Early Years and Technology: The design and evaluation of technologies to support young children's learning

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STELLAR 2nd Alpine Rendez-Vous 2011
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Early Years and Technology: The design and evaluation of technologies to support young children's learning

White paper

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March 2011


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Early Years and Technology:

The design and evaluation of technologies to support young children's learning

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1. Introduction and Motivation

1.1. Workshop Introduction

This workshop was proposed by Andrew Manches, (London Knowledge Lab) and organised with Janet C Read (University of Central Lancashire) and Ros Sutherland (University of Bristol). The workshop was funded by STELLAR. Invitations to the workshop were open and communicated through a range of national and international mailing lists. Applications for the workshop were made through 400 word abstracts, which were reviewed for quality and relevance to the workshop aims. 13 abstracts were accepted, although two individuals were unable to attend. In total there were 15 participants, with 11 presenting work. The workshop took place over the first 2 days of the STELLAR Alpine Rendez-Vous 2011.

1.2. Aim of this document

This white paper summarises the conclusions of the workshop. In this first section, the motivation and background is described. The second section then gives a short summary of the presentations and the emerging themes from discussions. Section three lists some of the key questions raised by participants, which were used to structure discussions of the Grand Challenges. The Grand Challenges were an important focus of the workshop, where the aim was to identify key research questions emerging from discussions that could inform future work. These Grand Challenges are presented in section five, and section six proposes the researchers and communities who might be involved in addressing these challenges.

1.3. Motivation

Whilst technologies such as pen and paper have a long history in supporting young children's learning, digital technology is comparatively novel, and the role it plays relatively less well understood. Designing technology to support younger children is arguably an emotive area. We are more protective of younger children and whilst we could reason that older children need to accustom themselves with technology for employment, the same rationale is not as convincing for younger children. In other words, if digital technology does not support the younger child's development, why should we present children with such devices?

The design of materials to support young children's learning has a long history, although the aim of supporting children's developing concepts might be traced to pioneers such as Froebel who generated his kindergarten 'gifts' for ideas such as number (Froebel, 1909). Digital technologies, however, offer a qualitative leap in what materials can be developed; children may continue to

love storybooks but now it is possible for these to sound out words, bring images to life, and be designed to respond to children's interactions. This information is not constrained to the physical artefact but can be sent, shared and recorded remotely. What is not clear is how these affordances of digital technology affect young children's development.

Whilst the possibilities offered by digital technology for supporting young children is exciting, it is important to be cautious. Various concerns have been raised, for example: does providing more independent interactivity impact children's typical social interactions? Does including certain digital effects affect children's propensity to imagine what other 'effects' could be possible? Does emulating physical activities in a virtual world discourage physical activity?

It is possible to continue speculating on the possible negative outcomes of digital technologies but these concerns often lack any empirical support. The key point is that we need to carefully consider how novel technologies reshape children's learning experiences – both in terms of the opportunities they bring and in terms of the possible limitations. This need motivated this workshop on evaluating the role of Digital Technologies for Children in the Early Years.

1.4. Workshop aims

In addressing the issues summarised above, the arching aim of the workshop was to explore through debate the role of digital technologies for children in the early years. The more specific goals were:

1. Share good practice of research innovations and case studies

2. Engage in debate and discussion of critical issues surrounding technologies for the early years both currently and in the future

3. Develop a framework for evaluating early learning technologies through discussion and group activities with commercial products

The first workshop aim – to share good practice in this field – was addressed by engaging with the high quality work being carried out by the workshop participants. In total, eleven presentations were given as well as other opportunities to discuss work. The backgrounds of the workshop's participants varied substantially. As a result, it was possible to share the different approaches, as well as terminologies used, of researching this area.

Participants demonstrated a willingness from the start to engage in debate, which often raised emotive issues, around the role (if any) technology should play in supporting young children. These debates were structured in sessions around specific themes such as the importance of context or the needs of young children. As such, the second workshop aim was achieved.

Debates also reflected differences in how we might 'value' different aspects of children's development - a critical issue when discussing how we might 'evaluate' the role technology has to play. It was clear through discussions that such evaluation had to take account of the specific context in which young children interact with different technologies as well as how any particular digital properties may shape these interactions.

