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Creative and playful learning: Learning through game co-creation and games in a playful learning environment

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ABSTRACT

This paper reports on a pilot study in which children aged 7–12 ($N = 68$) had an opportunity to study in a novel formal and informal learning setting. The learning activities were extended from the classroom to the playful learning environment (PLE), an innovative playground enriched by technological tools. Curriculum-based learning was intertwined with game co-creation, play, and computer games in the PLE. The results indicate that the children considered learning in groups, through co-creation and turning fact into fiction, to be a rewarding way to learn, practice group work and use their imagination for a common goal. Teachers felt their role was important and challenging, especially in terms of the amount of tutoring and lesson planning. The study shows that one way to foster activity, creativity, imagination, and group work skills-along with academic achievement-is to integrate fact and fiction and a playful learning environment in teaching, studying and learning.

1. Introduction

In the world of new technologies, the forms of education are changing, as are the sites on which education occurs. Some scholars argue that the school of the future should be based predominantly on innovation and interactive creativity with new technology and new ways of acting (e.g. Craft, 2005; Natriello, 2007; Sawyer, 2006a; Tuomi, 2007). This aim has been widely recognised globally in educational contexts, and it has been concluded that teaching approaches that are too formal may not match the methods that children and young people use in learning or working with media (e.g. Lemke, 2002; Sawyer, 2006a, 2006b). It also is argued that many students learn to solve specific types of problems but are unable to respond to unexpected situations, which inevitably arise in today's fast-changing world (cf. Cropley, 2004; Resnick, 2007). As Resnick (2007) and Sawyer (2006a) assert, most schools are not focusing on helping pupils develop as creative thinkers and are not teaching them how to *create* knowledge. Instead, in formal schooling, children are typically taught that knowledge is static and complete; they become experts at consuming knowledge (or media, as well) rather than producing and creating it (Sawyer, 2006a). Thus, innovative ways of using information, readiness to deal with the unexpected and flexible thought have taken on importance.

The present study contributes to the current educational debate by presenting a strategy for incorporating creativity, imagination and new technologies into education. The study offers an opportunity for children to co-create their own curriculum-based game content for play and for learning activities in a research-based and technology-enhanced playful learning environment (PLE). Many recent studies have focused on creativity in learning and concluded that classroom

Abbreviation: PLE, playful learning environment, an innovative outdoor playground enriched by technological tools, also called *Smartus*.

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discussions and participative activities can provide an ideal forum in which students may develop their creative thinking skills (Beghetto, 2007; Rojas-Drummond, Mazon, Fernandez, & Wegerif, 2006; Vass, 2007; Wegerif, 2005; Wegerif, Littleton, Dawes, Mercer, & Rowe, 2004). In keeping with this notion, and extending it, the present study explores the role of creativity and playfulness in collaborative learning using an innovative outdoor playground and its technological applications.

The playful learning environment (PLE) is a novel, pedagogically validated learning environment which combines information and communication technologies (ICTs) both in the classroom and outdoors in the playground. The PLE is also referred to as *SmartUs*, a technology-enriched playground system based in a combination of scientific research from the fields of education, physical exercise, technology and industrial design (see www.smartus.fi). The PLE forms the basis for a variety of learning experiences in local schools as well as for Internet games, which offer opportunities for learning in globally created learning environments. Children's views have been highly valued in defining the main characteristics of the environment and seeking a richer understanding of its potential in education (Hyvönen & Kangas, 2007; Hyvönen, Kangas, Kultima, & Latva, 2006; Kangas, Hyvönen, & Latva, 2007). Accordingly, the starting point for this study was to evaluate students' views and experiences of a pilot PLE and especially of the creative and playful learning processes which that setting provides for.

The PLE offers an opportunity to create one's own game content as well as ready-tailored games that aim to increase collaborative physical activity in the context of educational tasks. As a physical, educational and technologically affordable playground setting, the PLE enables children to actively take part in learning within a framework of creation, exploration, narration, imagination, collaboration and play. One of the goals of the present study has been to combine these perspectives on learning in order to create and to test *a game concept of the "Different World"* (Kultima, 2006) and to develop *a pedagogical framework of creative and playful learning* (Kangas, Kultima, & Ruokamo, 2006) that exploits the salient features of the PLE.

The present study focuses on the process of game design, knowledge co-creation and participation from the perspective of *creative and playful learning* (CPL), a theoretical and practical model that was developed as part of the research. The study embodies the first curriculum-based teaching experiment conducted in a PLE setting. The pilot learning environment was constructed in the yard of the Kauko School in northern Finland in 2006.[1] The students experienced learning content from a narrative perspective by creating a "what if" game world for the playground; they played in it and ultimately considered the differences between fact and fiction related to a topic in their syllabus. The goal of the study was to examine how students and teachers experience the PLE as a means to achieve creative and playful learning. Hence, the study recognises the importance of the educational stakeholder's views and contributions to understanding the way in which game co-creation, outdoor play, imagination and the PLE can offer settings that sustain creativity and playfulness in learning. The central question is: How does a playful learning environment foster creativity and what factors should be considered when developing pedagogies for creative and playful learning?

