Interoceanic Highway, primary and secondary forest (shown on the board, see Fig. 2), short-term and long-term crops, market sales, risk of fire, labor availability, climate change and external actors such as banks, companies, NGOs and the regional government.

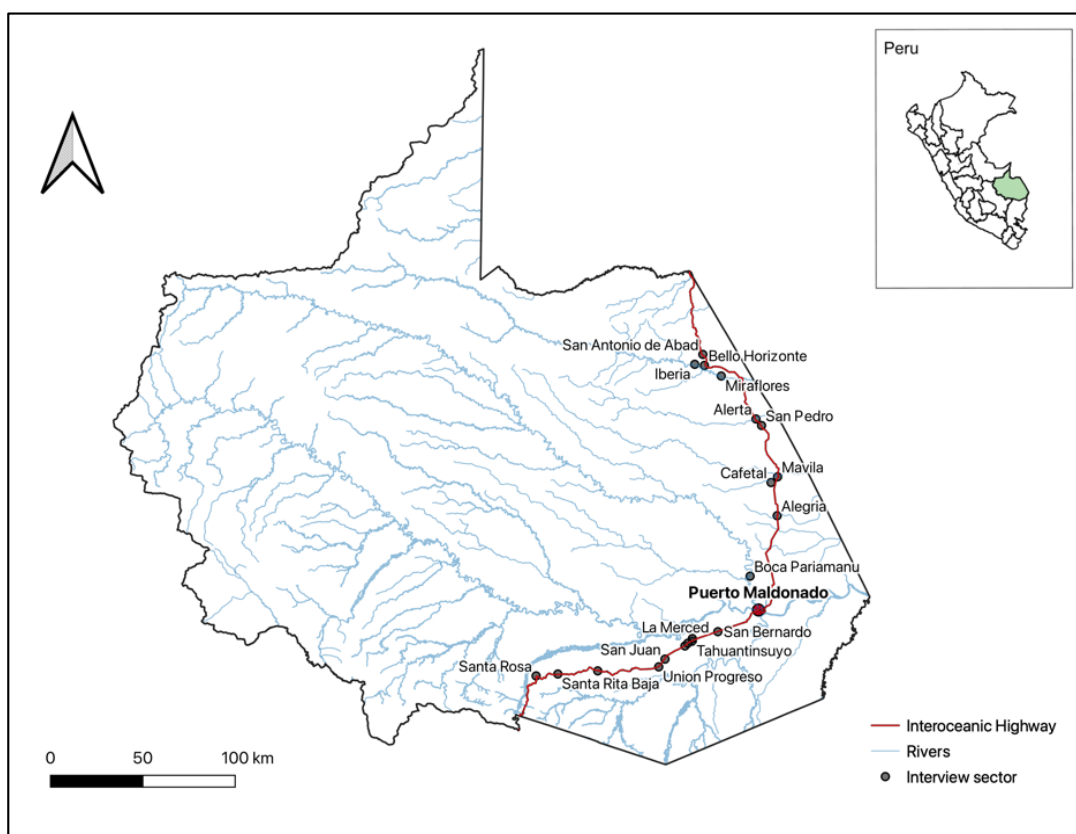


Fig. 1. Map of the department of Madre de Dios, Peru, showing the different sectors where interviews were carried out