The final sessions of the workshop aimed to draw participants' ideas together and identify key themes in this area. Developing this window on the role of technology in young children's lives addressed the third workshop aim, although it was agreed that the goal of creating an evaluative framework was too ambitious. Indeed, the challenge of addressing the third workshop aim informed the Workshop Grand Challenge. In order to develop a framework for evaluating learning technologies for this age group it is necessary to establish a more coherent and comprehensive understanding of how materials shape children's development, and the implications for digital designs.

2. Workshop description

13 abstracts were accepted for the workshop. As two invitees were not able to attend, a total of 11 presentations were given.

2.1. Participants

The names of participants / organisers is presented in Table 1 along with the titles of abstracts.

Table1: List of Participants

Name	Organisation	Country	Role	Abstract title
Andrew Manches	U of Nottingham	UK	Organiser / Participant	The effect of Novel forms of Interaction on Learning in the Early Years
Arjette Karemaker	U of Oxford	UK	Co-organiser / Participant	Assessing the effectiveness of a whole-word multimedia reading intervention designed to support development of early literacy skills
Audrey Mazur Palandre	U of Lyon	France	Participant	___
Christine Michel	U of Lyon	France	Participant	___
Christine Wang	U of Buffalo	USA	Participant	Exploring Young children's Epistemic Reasoning in Computer-Supported Collaborative Science Inquiry
Evi Mansor	U of Manchester	UK	Participant	Preschool Children's Fantasy Play in an Interactive Tabletop Environment
Inge Molenaar	U of Amsterdam	Netherlands	Participant	Developing Metacognitive Skills of Young Children with Interactive Agents
Janet Read	U of Central Lancashire	UK	Co-organiser / Participant	___
Javier Marco	U of Zaragoza	Spain	Participant	Using digital manipulatives in preschool education
Kaska Porayska-Pomsta	Institute of Education	UK	Participant	Echoes: Enhancing child-computer interaction with AI
Kristine Lund	U of Lyon	France	Participant	CogniK: adapting technology to children's learning profiles
Ros Sutherland	U of Bristol	UK	Co-organiser	___
Ruth Dower	Issacs, UK	UK	Participant	Dream Catcher - using digital technology to connect children's learning
Sarah Eagle	U of Bristol	UK	Participant	Children, adults and designed artefacts: what insights can older traditions and existing artefacts offer to designers of new technologies for young children?
Tilde Bekker	U of Eindhoven	Netherlands	Participant	Practicing social skills with open-ended play objects
Diana Yifan Xu	University of Central Lancashire	UK	Not able to attend	Children's Physical Play and Early Year Learning
Michael Evans	Virginia tech	USA	Not able to attend	Supporting PreK Learners Co-Construction in Informal Geometric Reasoning: An Evidence-Based Design Approach to Virtual Manipulatives

2.2 Summary of Presentations

The 11 presentations were grouped into three broad areas:

- *Physical and virtual materials*
- *Social interaction*
- *Meta-cognition*

These headings are used below to summarise the research areas presented in the workshop.

2.2.1 Physical and Virtual Materials

Technology offers new ways to present and manipulate information. Materials can be designed with particular audio or visual effects to help children build ideas, for example in Maths and English at School. The main form of interaction has been through the mouse and keyboard, however, there has been a growth in more direct interfaces: including interactive tablets or tables and more advanced designs integrating technology inside of physical objects. In order to understand the benefits of these new materials research has attempted to compare interaction with traditional materials to identify benefits and limitations.

Arjette presented work looking at the effect of technology on reading development by comparing commercially available software with traditional books balanced for content. The carefully designed comparison studies not only demonstrated a benefit of the software but helped identify possible causal factors: such as the highlighting of words which they were being sounded out, and the potential for children to independently select words to hear that they could not read.

Andrew presented work looking at the possible benefits of physical interaction in learning. This research is important in understanding the cognitive effects of moving interaction to devices such as the mouse, and helps evaluate the potential of novel technologies such as tangibles where physical objects are augmented by technology. Andrew presented work highlighted the range of actions and strategies generated when young children manipulated objects in a maths tasks and how these were constrained when using virtual materials using a mouse.