2. Theoretical background—creative and playful learning

According to Säljö (2005, 2006), learning may be seen as a tool-dependent and metaphorical concept and it should be specified in each theoretical framework. Creative and playful learning in the PLE setting refers to (1) learning that allows, stimulates and promotes learner creativity and knowledge co-creation, (2) learning through designing content for the PLE by using new technology, and (3) learning through a variety of playful and physical activities – hands-on and body-on – which take place in the PLE. Hence, learning is not only related to academic achievements, but also to all actions that take into account the person as a whole – body, mind and spirit – and the role of cultural tools (Säljö, 2004, 2005, 2006; Vygotsky, 1978; Wells & Claxton, 2002). The following features of learning that are based on earlier PLE-related studies (e.g. Hyvönen, 2008; Hyvönen & Juujärvi, 2005; Hyvönen & Ruokamo, 2005) are central for creative and playful learning:

- *Playfulness* refers to the learning actions and their qualities (e.g. Bodrova & Leong, 2003). It also refers to an attitude towards learning and a way of learning through play and games in the PLE settings. The literature related to playfulness shows that it is assumed to have positive effects on learning at various school levels and on learning in working life as well (e.g. Sawyer, 2006a).
- *Creativity* refers to creative knowledge building and learning creatively by using new technology and designing artefacts, games or media products (cf. Craft, 2005; Paavola, Lipponen & Hakkarainen, 2004). Creativity also refers to the use of *imagination* and *possibility thinking*; imagination is the ability to think of all things as possible (Craft, 2001; Cremin, Burnard, & Craft, 2006; Egan, 2005).
- *Narration* refers to a narrative mode of thinking and understanding as a key aspect of meaning-making (Bruner, 1996, 2002, 2003; Egan, 2005; Lyle, 2000). It follows from this that one way to make sense of experience and the world while learning is *narratives*. One strategy for stimulating and developing the imagination is 'narrative' (Egan, 1992), and thus narration is seen as part of creative learning.
- *Collaboration* emphasises knowledge co-creation and common design and play processes. Collaboration with peers encourages motivation and cognitive engagement (e.g. Blumenfeld, Kempler & Krajcik, 2006).

[1] The design and implementation of the teaching experiment was based on collaboration between Annakaisa Kultima and Marjaana Kangas, the researchers who, in addition to Pirkko Hyvönen and Suvi Latva, have worked in educational and scientific research projects that are closely linked to the development of PLEs.

- *Insight* refers to the opportunity to make discoveries and to solve problems (Hyvönen, 2008; Joubert, 2001).
- *Emotions* involve all human activity having a key role in thinking and learning (e.g. Mahn & John-Steiner, 2002; Vygotsky, 1978).
- *Embodiment* and *activity* refer to physical activities and the use of the whole body in learning processes where 'embodied knowledge' (see Hyvönen, 2008) can be achieved. The whole body is needed and used in learning activities. In the present study, the students engaged in their learning by participating in physical game-based learning in the outdoor playground and various hands-on activities when designing game worlds in the classroom.

Although the underlying rationale of the experimental design of this study was to integrate the partly overlapping above features on the theoretical level and in practice, the focus will be on the following approaches: *creative learning and knowledge co-creation, narration and possibility thinking in creative learning*. These will be discussed in more detail in what follows.

2.1. Creative learning and knowledge co-creation

During their formal schooling, children are expected to *understand* the issues at hand, that is, to be capable of seeing their application, which includes knowing how to present arguments for and against a case, being able to connect learning topics to wider contexts and observing phenomena from different angles (Ministry of Education, 2004). Increasingly, children are also expected to learn in collaboration, to negotiate with each other, to examine and elaborate different alternatives together and to construct knowledge together. From a sociocultural perspective, language is the main cultural tool for constructing knowledge (Mercer, 2000, 2002; Vygotsky, 1978), making an ability to communicate and to reason with others important for success in education (Wegerif et al., 2004). In creative collaboration, learners can become more reflective by acting as "revealing mirrors" to each other (John-Steiner, 2000). Rojas-Drummond et al. (2006) have defined knowledge as the product of the joint negotiation of the participants, who use a variety of communicative strategies to construct a shared understanding. Learning as a social process is assumed to occur first at the inter-mental level and next at the intra-mental level (Mercer, 2002; Vygotsky, 1978).