The game is tested and improved during n=6 trial sessions with various non-farmer experts of the farming system, including NGO representatives, researchers and farm technicians. The final game is then played with various (n=20) groups of 4 to 6 farmers (total of n=103 participants) during 3-hour sessions. Besides the game, each session includes an introductory survey (including questions about farmers' experiences with external interventions), a pre- and post-game short questionnaire aimed at assessing perceptions on external interventions [4], and a group debriefing. Each participant receives a land composed of 9 parcels (Fig. 2) on which they can choose to plant either a short-term crop, i.e., banana (*Musa sp.*), corn (*Zea mays*), yuca (*Manihot esculenta*) and rice (*Oryza sativa*), or a medium to long-term crop, i.e., cacao (*Theobroma cacao*), copoazu (*Theobroma grandiflorum*), citrus trees (*Citrus sp.*) and timber trees. A dice is used to represent the risk of uncontrolled fire when clearing forested land. In-between rounds, announcements are made by the moderator about the arrival of a given farmer outreach project that participants can vote to take part in or not. The projects (or interventions) represented in the game are those of an NGO (offering agroforestry seedlings in round 2), the regional government (offering cacao seedlings in round 3), a corn company (offering hybrid corn

seeds in round 4), a papaya company (offering to rent land, round 5) and a carbon project (offering to provide payments for ecosystem, round 5).

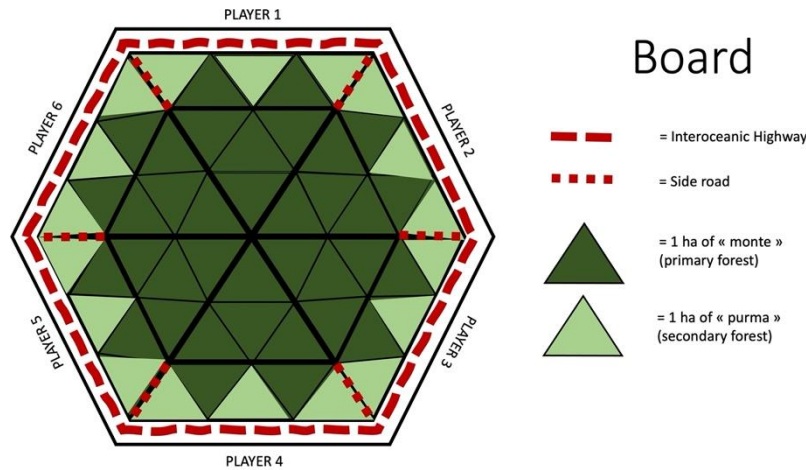


Fig. 2. Schematic representation of the board in its initial configuration before the playing of a Serious Game with 4 to 6 farmers in Madre de Dios, Peru. Dark green parcels represent land initially covered in primary forest; light green parcels represent land initially covered in secondary forest.

Results are drawn from the analysis of individual and collective decisions participants make in the game (e.g., how much and which land is cleared, which crops are planted, what kind of external support farmers are willing to associate for). The effect of collectively accepting external interventions on individual decisions is also explored. Individual questionnaires are analyzed to compare the impact of playing the game on farmers' opinions about external interventions. The debriefing discussion provides additional information on farmers' experience and on the links between decisions made in the game and in reality. Results are then used to reflect on the impact that interventions can have on farmers decision-making and on the rates of deforestation at farm and landscape-level. Interventions are identified that are preferred by farmers over others and therefore more likely to be adopted.

3 Initial results

Early results (based on 7 sessions with 33 farmers, see Fig. 3) show that the game is very well understood by farmers, who validate it as a representation of the regional farming system. As they do in reality, farmers typically start by planting short-term crops which they follow with long-term crops. Farmers who, in real life, have not received any support from a governmental agency or an NGO, tend to vote in favor of institutional support in the game. Interestingly, farmers who have received superficial (e.g. short-term or incomplete) institutional support in real life tend to distrust the NGOs and governmental agencies in the game. The intervention by the corn company is perceived by most as a good opportunity, driving farmers to deforest primary forest and install corn plots. When farmers are asked to choose between the carbon project and land rental to papaya farmers (which, in the game, provides the same economic benefit) a large majority of farmers voted for the carbon project, mentioning their desire to protect forest.

While the data collection and analysis phase is still in progress, these initial results suggest that serious games, as the one developed for this study, are useful tools to simulate the effect of various intervention strategies on the farming system, thereby providing the opportunity to inform land-use policies.