Javier also examined the potential of augmented physical objects with technology through studies using sets of physical toys linked to digital information on a tabletop computer. As well as showing the appeal of the materials, the research showed the potential for these designs to reinforce explorative and collaborative behaviours through sharing, turn taking and role-playing.

Evi examined the effect of using virtual technologies on young children's fantasy play – a key part of their development. Three evaluation studies were conducted on a multi-touch table and after addressing certain design issues demonstrated the potential to create virtual environments to support fantasy play.

2.2.2. Social interaction

Traditional materials (such as balls or books) have played a key role in mediating collaborative activities between children or between children and adults. Digital technologies can shape these interactions. Digital effects can respond to children's actions that can open up new forms of discourse, although there are concerns about how the interactive nature of technology might impact children's interaction with others.

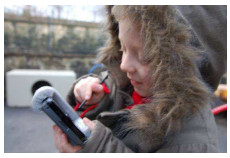
Sarah looked at how digital toys shape interactions between children and their families. In her presentation, Sarah focused on interactive devices such as story books and demonstrated how the designers choice of activities can shape communication – often focusing on the 'right way' to solve the problems presented rather than build on children's more imaginative and personal discourse. This research provides a valuable lens with which to consider how technology might be designed to foster this important aspect of interaction.

Tilde presented research looking at how augmented objects may foster novel types of social interaction between children. Tilde discussed two designs: ColoFlare and Moveable Sound using lights and sounds respectively to engage children. The designs are simple, providing space for children to discuss and negotiate their own games and activities around these materials.

Kasksa presented work from a project: Echoes, which examines the increasing potential for technology to play a role as an equal social partner for children. The project builds upon recent developments in how technology can sense information (e.g. gestures / expressions) and respond (using Artificial Intelligence). For children with social difficulties (e.g. children with autism), these forms of technology may help provide a safe and secure way to empower children by developing social skills.

2.2.3. Meta-Cognition

Becoming more aware of our own experiences and learning is a key aspect of cognitive development, although this is traditionally considered challenging for younger children. Digital technology presents new opportunities for children by providing simple ways them to record and revisit their experiences using different media and to feedback information about their own learning.



Ruth presented work from a prototype research project DreamCatcher where children used technologies to record things important to them to share with home and school. Although the aim was to see how the technology could foster links between home and early school settings, it was interesting to hear how children were given the opportunity through the technology to record and then voice their personal experiences.

Inge presented work from her PhD where she developed a dynamic scaffolding system to support students (8-12 yrs) self-regulation while they learn in computer based learning environments using Avatars. It was demonstrated that technology can support meta-cognitive skills – where interaction between students amplified the effect of digital scaffolds and when the scaffolds were presented in the form of questions. Inge raised questions in the workshop about the potential for this form of technology to support younger learners.

Kris presented work from three projects she is involved with through her doctoral students. Two of her students are working on a commercial project: Cognik, that Kris co-founded, that provides education gaming activities for children adapted around their cognitive competencies. One area of research is looking at the impact of different forms of interaction (mouse versus touch) whilst another examined the content of the games according to cognitive profiles. This ambitious project highlighted the potential, and some of the challenges, of designing effective learning environments that monitor and adapt to children's cognitive abilities.

2.3. Workshop themes

2.3.1. Introduction

Understanding the role of technology in learning is complex, and perhaps more so for young children where there is less emphasis on more formal educational objectives and more on developing certain emotional, social as well as cognitive skills. Young children are quickly changing how they interpret the world around them. They also face a major transition in learning environment – from home to school – where the learning they bring has large effects on their later achievements. It is therefore important to understand how technology shapes young children's experiences and development – whether digitally augmenting materials has a positive effect.

In this regard, one approach to understanding the role of digital technologies is to look at the new 'affordances' and discuss what benefits these bring. The difficulty with this approach is the benefits or 'effectiveness' of these different properties will ultimately depend upon a range of factors. These factors are complex, involving an intricate mix of social, cultural factors as well as child's own cognitive and emotional characteristics. Although this is the case in evaluating any form of technology with different age learners, this may be particularly pertinent to younger children where such factors are constantly reshaping as the child and their context change at a significant pace. Young children's choice of device and activities is also much more determined by the practices of others, be they parents, grandparents, carers or teachers.