In this study, knowing and learning are viewed as a creative process (Craft, 2005; Säljö, 2004) that involves not only the individual but also the social community as a whole (Scardamalia & Bereiter, 2006; Wells & Claxton, 2002; Wenger, 1998). The concept of knowledge co-creation is thus a focal part of creative and playful learning. Learning is seen as a process of discovery in which the term "transformation" has a special meaning. As Säljö (2006) notes, it implies that learning is no longer repeating what is known, but creating something new. In this sense, learning and creativity are closely intertwined and learning is seen as taking place through creative practices. Anna Anna Craft (2005, 52) illustrates this interaction:

> We are constructing knowledge, and in this sense we could perhaps describe what we are doing as being creative. The more we are engaged in the meaning-making, the fuller and more fully owned by ourselves is the map that we are constructing. This is perhaps the most engaged space we can be in when we are in the process of imaginative playfulness.

The knowledge creation approach emphasises that *knowledge* is not only created via traditional learning but can emerge from the construction of *artefacts* (Paavola et al., 2004). In the present study, those artefacts take the form of a novel and appropriate collection of game and play contents that children designed for the PLE in their learning community. Playfulness can be associated with the creation of imaginary worlds through role-play and being open to playing with ideas and new possibilities (Egan, 2005; Craft, 2001). Hence, it may help children to think about and reflect on the world in a way that is free from constraints. One form which this can take is word play or humour between participants to create common ground. Playing with words and ideas assumes a context of mutual trust and support, where each participant knows that what he or she says (draws, performs, etc.) will be accepted (Wegerif, 2005). Wegerif (2005) argues that it is very hard to get children to perform any kind of task at school unless they are encouraged to be creative with language.

Viewed from these standpoints, *knowledge co-creation* entails a learning process where knowledge and understanding are not only shared but also jointly generated and socially validated. It refers to *action, dialogue and emotions* (c.f. Wells, 2002). Many similar concepts are used in research to refer to comparable understandings of the decentralisation of knowledge: learning involves activities that are shared, constructed and created in co-operation with others. These terms are, for instance, *collaborative knowledge building* (Wells, 2002) *knowledge co-construction* (John-Steiner, 2000; Wegerif, 2006; Wegerif et al., 2004) and *creative co-construction* (Craft, 2005). According to Egan (2005), imagination in learning processes is strongly tied in complex ways to learners' feelings. Thus, it can be assumed that in learning through knowledge co-creation, special roles are based not only on creativity and imagination, but also on emotions and narrative thinking.

2.1.1. Narration in creative learning

It has been argued that the use of narratives or story telling is one way to help learners make sense of experiences and the world around them (Bruner, 1996, 2002, 2003; Egan, 2005). The words *narrative*, *narration* and *narrate* share a Latin root that suggests a close connection with knowledge and skilful practice (Whyte, 1982). A narrative is *a mode of thinking*, a continuous account of a series of events or facts that shapes them into *an emotionally satisfactory whole*; it involves a sequence of events (Bruner, 1996; Egan, 2005). It follows from this that, in the process of learning, thinking needs to take on a shape in order for it to become explicit and thus easier to process (Bruner, 1996). In the present study, the children

were advised to co-create coherent narratives for their fictional play world and ready-made game templates facilitated story shaping. The starting point was for the children first to develop a coherent story-line to make the game and the play world in the playground more meaningful and to enhance their understanding of the topic. Through the narratives, the children created, constructed and validated their shared understanding of the topic as well as their common, imaginary play worlds (cf. Juujärvi, Kultima, & Ruokamo, 2005; Kangas, Kultima, & Ruokama, accepted).

Bruner (1996) points out that narrative is both *a mental structure* for organising information, thoughts and emotions into coherent entities and *a vehicle in the process of education*, particularly in science education (Bruner, 1990, 1996, 119). Bruner also observes that children are very skilful at creating narratives, especially about unusual specific events and things. In this light, narrative has a significant role in creative and playful learning and in knowledge co-creation. One way to develop narrative thinking in school teaching is to link pupils' imaginations to the material that is being learned and to stimulate children's imaginations *through fiction* (Bruner, 1996; Egan, 2005). This approach was applied in the present study.

2.1.2. Possibility thinking in creative learning

According to Craft (2000, 2001), "possibility thinking" – also involving knowledge co-creation processes – can be viewed as the core of creative learning. To facilitate understanding of new concepts or phenomena, learners should have the opportunity to develop multiple and flexible perspectives and to apply their knowledge creatively (Burleson, 2005; Joubert, 2001). The potential of *designing* in learning science is that the design task, for example, the creation of imaginary game worlds, provides a context for applying the scientific knowledge or content (Sidawi, 2007). In the present study, children were asked to *imagine a fictional world which had to deviate from the real world with respect to the science content that had been previously studied*. They had to consider the differences between factual and fictional worlds in their curriculum-based studies by testing their views of reality against possible worlds through *thought experiments* (Bokulich, 2001; Kultima, 2006). In philosophy, thought experimentation has been reported to play an essential part in testing a theory's consistency and explanatory power (Bokulich, 2001). Similarly, Jeffrey and Craft (2006) have pointed out that the construction of possible worlds is essential for creativity. For instance, if children first think about the fact that day and night are different on Earth, they might design a planet where it is day all the time. The reasons for and consequences of actions that learners put forward reflect their grasp of the phenomenon in question, providing insights into their understanding of the curricular topic (Kangas et al., 2006; Kultima, 2006). Although the basic idea of the teaching experiment was to enhance students' creative thinking, the focus was not on academic achievement, science learning or development of thinking skills as such; therefore, these were not tested either before or after the teaching experiment. Instead, the study focused on children's and teachers' *experiences* of creative and playful learning processes.

