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Serious games in favour of knowledge management and double-loop learning?

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Abstract

How can universities develop a knowledge management dynamic in order to train knowledge workers who are effective in an organizational learning process? Can games, and more specifically serious games, contribute to reaching this goal? To answer this question, we hypothesize that play can serve as a lever for knowledge management and double-loop learning. The purpose of this article is to show that serious games contribute to training knowledge workers in an organizational learning process. From this perspective, we attempt to understand how serious games promote the acquisition of knowledge and we explain the research method used in the field (participant observation, investigation using questionnaires). The final part analyses the main results: a community of practice and organization learning, internalization through Learning by Doing and better understanding of the environment's complexity, towards double-loop learning and student satisfaction with the serious game.

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Keywords: knowledge management tool; organizational learning; double-loop learning

Introduction

Knowledge and its corollary, education, constitute the pillars of competitiveness in the context of international competition. Yet how can universities develop a knowledge management dynamic in order to train knowledge workers who are effective in an organizational learning process? Can games, and more specifically serious games, contribute to reaching this goal? To answer this question, we hypothesize that play can serve as a lever for knowledge management and double-loop learning.

Here we observe that it has been used for a very long time in teaching young children (Piaget, 1945) and a great deal in universities as well (Sabin, 2007; Young *et al.*, 2012). The use of games for educational purposes was formalized as early as 1970 under the term *serious games* and a definition was provided by Abt the same year that remains relevant today (Abt, 1987, pp. 6–7):

Reduced to its formal essence, a game is an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context. A more conventional definition would say that a game is a context with rules among adversaries trying to win objectives. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement.

In management sciences, serious games have been the object of mostly qualitative research (Malone, 1981; Wilson *et al.*, 2009). We intend to deepen our understanding of the mechanisms through which serious games influence the knowledge acquisition process.

For our demonstration we attempt to understand to what extent serious games promote the acquisition of knowledge. Afterwards, we explain the research method used in the field, in this case participant observation and investigation using questionnaires among 190 students, before and after their participation in a serious game related to project management. The final section of this article analyses our main results.

Serious games for acquiring knowledge and learning?

Playing a serious game allows us to understand complex issues within a complex environment due to its systemic character. Therefore it could play an important role in a knowledge management process and more generally in organizational learning as the following sections explain.

Serious games: understanding a complex reality through learning by doing?

Knowledge management consists in bringing out, circulating and capturing knowledge in order to promote innovation and creativity while improving an organization's performance and competitiveness (Nonaka, 1991, 1994). One of the major challenges for knowledge management is the conversion of tacit knowledge (customs, practices and other knowledge that a person is not necessarily aware he possesses) into explicit knowledge (formalized and transmittable knowledge). This simplified model acquires its full meaning by taking into account not only transmission of different forms of knowledge but also the conversion mechanism between tacit knowledge and explicit knowledge. To this end, Nonaka (1994) developed the SECI model (socialization, externalization, combination, internalization) which includes four processes:

- The first of these processes, *socialization*, refers to informal sharing of experience (tutor-apprentice relations, informal discussions, exchanging best practices, etc.).
- Converting tacit knowledge into explicit knowledge (*externalization*) involves work on formalizing tacit knowledge through, for example, modelling or systematization (in the context of a quality programme, for example).
- Constructing new explicit knowledge based on existing explicit knowledge is called *combination*.
- Finally, transforming explicit knowledge into tacit knowledge is based on appropriation (*internalization*), which is similar to the process of Learning by Doing that we want to set up by organizing serious games with students.

Understanding the various dynamics at work in constructing knowledge inside the firm helps prepare students, or future knowledge workers, for the challenges of knowledge management and even makes them managers of their own knowledge in order to develop their capacity for initiative.