Another approach therefore is to try and understand the factors that mediate the role of technologies and use this understanding to predict how different digital designs may shape

children's interactions and the ideas that may subsequently develop. This approach gained support in the workshop, where a key aim was to explore the factors influencing the effect of technology and to develop a lens with which to discuss, and ultimately evaluate, the design of technologies in this area.

During discussions, certain themes were recurrent. This section attempts to describe these under several headings. These themes are not considered comprehensive but rather those considered more salient in the workshop. The particular affordances of digital technology are not discussed as a separate theme but rather are integral to each theme. In other words, each theme is intended to act as a window with which to consider how particular digital properties may shape children's interactions and ultimately the ideas they develop.

2.3.2.Themes

Continuously redeveloping tools

Technology will be used and interpreted in often-unpredictable ways depending on the cultural context in which they are used. Consequently, good design practice should attempt to follow this process and evolve the designs if the intention is to foster certain (learning) interactions. This may be more easily achieved when the technology is software, where interactions can often be tracked and updated relatively easily. In contrast, physical technologies may require a greater level of investment in studying use and developing novel designs from this information. The ability to create and update / change online materials may also reflect the proliferation of simpler resources with less investment in development. This possibility may generalize to the growth of applications on novel devices e.g. Ipad.

Implications for Early Years

This issue may be particularly relevant to children in the Early Years where physical designs are more prevalent. It may also be more challenging to obtain 'user' information given the developing communication skills of younger children. Furthermore, there is arguably a greater responsibility felt in the Early Years of considering what is 'good' for children: to limit access to frivolous games designed with minimal consideration of children's needs.

Structure of activity

Activities can range between those that are more structured or intentional, and those that are more exploratory, unstructured and unintended. Although the latter is often presented as providing more creative opportunities, this may not always be the case: structure may help children consider new ideas. It is important, however, to consider how technology may shape the type of activity. Certain virtual environments need to constrain the range of interactions in order to provide children with feedback, although developments mean more open exploration may be

possible. Novel forms of Interaction (e.g. tangibles, commercial systems such as the 'wii') are also providing ways for children to interact in less structured ways with technology – adapting and interpreting digital effects in different ways. By opening up ways to interact with technology, these devices are not only more accessible but may help 'hide' the technology and help children focus on activity.

Implications for Early Years

This issue may be particularly relevant to children in the Early Years where an emphasis is on fostering exploration and creativity. Developments in technology may offer more possibilities in terms of the structure of the activity by being more adaptive to children's interactions. The development of novel forms of interaction may be particularly important by making designs more accessible and easier for children to adapt to different contexts and activities.

Interaction with others

Technology can engage children independently by providing feedback to their actions. Alternatively, the technology can act as a tool to foster interaction with others, for example by using sounds to support joint attention, or allow communication over distance. When technology is designed as a social partner for children, it possible to control certain aspects such as who initiates interaction, how predictable responses are, or the emotional level of response. Although the complexity of human interaction has yet to be achieved, it may be possible to use these features in a way that makes the computer more than a poor human replacement.

Implications for Early Years

This issue may be particularly relevant to children in the Early Years because there is great emphasis on developing children's social skills and concerns that independent activity with technology cannot provide the form of interaction needed. Younger children need to develop particular skills, such as attention and listening, and it is interesting to consider how technology may be able to target these early competencies.

Motivation

Digital Technology can be designed to capture children's attention. Whilst engagement may be short lived for some novel designs, the effect of technologies such as gaming demonstrates the potential to sustain motivation. The aim of tapping into gaming as a way to engage learners is being addressed although generally for older children.

Implications for Early Years

For younger learners there is arguably a greater feeling of responsibility over children's choice of activities, and questions about whether we should necessarily try to motivate more prolonged use of particular technologies. Young learners also differ in how technologies are provided for them rather than actively choose their own materials and how they may be more curious to try what is

presented. Younger children may also differ in what digital effects capture attention, such as the use of colour or audio.

Meta-learning

Technology has changed the way information is authored, presented and shared. There are increasingly more opportunities for children to author information and create their own digital artefacts. This may offer new opportunities to change how children perceive information and develop their understanding of knowledge generation.