3. Aims and research questions

The goal of the study was to investigate the playful learning environment (PLE) in primary school settings and to examine how children experience creative and playful learning (CPL) processes that are based on game design and knowledge co-creation and on playing in an outdoor technology-enhanced playground. An additional aim was to consider teachers' experiences and views on CPL and to develop a model for CPL. The research questions addressed are the following:

(1) How do children and teachers regard the PLE and creative and playful learning that is based on game design, knowledge co-creation and integration of fact and fiction in PLE settings?
(2) What type of new knowledge does the teaching experiment yield for developing a pedagogical model for creative and playful learning?

4. Research setting: the playful learning environment

The pilot playful learning environment (PLE) where the present study was conducted is located at the Kauko Comprehensive School in the city of Rovaniemi, in northern Finland. The school playground was opened in March 2006. As the children and teachers at the school were the first users of this new type of learning environment, their role as designers and developers of the environment and the pedagogy was significant. The PLE provided at the school consists of different pieces of non-technological playground equipment, that is, the *exploration unit*, *stage*, *jungle gym*, *wave platform*, *stepping stones*, *drawing walls*, and *spinning mill*, and the *SmartUs* technology, comprising the *iStation*, *iGrid* and *iPosts* (see Fig. 1) and related software. During the teaching experiment the weather conditions were wintry and snowy, and therefore the outdoor playground area in the school yard was set up under cover so that all the playground equipment could be used.

The technology is located in the central console of the school yard, the *iStation,* which guides gaming with images and audio. The computer screen in the iStation is the same size as that of an ordinary desktop computer. Technology in the playground is also located in gaming posts, or *iPosts*, which provide gaming points for the play and learning environment. The technology includes Radio Frequency Identification Devices (RFID) in the iPosts that are located throughout the PLE and recognise tags on iCards, which children use as they play. RFID is also located in the *iGrid* jump mat that works together with the iStation. The *Smartus* Software, game creation tools in classroom computers and the Internet connection in the PLE form a system that gives children and teachers the opportunity to create games and play worlds for their own purposes and to implement them in the PLE. At the time of the study, the PLE consisted of a prototype version of the technological

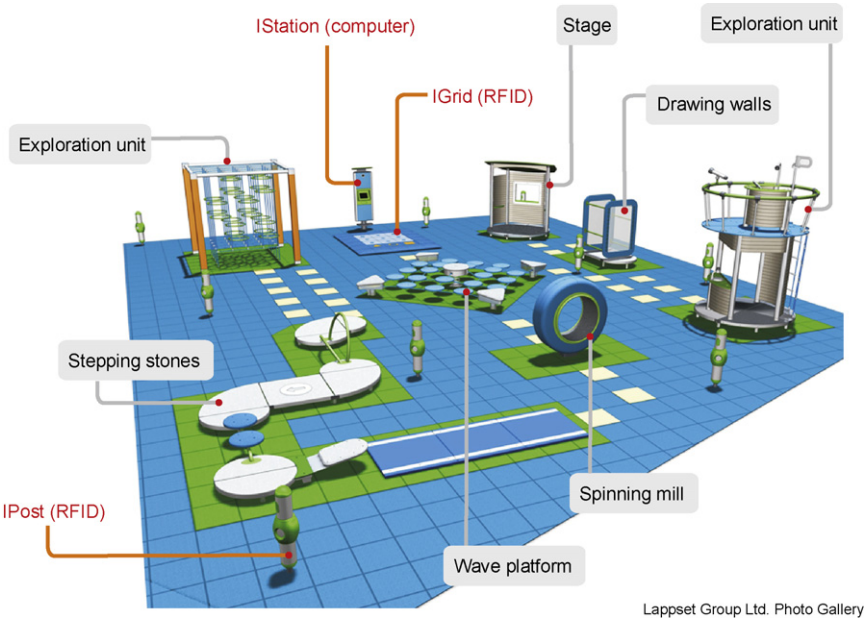


Fig. 1. A view of the *SmartUs* playground: a playful learning environment (adapted from an image provided by Lappset Group Ltd.).

applications and tools. The Internet connection and game development tools were still under development, and students could not yet create games via classroom computers. Instead, they designed their game and play worlds using templates and sheets of paper, and their ideas and plots for the narratives in the game world were transferred by the researchers[2] to the playground applications. In this regard, the experiences documented by the present study have had an essential role in PLE development, especially as regards the digital technologies, software and teaching methods that underpin the environment.