Identifying, prioritizing, contextualizing, connecting and decompartmentalizing knowledge are key skills for

future knowledge workers (Levy, 2010). Games can be used to simulate complex situations. Hence, various armies have engaged in war games since the 19th century. These practices, which started with the Prussian army's *kriegsspiel*, have been significantly developed, notably by the American army after World War II. These games, aimed at training in decision-making in complex situations and, on the other hand, at assessing the impact of decisions in view of defining a strategy, were gradually applied in the business world (Gilad, 2009). A serious game is therefore a dynamic and complex system, consisting of objects and initiatives that evolve in the course of play according to rules and the players' actions (Thomas *et al*, 2011). In serious games, the knowledge that needs to be acquired is the object of the game (scenarized simulation, role play or video game and in some cases a reward system for players who reach their goals). Serious games therefore allow contextualized (Shaffer *et al*, 2005) or situated learning (Lave & Wenger, 1991) that encourages independence, taking the initiative and making complex and critical decisions regarding situations that are also complex and critical (Dickey, 2005).

Serious games are part of a Learning by Doing approach or, in other words, they are similar to an internalization tool as defined by Nonaka. Beyond the question of knowledge management, it is logical to suppose that serious games could also play an important role as an organizational learning tool.

Learning through serious games?

Organizational learning as defined by Argyris & Schön (1995) concerns knowledge, skills, techniques and practices. Organizational learning depends on learning from individual interactions, these interactions being affected in return by organizational learning. In our specific case, the pedagogical team (the teachers organizing the serious game) and groups of students (who are supposed, in our serious game, to open a restaurant) have to learn collectively through the game from interactions between students, and between students and teachers. Consequently, learning among the students will progress and influence, in turn, individual interactions. According to Argyris & Schön (1995), this learning phenomenon is all the more important if the organization's culture encourages its continuous progress and creates situations that are more favourable for changes and innovations.

When applied to serious games, the theory of organizational learning considers that each student, gathered in team to play the game, learns individually which contribute to team learning (organizational learning). The team learns through the students' search for solutions (or investigations) that produce informational content. The students build up a wealth of knowledge that can take on the form of hard or electronic files, wiki, content curation platforms, etc. According to Argyris *et al* (1985), this knowledge constitutes theories of action or, in other words, it is produced to reach a goal and is the result of strategies

deployed to perform complex tasks (in our experiment) linked to the serious game.

The theory of action approach begins with a conception of human beings as designers of action. To see human behavior under the aspect of action is to see it as constituted by the meanings and intentions of agents. Agents design action to achieve intended consequences, and monitor themselves to learn in their actions are effective. They make sense of their environment by constructing meanings to which they attend, and these constructions in turn guide action. In monitoring the effectiveness of action, they also monitor the suitability of their construction of the environment. (Argyris *et al*, 1985, pp. 80–81)

Argyris *et al* distinguish two kinds of theories of action: 'Espoused theories are those that an individual claims to follow. Theories-in-use are those that can be inferred from action' (Argyris *et al*, 1985, pp. 81–82). In other words theories-in-use, that is, what a person actually does (and not what he says he intends to do), allow the creation and ensure the longevity of a learning system that itself contributes to cultivating theories-in-use (good or bad ones). The link between learning system and theories-in-use has an impact on the process of searching for solutions and therefore on the construction of knowledge. Argyris & Schön (1995) present two ways of learning: single and double-loop learning. In the first case, action strategies are modified but not the values of theories for action (espoused theories). On the other hand, in the second case these values, and the strategies themselves, evolve with use. Simply put, this leads to a reduction in defensive behaviours and anomalies that allows a shift to double-loop learning, which is characterized, in particular, by the disappearance of defensive routines:

Double-loop learning occurs when error is detected and corrected in ways that involve the modification of an organization's underlying norms, policies and objectives. (Argyris & Schön, 1978, pp. 2–3)

Students on a team are in an organizational learning situation when they are faced with a problem in the course of the game and start to look for solutions on behalf of their team. The content of information produced through learning (deployed thanks to the solution searching process) should, according to the authors, contain proof of a change in facts, customs and practices. Double-loop learning can determine what type of behaviour is appropriate and the correct action to achieve an expected result.