By providing ways to mediate and record interactions digital technologies may provide novel opportunities for children to plan and reflect on their own learning. Technology may also provide a way for children to become aware of their own emotions in a safe and more predictable environment.

Implications for Early Years

Aspects of meta-cognition have been considered a great challenge for young children. However, authoring of information is arguably becoming more accessible for this younger group, and media such as images or audio recording may help children recollect and communicate their own learning and feelings. By providing a way for children to generate and share information, digital technologies also raise the possibility of empowering younger children in terms of their understanding of how information is shared more widely and knowledge is generated.

2.3.3. Summary

In this report, we have identified five themes that were recurrent in discussion about the role of technology to support learning in the Early Years: Continuously redeveloping tools, Structured Activity, Interaction with others, Motivation and Meta learning. These themes are not necessarily areas where technology offers the most potential but rather represent important areas to consider when trying to understand the role of technology in young children's lives. The themes highlight the importance of considering the particular needs of younger children.

That said, these themes often do indicate areas where new technologies present exciting opportunities to support young children. However, it is necessary to examine these possibilities and avoid unwarranted claims. The effect of technologies will depend upon a complex range of factors, from the context in which they are used to the particular design. In this regard, the themes identified in the workshop emerged as important points to consider when evaluating the role of technology in young children's learning.

3.Emerging (Research) Questions

In the final sessions of the workshop, participants were asked to raise certain questions surrounding the role of technology for children in the Early Years. These questions then formed the basis with which to identify more overarching questions for the Grand Challenges – presented in the final section. Rather than filter these question, they are listed below, removing cases of repetition.

- How do children interpret the culture of technology?
- How can technology enhance parent / child interaction?
- What are the appropriate research questions in this area?
- Do young child want to develop their own games?
- How does theory underpinning research influence what you see in 'empirical studies'?
- How do we decide and define the key cognitive skills for this age group?
- Can novel forms of interaction provide resources that allow more open-ended exploration for young children?
- How do certain digital effects shape interactions between children?
- How do different design features motivate children's interest and also that of adults who buy these technologies?
- How long do these motivational effects last?
- How can new forms of recording (cameras etc) change children's understanding of knowledge generation?
- How do we define the age groups for Early Years? Do we include children under three?
- Does neuroscience have any important messages to inform the design of technologies in the Early Years?
- How do we avoid imposing the 'right' way to do things when designing technologies or interacting with children around technologies?
- Can we differentiate between effects with and effects of when evaluating technologies for learning?
- How open should activities with technologies be?
- Is it possible for technology to replace a human teacher or guide?
- How can we take account of parent / carers' expertise when designing technology for children?
- What role does technology play in fostering self-regulatory behaviour?
- Can we successfully measure learning in this age group?
- Are there too many variables to consider when trying to understand the effect of a particular technology?

- What is the 'goal' of children's interactions?
- How do digital technologies play into ecology of learning?
- Should we design for surprise in these technologies?
- Where is the pedagogic heart of the 'technological design' discussion - how can we build on the child development thinking that is so embedded already into early learning environments?
- Would a child from one national community have the same experience with a technology as a child from another?
- Can technology open up opportunities for role-play?
- Can technology give children opportunities to explore and respect other cultures?

4. Grand Challenge Problems

Supported by the workshop provocateur, Ros Sutherland, several grand challenges were identified during the two-day workshop. The workshop identified four grand challenges in total, although the first can be considered the main, over-arching challenge. The subsequent three reflect areas of focus within this main challenge.

4.1. Grand Challenge 1

Develop an agreed set of principles for designing and evaluating digital technologies for the early years that are informed by our understanding of early child development.

The proliferation of digital technologies in homes and early school settings emphasizes the need to understand their impact on young children's development. This understanding needs to inform guidelines on evaluating and designing novel technologies. These guidelines are needed by a range of stakeholders: by parents to inform purchase decisions and value their role in children's interactions with these technologies; by teachers to evaluate designs for learning and know how best to integrate devices into class; by policy makers to inform wider decisions; by designers to inform product development, and by researchers to help illuminate the most pressing questions in this field.