5. Method

Where methodology is concerned, this study is based on design-based research (Barab & Squire, 2004; Barab, 2006; Brown, 1992), an approach that goes beyond merely designing and testing particular teaching experiments. Design-based research is defined as "*a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories*" (Wang & Hannafin, 2005, p. 7). That is, design-based research allows for the creation of new theories, artefacts and practices for PLE contexts. However, as mentioned earlier, the present "within-site" study comprises the first part of an iterative design cycle; redesigned "multi-site" studies of the educational uses of PLEs have since been implemented in another context (e.g. Kangas et al., 2007; Kangas, Randolph, & Ruokamo, 2009). Thus, the study presented in this article is best regarded as a qualitative case study focusing on the description and interpretation of the initial experiences of a game co-creation and a playful learning environment.

5.1. Participants, data collection and data analysis

A week-long teaching experiment was carried out at Kauko School in March 2006. The school is quite small and situated in a peaceful, rural area in the city of Rovaniemi, Finland, close to forests and a river. The school has a total of 68 students aged 7–12, as well as four full-time teachers, all of whom participated in the teaching experiment. Thus, each of the classes put all of its efforts for over 1 week into the project and studied according to the ideas of the Different World Game concept (Kultima, 2006) and creative and playful learning (Kangas et al., 2006). Classes in the school were divided such that third- and fourth-graders, and fifth- and sixth-graders, studied together, which meant four participating classes. For working and studying during the week, the children were assigned by the teachers to three- to six-person heterogeneous groups. The teachers were asked by the researchers to create groups that would each represent both genders as well as children with varying cognitive and social skills. These small groups of children co-created the main parts of the "what if" game worlds, which were validated afterwards at the classroom level. Hence, as a result of small-group and whole-group working, four different "what if" play scenarios – one per class – were co-created for implementation in the playground.

[2] Annakaisa Kultima and Marjaana Kangas.

Fig. 2. Views of creative and playful learning.

The data were collected using semi-structured thematic group interviews of children ($N = 38$; 15 girls, 23 boys) and the teachers ($N = 4$), participant observation in classes and the playground, and video recordings. During and after the 1-week teaching experiment, students from grades 3 and 4 and grades 5 and 6 were interviewed in pairs or in three-student groups in accordance with the interview themes: (1) experiences encountered at various learning phases, (2) experiences related to working in groups, (3) emotional involvement with the learning processes and (4) perceptions of learning outcomes. First and second graders were interviewed in informal ways as part of participant observation. Interviews were audiotaped, transcribed and analysed using *qualitative content analysis* in accordance with themes that emerged in the interviews. Content analysis involved the making of inferences about data by systematically and objectively identifying special characteristics and categories within them (Gray, 2004). These categories were derived from the model of creative and playful learning and its theoretical background.

Teachers ($N = 4$) were interviewed after the 1-week experiment by two researchers[3]: one interviewer acted as chairperson, who controlled the direction of the interview and asked semi-structured thematic questions, while the other took notes. The interviews were both audiotaped and videotaped. Design research usually collects large amounts of data, such as video recordings, in order to understand what is happening in detail (Collins, Joseph, & Bielaczyc, 2004; Confrey, 2006). Therefore, video recordings were also gathered at each of the learning phases during the teaching experiment. These data, as well as the notes from participative observation, were compared with the data obtained from interviews. Video recordings were also gathered from game co-creation sessions of the fourth class, comprising 9–10-year-old children ($N = 22$), who worked in five small groups. These data complemented the interview data encompassing children's experiences of group working and experiences of game design processes. The themes in the teacher interviews focused on the potential and challenges of applying creative and playful learning in teaching, on the role of teachers in PLE and in creative and playful learning processes, and on learning outcomes.