The following section concerns the details of the method used to collect and analyse the data in order to test this hypothesis and perform our demonstration.

Method for collecting and analysing data

An action research (Gummesson, 2000) has been conducted with students enrolled in a French university (Lyon 1). It has consisted in a research part to acquire knowledge of serious games and an action part to set up a conversion process (in this case the development of knowledge management and organizational learning among students).

Research model

Using elements in the literature, we have designed a model to study in greater depth the link between serious games, knowledge management and organizational learning. To study this link, we start by analysing the connexion between interactivity made possible by the serious game and perceived effectiveness of the learning process among students. We attempt to show that several variables interact and promote this link.

As stated earlier, we hypothesize that *playing serious games can serve as a lever for knowledge management and double-loop learning*. Based on this model, this paper goes on to provide various secondary hypotheses (SH) adapted to the case of our experiment. We have sorted these hypotheses into three broad categories discussed later in the article.

Interaction between individuals and teacher involvement

SH1: *Proposed student interaction during the serious game positively affects attitude towards pedagogical tools.*

SH2: *Proposed student-teacher interaction during the serious game positively affects attitude towards pedagogical tools.*

SH3: *Proposed student-teacher interaction during the serious game positively affects perceived involvement of the teachers concerned.*

Perceived efficacy and interest of serious games and attitudes toward the serious game

SH4: *A good attitude regarding pedagogical tools positively affects student interest during the serious game.*

SH5: *Student interest during the serious game positively affects perceived efficacy of the learning process.*

SH6: *Perceived teacher involvement positively affects perceived efficacy of the learning process.*

SH7: *Relevance of pedagogical tools positively affects perceived efficacy of the learning process.*

Student satisfaction with the serious game

SH8: *A good attitude regarding pedagogical tools positively affects student satisfaction.*

SH9: *Perceived efficacy of the learning process positively affects student satisfaction.*

Interaction with the teacher, interaction among students and student interest in the game are considered formative variables and are measured with the scales proposed by Paswan & Young (2002). Other scales are used in the course of our study to measure other formative variables, such as teacher involvement (Paswan & Young, 2002), attitude regarding pedagogical tools (Cheng & Wang, 2011), perceived efficacy of the learning process, relevance of tools and satisfaction (Chou & Liu, 2005).

Sub-hypotheses 1–9 presented above are the object of a quantitative analysis conducted by administering a questionnaire.

Online questionnaire and observation

During the serious game organized for students enrolled in a Business and Administration department at Lyon 1 University in June 2013, an online survey was conducted via the school's digital platform. This is a tool commonly used by the students. Access was secure and it was possible to monitor the level of participation and send reminders to students. After the game the students were asked to answer a two-part enquiry: 49 questions designed to understand perceptions of the game and the way this pedagogical tool can influence learning; two general questions were used to identify student gender and type of baccalaureate degree. Each question is ranked on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Structural equation analysis was used to assess this model since we wanted to test complex causal structures with several latent variables. Structural equation analysis is a family of statistical methods used for estimating models of linear relationships among variables. [It is] *'used to specify the phenomenon under study in terms of tentative cause and effect variables and various causal effects. Each equation in the model represents a causal link rather than a mere empirical association, and the structural parameters do not, in general, coincide with coefficients of regressions among observed variables'* (Jöreskog & Sörbom, 1982, p. 404).

We use the PLS method (partial least squares), based on analysis of the variance, which can be used to model data through a series of multiple regressions (thus translating the existence and strength of links between variables). This choice is justified by the exploratory nature of the study, the small sample size and the fact that our model is a partial one (Tenenhaus *et al*, 2005). Indeed, it only concerns part of a global model, within which other explanatory variables can be considered. Completing the questionnaire was not considered mandatory but the students were reminded by the teachers who organized the game in order to get as many answers as possible. Only 119 students took part for a response rate of 63%. Twenty-nine questionnaires could not be used (because they were incomplete), reducing the final response rate to 51%. This rate is relatively high for self-administered online surveys. According to Chin (1998), an empirical rule requires that the number of observations must be 10 times greater than the number of structural links and 10

times greater than the number of indicators for the most complex formative variable, which is the case in this study.