What is missing from current guidelines is a more thorough understanding of how certain digital designs shape children's social and physical interactions. Understanding how novel technologies affect young children's lives requires greater consideration of the role played by traditional technologies such as blocks or books in a range of interactions, in different settings, with a range of actors - from peers and teachers to parents and grandparents. Whilst existing work (e.g. NEAEYC[1] 2011 draft position statement) addresses this area, reference is often made to 'developmentally appropriate' use of technology without clarification of what this entails.

Addressing this grand challenge therefore requires the generation of specific guidelines adapted to different user groups. These guidelines should be comprehensive but digestible. They should be accurate and easy to comprehend. They should be practical without making unwarranted claims.

1 National Association for the Education of Young Children
http://www.naeyc.org/positionstatements/technology

4.2. Grand Challenge 2

Design and evaluate technology that supports grandparents, parents and carers to focus on children's early literacy activities with their children. Such technology should take into account literacy and technology practices in the home environment.

Many technologies to support children's literacy focus on practising specific skills such as phonetics or word recognition, and often do not recognise the important social factors that engage children and bring meaning to reading as an activity. One challenge therefore is to examine ways to design digital technology to foster productive interaction around reading. As stated in the challenge, designing such technology requires a good understanding of literacy practices in the home. Addressing this challenge would require using this understanding to develop a prototype design that could be evaluated by examining the effect on interaction, shaped by the technology.

4.3. Grand Challenge 3

Design and evaluate dynamic digital representations that allow children to express, explore, make visible, share and reflect on ideas in novel ways in areas such as maths and physics.

New forms of digital representation provide novel ways for children to explore information and develop meaning. In domains such as Maths and Physics, this may be particularly beneficially by drawing children's attention to certain aspects of the materials. For example, focusing on numerical patterns or processes such as forces or electricity. In order to build these representations, it is necessary to not only have a solid understanding of the domain but also develop representations that draw children's attention to ideas in these domains.

For younger children, new forms of interaction provide new ways to manipulate, explore, and share digital representations. Tangibles for example allow children to manipulate physical objects augmented with digital technology. These new forms of technology have generated a lots of commercial and research interest in their potential to support young children's learning, however, more research is needed to understanding the effect of these novel materials on young children's learning. This need would be addressed by this challenge by designing and evaluating novel forms of representation to allow children to explore ideas in domains such as maths and physics.

4.4. Grand Challenge 4

Design and evaluate digital technologies that foster regulatory behaviour of emotions and meta-cognition

It was highlighted in the workshop that digital technologies have lowered the threshold in terms of how easily young children can record and reflect upon their own interactions and experiences. Devices such as cameras or sensors can help record aspects of children's interactions in ways not previously possible. This opens up novel ways for children to reflect upon their own learning and behaviour, which if designed appropriately, can be used to help develop children's regulation of their own behaviour and learning.

Developments in artificial intelligence also presents ways in which technology can be designed as an equal social partner with which children are able to explore and have feedback on their social interactions. By designing digital partners, children may have novel opportunities to explore the consequences of their behaviour in a safe and secure environment.

5. Researchers and Communities

For the first grand challenge, the initial emphasis will be on gathering the knowledge and thoughts from experts on child development, e.g. psychologists, as well as those with an understanding of how technology can shape interactions with technology. However, in order to develop guidelines, it is essential to work with different stakeholders including designers, educationists, policy makers and parents. For the other three grand challenges, there is a need to draw together teams of research in psychology and education with computer scientists. These teams need to collaborate in an iterative design process.

The grand challenges refer to a wide range of learning domains, including children's physical, social, cognitive and emotional aspects. Common to all these, however, is the focus on early child development. As discussed in the workshop themes, there is strong reason to believe that there are significant differences for this younger age group, which will affect the design and use of different technologies. It is important therefore to draw together different communities researching in this age group – including those who have not focused on technology - and to integrate the different approaches taken to examine the role of technologies. (e.g. Antle, 2007; Clements & Sarama, 2003; Druin, 2009; Eagle, Manches, O'Malley, Plowman, & Sutherland, 2008; Luckin, Connolly, Plowman, & Airey, 2003; Members, 2008; Plowman & Stephen, 2005). It will also be important to draw upon existing work on designing and evaluating technologies for and with children (e.g. Druin, 2010; Markopoulos, Read, & MacFarlane, 2008).

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