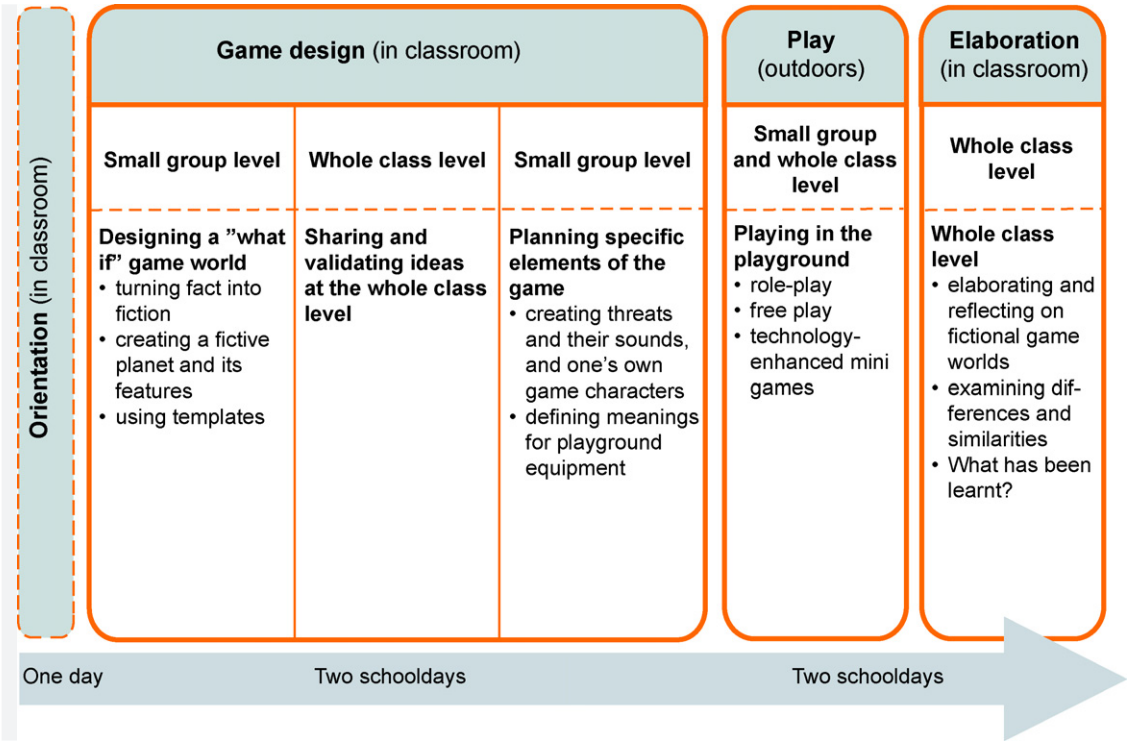
5.2. Research design

As mentioned in regard to the theoretical background, the teaching experiment followed the Different World game concept designed for the PLE and the pedagogical framework of creative and playful learning (Kultima, 2006; Kangas et al., 2006). In addition, the teachers of the Kauko School participated in planning and carrying out the experiment. The rationale for conducting the experiment at the Kauko School was based on previous collaboration during the PLE development and on the fact that the PLE was not yet in use at any other primary school in Finland or other countries. The teachers were motivated to implement the new outdoor learning environment in their school. They had also participated in the development of the PLE and so were able to offer their views on pedagogical issues in multidisciplinary research teams. However, the ideas underlying the Different World concept were new for them. Therefore, at the beginning of the implementation, the teachers were introduced to the rationale underlying the teaching experiment and the theoretical framework behind it. It was explained that even though the practical goal was to test the PLE in curriculum-based learning, the purpose of the experiment was to consider the differences between factual and the fictional worlds and in that way to deepen the children's understanding of certain curriculum-based topics. The practical pedagogical arrangements were planned in collaboration with the teachers, which is the ideal in design-based research: the design needs to be thought of as an integrated system, and the evaluation of the design is an ongoing process that changes as the design changes (Barab, 2006; Brown & Campione, 1996; Collins et al., 2004). The teachers modified the curriculum to fit the different ages of children and in so doing transformed it to some extent. The learning phases in the PLE are shown in Fig. 2.

The curriculum-based topics related to science, examples being space, the Solar System, and the concept of time. The learning methods used varied between classroom activities and playground activities and were divided into four phases: (1) studying the topics in diverse ways in the classroom (orientation phase), (2) planning a "what if" play world by turning fact into fiction (planning phase), (3) playing a common class game in the playground (play phase), and (4) reflecting on and evaluating both factual and fictional issues in the classroom (elaboration phase). The implementation of the phases varied slightly with grade in accordance with the children's ages and developmental stages. The teachers and researchers

[3] Annakaisa Kultima and Marjaana Kangas.

Table 1
Research design.



worked as co-ordinators, supporters, and guides during the processes of learning and co-creation. The aim was that the teachers would not give children ideas but would facilitate group thinking by asking about key points and posing questions. In the playground, the researcher's role was emphasised because of insufficient recourse to the technology at that time. For instance, the researchers simulated some parts of the games and guided the children in their play worlds. The process as a whole is summarised in Table 1:

5.2.1. Orientation

For the purposes of the intervention – to nurture children's imagination and creativity – it was important to ensure that all of the children would gain basic knowledge about the topic and would have access to essential information. In addition to listening to short lectures by the teachers, the children acquainted themselves with the themes by watching space videos and by studying space through books and the Internet. They also created topic-related art, consisting of drawings, representative art, and crafts dealing with space, the planets and the Solar System. Thus, in the orientation phase, children used a variety of information sources and tools for learning and they negotiated and discussed the issues at the small-group and classroom levels. The purpose of the orientation was to motivate and stimulate learners and to provide them with an opportunity to become acquainted with the relevant factual content of the topic. Moreover, forthcoming learning activities were framed in terms of questions such as, What are the purpose and the goals of the process and what phases are involved in the process? It was important to explain to the children at the outset how and why they were to continue with the theme in the PLE and in the classroom after their playground activities. These were significant issues in developing the children's abilities to reflect on their own learning.