To test the 10th sub-hypothesis, that is, whether serious games promote double-loop learning, we conducted participant observation from an internal viewpoint (Jorgensen, 1989). We took advantage of our position as a research professor to take on the role of teacher in management science, while maintaining a certain distance in order to ensure the validity of our results. These observations were conducted while leading a serious game with the students, a game that took place over 5 days. We took notes and filled in a log book. However these observations were not systematic. We took notes when it was possible in the course of the game. As in Garfinkel (1967), the aim was to render ordinary situations experienced by the students more visible. These situations have all the features of accountability (reportable, describable, observable, and summarizable for practical purposes). The notes taken in the log book were simply read and analysed to check for the principal of Learning by Doing and double-loop learning.

The game played by students enrolled in a business degree at Lyon 1 university

The objective of the serious game consists in opening a restaurant in a mid-sized French city. It is similar to a role play to the extent each student must play a specific character (manager, chef, banker, waiter, etc.). The students play in teams of 5. In this case 190 students formed 38 teams. Several teachers lead the game. However, standardized course materials and good teacher coordination during the game ensured the different groups were treated in a homogeneous manner. The game consisted in six stages that took place over 5 days:

- Presentation of market research by the groups to a pair of teachers and this provided the opportunity for an initial assessment of the students' work and advice on how to succeed in the next stages of the game.
- Presentation of a brief business plan to the team of teachers, who played potential financial backers.
- Presentation of communication campaigns. Each restaurant presented its menu, its website, a model flyer that will be handed out and detailed plans of an event that will be organized for the launch.
- Presentation of the first results after 6 months of activity.
- Presentation of actions implemented to cope with difficulties and solve problems.
- Presentation of the results and level of performance after one year in business.

After these six stages, the teams filled out a questionnaire at the end of the game.

Results of the study: presentation and analysis

The results of the study reveal several salient facts which we develop in more detail here.

Interaction between individuals and teacher involvement: a community of practice and organization learning

We observed that role plays encouraged students to interact (organization of discussion periods, exchange of emails, etc.) in learning situations (95% of students agree or strongly agree with the fact that the game facilitated interactions between students), while this is rarely the case when more traditional technologies are used such as lectures or even case studies (Prince, 2004). Pedagogical games are therefore a good way to encourage exchanges between students. They influenced both the effectiveness and the design of the game (rules, pace, sequences, script, etc.). Students learned by socialization trying to solve problems (Hung, 2002). This situated learning (Lave & Wenger, 1991) relied on sharing ideas and knowledge that allowed the students to learn collectively and succeed in creating their restaurant (coordinated activities) thanks to a self-organization process. Communities of practitioners (Lave & Wenger, 1991) developed through groups of students with shared theoretical knowledge linked to the game, as well as the objective of creating an economically sustainable restaurant by learning together and developing knowledge. In these communities of practice, the acquisition of knowledge was a social process, not highly formalized (note taking and discussions), but they nevertheless allowed students to pool and share 'good ideas and good solutions' that emerged in the groups of students. Each of them learnt by the group. They also encouraged learning and the dissemination of knowledge inside groups and from one group to another.

The inquiry also allowed us to measure perceived teacher involvement during the serious game (Paswan & Young, 2002). While pedagogical games tend to encourage interactivity between students and teachers, they also require strong involvement of the latter: 76% of the participants agreed or strongly agreed that teachers (among them the authors) were open to discussion and to unusual ideas during the game. In line with the work of Argyris & Schön (1995), presented earlier in this paper, the results tend to show that serious games stimulate the emergence of new situations and therefore thinking linked to change. In this environment, the students make progress and positively influence interactions between students as well as with the teams of research professors.