Fig. 3. Photography of an early game session with 5 farmers in the sector of Alegria, Madre de Dios, Peruvian Amazon

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Impact assessment of serious games: a conceptual proposal

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Abstract. In sight of today's large societal and environmental challenges, the governance of landscapes and the management of natural resources is increasingly difficult. In this context, the interest for novel methods and tools to address this challenge continues to grow and there is substantial interest for serious games used as boundary objects and (social) learning tools. On the other hand, scientific evidence about the type of impact serious games have in practice is often falling behind the ambitions. The majority of literature on serious games used in the context of natural resource management lacks objective impact assessment and therefore often remains anecdotal. How to move forward in assessing the impact of serious games remains a very important and debated topic in this transdisciplinary field. Here, we aim to further this current debate by bringing forth ideas for how to go about critical assessment of current initiatives and to propose a conceptualization of the role of serious games and impact assessment in moving issues through the issue-attention cycle.

Keywords: Natural resource management, Game evaluation, Transdisciplinary research, Social learning, Assessment framework

1 Introduction

In sight of today's large societal challenges, the governance of landscapes and the management of its natural resources (NRM) within is increasingly difficult. These complex systems on which many people's livelihoods depend, are facing evermore competing interests and multi-level claims to land and other resources with a growing host of stakeholders [1-3]. As a result, steering resource and landscape management towards increased sustainability is recognized as one of biggest and most important challenges of our times [4,5].

Transdisciplinary research, in which different types of knowledge from diverse sources e.g. scientific, traditional, indigenous, are combined on equal footing to develop a fuller and more inclusive understanding of an issue, is emerging as a prominent approach to explore and study these complex systems [5]. It is in the context of such transdisciplinary research collaborations that serious games hold promise [6,7]. These games facilitate inclusive discussions among a wide variety of stakeholders, in which the game functions as a boundary object through which participants can explore consequences of decisions in a condensed, often stylized, representation of a social-ecological system [2].

In this it is important to observe how while some documented a range of learning effects after using games for serious purposes e.g. [8,9] the field as such seems to lack a solid evidence base documenting casual attribution to assessed learning. In light of the current trend of research needing to directly contribute to, and have an impact on today's large societal challenges, the lack of this evidence base is a shortcoming requiring further research. We acknowledge that assessing the impact of games is not straightforward and in particular not when causal attribution is sought (or assumed) in relation to both behavioral and socio-ecological outcomes as recognized also by others [11,12]. Here, we make a conceptual proposal aiming to contribute to the debate on impact assessment of games used for serious purposes in NRM contexts.

2 Current status of serious games impact assessment

Several extensive and systematic reviews of academic literature on games have been done e.g. [10-14]. Yet, none appears to be exclusively focused on impact assessment in the context of NRM. It seems that assessment methods developed and employed in studies undertaken within the field of education and training appear to be more profound, objective, and more structurally applied than those in the field of NRM. Papers that report on an assessment in NRM contexts appear to have focused mainly on learning of the individual players and to have undertaken this assessment of game impact by means of a subjective reflection made by the participants with interviews and self-reporting questionnaires and surveys being most frequently used e.g. [15-17], while the need for more objective game impact assessments is increasingly recognized e.g. [7,10,18,19].

The body of works on serious games in a NRM context is prevalently empirical. It often includes reports about the development, and application of a single game. And, that in most cases, does not include discussions about game impact and assessment. Literature reports how the core objective of game development and game use was to stimulate learning and trigger discussions, and to share ideas and experiences amongst the game participants, while a critical and deeper view on the desired learning process and outcome, and of what is the game's contribution to reaching that are largely lacking. Also the discussion of what could be the most suitable assessment method to evaluate all that is also largely lacking.