5.2.2. Planning and play world design

Next, the children were asked to imagine a fictional world which would deviate from the real world with respect to the details that had been studied in the fact-based orientation phase. Prior to this, the teachers had composed a letter from an imaginary outsider, named Zed, who lived on another planet. The teachers collaboratively created a story for the play world setting; they composed a letter from Zed and decided to start the game planning phase by reading it aloud to their students. The children then had to imagine a different and a new kind of world and planet for Zed, as there were many reasons why he could no longer live on his planet. For the "what if" game of world design, the classrooms were organised by the teachers such that children worked in mixed groups of three to six girls and boys. To facilitate co-creation of their planet, the children were given a set of templates with all of the information needed to plan and design the play world. The children were asked to write and draw their ideas on these templates. Each small group designed the features, narratives, incidents or "threats", figures and characters for the game. When playing in the playground, each child assumed the role

Fig. 3. Free play and technology-based mini-games in the PLE.

of the character that he/she had created. The game world was first planned at the small-group level; the ideas were then shared and validated at the whole class level, with the class choosing the most sensible ideas and creating a common, narrative "what if" world. Following this, the children, working in the same small groups, devised "threats" to the common play world.

The process of creating the game world drew on a number of story-planning questions: What is the game world like? What does the playground equipment represent in the game world? What incidents or "threats" will be encountered in the play world, and how can they be overcome? An incident might be an invisible satellite that steals shadows from trees, buildings and occupants, for instance. In the game world of fourth–fifth graders' the exploration unit was Zed's weather station, the wave platform represented Lava Ocean, the drawing walls were the monster of the Naluki game world and the spinning mill was a language lab that the occupants, the players, used. The incidents emerged unpredictably during play and were averted by playing a small computer game designed by the researchers. Here, the children had to choose a multimedia sound element to represent the incident. An incident might be a hail of colourful flowers from the sky and the only way to counter it would be to succeed at individual computer games outdoors. Finally, the children planned their own game characters by drawing and naming them. All pictures, narratives and figures that related to the play world were copy-pasted and transformed into images that could be seen in the playground (see Fig. 3). Overall, the implementation of the orientation and planning phase took 3 days of the entire process.

5.2.3. Playing

When each class had reached the phase in which it had created its own game world with the basic features and "threats", it was time to head to the outdoor playground to play. The purpose was to engage in role-play – for children to use the playground equipment and to put their soul into the class's play world – and to save their own world when the randomly emerging incidents or "threats" appeared. Role-play took place in the small groups and five to six children played at each point – *exploration unit*, *stage*, *jungle gym*, *wave platform*, *stepping stones*, *drawing walls*, *spinning mill* (see Fig. 1) – at any one time. Role-play was based on the class's common narrative and the roles assigned to the equipment in the play world. The incidents or "threats" – as many as the number of groups in the class – had to be overcome by playing the technology-enhanced mini-games planned for and programmed into the playground system by the researchers. The mini-games lasted only a couple of minutes but they made the playing phase on the playground more physical and exciting. The games consisted of educational tasks that had to be solved by seeking the right answers from the iPosts in the playground (see Fig. 1). The researchers also decided the time when the incidents occurred and when the mini-games would start. An approaching incident, represented by a signal from the multimedia sound element, was announced by the researchers. The sound and the incidents or "threats" were familiar to the children, because they had planned them themselves in their classrooms. However, the timing of the incident and the content of the mini-games were impromptu. The narrative context of the play world, the representations of the playground equipment and the contents of the incidents were all displayed in the iStation (see Fig. 3).

When the sound of the "threat" emerged, the mini-game started and each of the children had to get through it in a certain time. The whole playground was in use during the game. The common score of the classes determined victory over or defeat by the "threats". The teachers tutored pupils in dealing with the tasks of the mini-games and participated in role-playing during the free play on the playground that represented the space-like "what if" world of each class. The entire play phase outdoors on the playground lasted for approximately one lesson and consisted of four to five mini-game phases depending on the size of the small groups and nature of the "threats" created in the classroom. This phase of learning was playful and imaginative and entailed the use of the whole body while playing and learning. Outdoor circumstances were very wintry, but as the playground was under cover, the children had quite comfortable conditions for their play. Fig. 3 illustrates the playing phase: children in their play activities on the drawing wall, on the wave platform, in the exploration unit and querying the iStation for mini-game instructions.

5.2.4. Elaboration

When the game on the playground was over, the children elaborated and reflected on the fictional world created by the class, as well as the real world and the studies from which the process had started. The differences and similarities were examined in small groups and recorded on the blackboard. In addition, the students in two of the classes were asked to make

a mind map outlining what they had learned during the process. The same children had been given an identical task as a pre-test. Teachers were asked to report on the tests in the interviews.