In turn, student and student-teacher interactions encourage a more active learning, which improves learning (Blasco-Arcas *et al*, 2013). Active learning encompasses practices that involve the student in the learning process. It has been shown that students learn more when they actively take part in the learning process than when they passively attend a class (Prince, 2004). Collaborative learning develops when students work together in small groups to reach a common goal. Knowledge, experience and authority are shared, creating positive interdependent relations between students that encourage critical thinking, participation, explaining and justifying different points of view. In this context, students take part in creating

knowledge. The consequences are greater involvement and satisfaction. Active learning with serious games also increases the likelihood of all the students learning the course and diminishes the chances of only a minority understanding it (Soller, 2001).

Perceived efficacy and interest of serious games and attitudes towards the serious game: internalization through learning by doing and better understanding of the environment's complexity

We have sought to understand the perceived efficacy of the learning process and student interest during the game (Paswan & Young, 2002). We observe that the vast majority of students found the learning process meaningful (84%) and recognized they were more interested by this type of approach (72%). Two thirds stated they were able to synthesize what they had learned during the game and believe they can apply these concepts in a professional setting, thus pointing to the efficacy of Learning by Doing. We also observe that 9 out of 10 students recognized being very attentive during the game.

Regarding attitude to the game (Cheng & Wang, 2011), most students admit that taking part in the game was easy (81%) and the experience turned out to be interesting (68%). Nine in 10 hoped to learn more through participative methods, yet only 55% wanted to use this type of game again. More than three quarters of the students feel they combined theory and practice in the course of the game thanks to the application of concepts learned in project management and marketing. Once again, the results tend to show the efficacy of Learning by Doing.

Relevance of the serious game: towards double-loop learning

Regarding the relevance of serious games (Huang *et al*, 2010), the inquiry shows that two thirds of students make the connection between the concepts put into practice and those already studied in class.

Argyris & Schön (1995) distinguish three types of organizational learning, depending on the role of searching for solutions. In an initial case, the latter leads to an improvement in accomplishing organizational tasks. In a second case, it helps the organization search for and redefine values and criteria that it uses to improve performance. Finally, it allows the organization to improve the completion of organizational tasks as well as to search for and redefine values and criteria for improved performance. The qualitative results from our observations show that the students fall into the third category. Practices change and evolve as the game unfolds. At the start of the game, the students divide the work and analyse problems according to the discipline concerned (procurement, marketing, etc.) and in a very linear way. Starting from the second day, approaches change: questions are considered from an increasingly multidisciplinary perspective and the students tend to apprehend variables from a more systemic standpoint. They try to find the information they require in their university courses, but also outside them (personal

experience, academic and professional literature, discussions with other students or professionals, etc.) We can see that the search for solutions offers a better understanding of the theoretical concepts underlying the creation of a firm (organizational tasks related essentially to accounting, management control, marketing and procurement) thanks to simulation through role plays. Their investigations also allow them to define performance criteria for a new firm in a more systemic way, in this case based on transmission of information and consultation between decision-makers, but also planning, scheduling tasks, monitoring activities and performance in order to apprehend the complex situations and relationships between the different variables involved in creating a restaurant. Double-loop learning therefore emerges in the course of the game, more or less quickly depending on the teams (1 to 2 days). Yet all students are concerned as our observations show they are not satisfied with simply correcting their errors but gradually change their way of thinking and defining the creation of a restaurant. Thus they show signs of real Learning by Doing: they learn to learn from their errors and successes. Thanks to the experience of the serious game, the students tend to develop double-loop learning.