3 The role of games and their impact in the knowledge to action chain

Research with games in NRM contexts where games function as interventions are most often positioning the game in relation to the ecological and social context. Such positioning frequently relates to the cyclic nature of human activities. Also in natural resource management contexts, the cyclic nature of issues is gaining prominence as issues grow in importance, are being addressed or just fading away to the background as new issues emerge and take over the prominent spot in the eyes of the public. The five stages in this so-called issue-attention cycle that becomes cyclic as a new issue gains prominence [20]. In view of the need for research to directly contribute to impact on issues, we identify the issue-attention cycle with its five stages as guiding framework to conceptualize the role games and learning through games can play in maneuvering an issue through the five stages of the issue-attention cycle (**Fig. 1**).

Games can function as a useful vehicle to move an issue forward in the issue-attention cycle by creating momentum among stakeholders and taking the first steps in going from knowledge to action [22,23] (**Fig. 1**). Learning is a key process intrinsically linked to the use of serious games. Many papers aim to reach learning impacts, but few were explicit about the objective of learning, who should learn what should be learnt and how, the 'who-what-how' questions. Understanding where the issue at hand is in relation to its issue-attention cycle, may help in describing the game objectives, and its expected outcomes and impacts. Positioning learning in relation to the intended use of serious games on an issue-attention cycle, and subsequent steps to be taken, can guide researches and practitioners on the path from knowledge to action. And, may help them to weight which form of learning would be best desirable and beneficial.

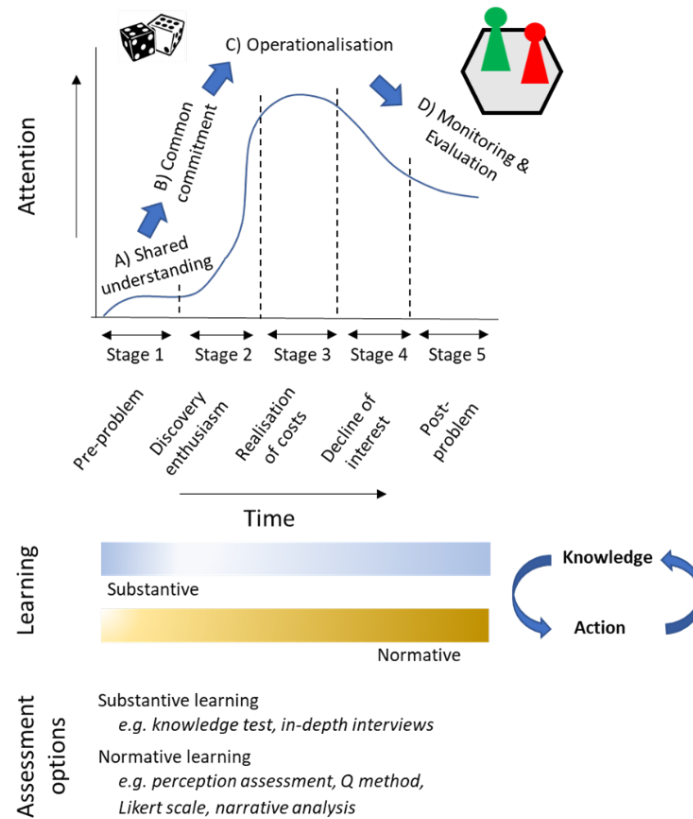


Fig. 1. Conceptualization of the role games and learning through games can play in maneuvering an issue through the five stages of the issue-attention cycle [20] (**SOURCE:** [21]).

4 Conclusions

Serious games as a learning and intervention tool within the field of natural resource management has become increasingly popular. The fast growing and largely case study based body of literature falls behind theoretical and methodological aspects of game development and use, falls behind its fast-growing empirical base. The lack of objective game impact assessment limits comparative potential and restricts the building of a robust body of evidence about game impact which is needed for a research field to learn and thrive further. We propose a conceptualization that links the use of serious games to the different stages of and associated needs within the issue-attention cycle, to specific learning objectives and impact assessment to allow an issue to be moved forward in the cycle.

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