Student satisfaction with the serious game

Regarding student satisfaction (Chou & Liu, 2005), two results are worth noting. First, the game is considered globally satisfying (by 74% of respondents) and the proposed means of learning are appreciated by 9 in 10 students. Furthermore, the teaching methods are attractive (69%), but fewer respondents positively assess the game in terms of providing knowledge and skills (51%). This perception does not fit with the results presented above. The students do not seem aware of the methods and tools they tested and integrated: organizational learning, a community of practice, knowledge management via internalization and Learning by Doing.

This can be explained by the construction of an organization with a visible and a hidden part, like an iceberg (Savall & Zardet, 2009). The superstructure encompasses visible phenomena of the external and internal environments (the emerged part of the iceberg). These are the visible and relatively stable components of the organization such as individual satisfaction. The infrastructure includes systems that organize and jointly determine, in particular, the quality and efficiency of the organization (hidden part of the iceberg). These systems are not clearly perceived by the students, yet they are the source of the visible phenomena in the superstructure.

Contributions of this study

Quantitative studies in management science often use structural equations models to analyse complex causal relations. Indeed, they can be used to aggregate several latent variables which are supposed to represent a phenomenon that cannot be observed but is important in understanding the system under consideration. We use

the PLS method (partial least squares), based on analysis of the variances, to estimate a structural relations model. The usual method for testing this type of model consists in three phases: making sure the links between the variables really exist, testing the validity of the scale and the structural model and, finally, confirming the hypotheses. The significance of the coefficients is assessed after bootstrapping, a technique that replicates the model with a large number of random samples generated with the data collected (in this case 250 samples of 137 individuals).

Correlations do exist between the latent variables in the model that we assume are linked and they are significant.

In the case of formative variables (manifest variables that contribute to shaping a construct that is by nature unobservable) it is not wise to test the internal consistency of the scales by calculating Cronbach's alpha because the indicators are not assumed to covary (Nunnally & Bernstein, 1994). We made sure upstream that the constructs studied were representative. All of them had been tested in previous research. However, an analysis of the cross-loadings matrix is required, which corresponds to the results of an exploratory PCA (principal components analysis), in order to check that the greatest factor loadings for each indicator are really linked to the corresponding latent variable. This is globally the case for our study. After the bootstrap procedure, we also make sure the indicators contribute significantly to the formative construct, that is, that the value of the *t*-test (critical ratio) for each manifest variable is greater than 2. In our study only one variable does not comply with this criterion. This is the item 'The concepts used in the game were related to things I already knew' of the latent variable or construct 'Relevance of tools'.

In the PLS method the fit indicator is GoF (Goodness of Fit). The closer the latter is to 1, the more the model is confirmed by the data. Furthermore, we need to ensure that the values are not too different before bootstrapping, in order to confirm the model's stability. In our study GoF is 0.448 and thus very close to its bootstrap estimation. Relative GoF and GoF based on the internal and external models are very high and tend to indicate good fit between the model and the data.

Once the measurement model is studied, the structural model needs to be analysed in order to confirm the research hypotheses. This depends on the importance and significance of the structural relations obtained. The coefficients of determination (R^2) reflect the explained variance of the latent variables and therefore indicate the predictive character of the model. The values of the structural coefficients correspond to the different influences of the explanatory (or exogenous) variables on the latent (or endogenous) variable. Once again, for these influences to be significant, the value of the critical ratio must be greater than 2, which is the case in our study. These different elements show the reliability and validity of the variables used in this study.

The different structural relations in our model are represented in Figure 1. We can make several remarks about this model. First, it seems highly relevant for measuring

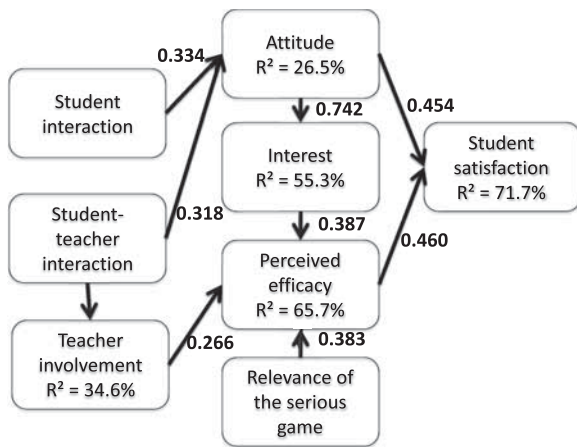


Figure 1 Structural model.

perceived efficacy of the learning process ($R^2 = 65.7\%$) and student satisfaction (71.7%). These two constructs are essential for our study and measuring them allows us to confirm many hypotheses.

There is a positive link between interactions proposed during the game, students attitudes regarding new pedagogical tools, interest in the game and, in the end, perceived efficacy of the learning process. These links are not direct and other variables interfere in the process. The level of interactivity offered by the game, with the teachers as well as other students, is obviously appreciated and explains a significant share (26.5%) of the students' favourable attitude to the serious game. The moderate value of R^2 means that other unobserved factors help explain the construct's variance. Similarly, perceived teacher involvement, student interest and relevance of the tools used during the game explain a significant share of perceived efficacy of the learning process.

Conclusion

We hypothesized that serious games could help students become knowledge workers because they can function as a lever for knowledge management and double-loop learning. To test this we conducted action research with students during which we collected, processed and analysed quantitative and qualitative data. The results confirm the relevance of our model and help confirm our research hypotheses.

However, quantitative inquiries have some limitations. Respondents are increasingly solicited and response rates to self-administered questionnaires tend to decline (Dillman, 1999). A certain fatigue with this type of inquiry, associated with apprehension about revealing certain information, can

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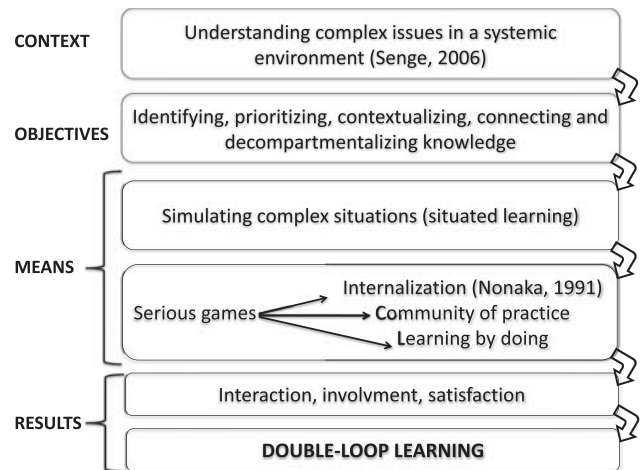


Figure 2 Serious games and double-loop learning.

explain this high refusal rate. Questionnaires are often complex in order to collect large amounts of data and therefore more tiresome to complete (time, effort to remember, etc.). Despite the time set aside for students to respond, the participation rate remains moderate. Moreover, the large number of questions and the standardized answer format (5-point Likert scale) could bore respondents and affect their answers. Finally, some of the constructs studied, such as attitude regarding new pedagogical tools and efficacy of the learning process, are highly complex. While the scales used to understand them had been tested in the literature, these variables remain difficult to measure with quantitative inquiries. There are also limitations to our observations in the field (Starbuck & Milliken, 1988). Our attention could have been focused exclusively on facts contributing to double-loop learning, creation of a community of practice, while overlooking data that could have diminished the impact of our results. Possible interpretation bias could have led us to interpret certain situations as chains of cause and effect whereas they could have been appreciated differently.

Despite these limitations, we show that student and student-teacher interactions, as well as teacher involvement, lead to the construction of a community of practice and subculture and encourage organizational learning. Then we highlight the beginning of internalization through Learning by Doing. This is due to the interest aroused by the serious game, the perceived effects of play and attitudes towards the serious game. In the end, the students are satisfied with the serious game they took part in. Finally, the qualitative results of our observations in the field show the relevance of serious games as they promote double-loop learning (Figure 2).

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