6. Results

6.1. Creative and playful learning potentials and challenges—children's view

Four exciting play worlds with their narratives and plots were created and acted out in the PLE. These imaginative play worlds, named *The Naluki*, *The Udeko*, *The PVEP* and *The Wonderland*, consisted of a variety of features, causal explanations and hypotheses for a "what if" world that consisted of both factual and fictional knowledge of the real world. The children felt that it was inspiring to design a common game world, to create narratives, to refine ideas and to elaborate a world that was "upside down". They reported they had learnt about space, the planets, the Solar System and the concept of time, that is, the curricular content. In addition, they felt they had learnt to use their imaginations and to collaborate, and that it was challenging to design and create knowledge collaboratively, because everyone contributed his or her own opinions; in fact, one can see all the facets of learning that learning in the sciences emphasises (see Sawyer, 2006c). On the basis of the children's views, five categories were posited that illuminate the learning potential and challenges that the children experienced during the experiment.

Intellectual potential and challenges relate to the creative and narrative processes as well as the use of imagination and possibility thinking, that is, skills that arose in turning fact into fiction and in composing stories. Most pupils thought they had had *an opportunity* to think imaginatively and creatively while learning. The replacement of traditional teaching methods by a range of creative and playful activities seemed to inspire the children. For instance, they reported being eager to study in this way because "you didn't have to use only workbooks" and "you were allowed to use your imagination". However, imagining a "what if" game world was not always regarded as a straightforward and easy experience; although using one's imagination was mostly considered exciting and fun, the necessity of doing so was sometimes regarded as quite strenuous and even stressful. Some pupils found it "hard to come up with something different" and difficult "to think about the relationships between fact and fiction". Thus, use of the imagination and making coherent narratives were not self-evident processes for all pupils and in all groups.

Participative potential and challenges related to small-group working and collaborative decision making in groups and at the classroom level. Working in groups and deciding the characteristics of a fictional play world collaboratively was considered a motivating experience, especially when there was a substantial flow of ideas. Since the objective was to create a common play world, it was necessary first to establish a common goal at the group level and then at the classroom level by making compromises, negotiating and deciding what ideas were to be included in the common plan. The children thought that they had learnt group work skills and felt that this was a good way to study and design, because they had an opportunity to "*talk and work things out with the group*". The results show that children conceived of learning outcomes in a way which is in line with the principle of creative and playful learning: they felt that they had learned about negotiation and respect for the ideas of others during the process, although they also had difficulties reaching a common understanding. As one noted, "*Sometimes we argued about stuff, but then like, you know, in the end... everyone agreed about it*". This is understandable, because no specific ground rules for negotiation skills in groups had been taught beforehand. On the other hand, misunderstandings and disagreements are central to learning and it is often erroneous to assume that children automatically learn better when collaborating. Mercer (2000), for instance, has acknowledged that shared knowledge and understanding can be equally attained through conflict or co-operation. Indeed, the considerable potential and challenge associated with participation were experienced simultaneously, as positive and negative elements: participation was a *chance to discuss and decide things collaboratively and brought the challenge of having to reach agreement*.

Potential and challenges in knowledge co-creation were categorised separately from the participatory approach, and were divided into two parallel processes: (a) fact-based co-creation and (b) fiction-based co-creation, which was emphasised in the planning and play phases. These processes seemed to compete with each other and teachers' and researchers' participation and questions in particular were able to create spaces for considering factual and fictional issues at the same time. The children reported that they learned that "everybody has individual ideas" that have to be taken into account, which is also true of challenges and potential in knowledge co-creation. Playfulness appeared in many ways, for example, in situations such as playing with language and expressing funny ideas. The following extract illustrates fiction-based co-creation. The children are talking about and designing the main features of their planet:

Girl 1: *It's the kind of planet that doesn't go around at all because it doesn't want to go around. Then on one side it is always night and on the other it's always day. And on the night side it's sort of scary and stuff and on the day side it's more fun and stuff.*
Boy 1: *And then there's like a ring around the planet where it always goes to the night side and day side.*
Boy 2: *And there on the night side there's a volcano and every time it erupts then out come these fiery men.*
Boy 3: *And then lightning comes out and when the lightning bolts hit the ground, they turn into these...*
Girl 1: *electric...*
Boy 2: *Yeah, electric men.*

The extract illustrates how the pupils' narrative and emotions are very much part of knowledge co-creation. The game world has to be scary and fun and has to have a clear plot. However, emotions were also reflected in action and in non-verbal communication. Depending on the quality of knowledge co-creation, the individual strategies and the teacher's or researchers' guidance during the processes produced qualitatively different possibilities for shared understanding. The teacher was involved in the excerpt below, where children (aged 9–10) are discussing the roles for playground devices in their play world, Naluki. Plans and narratives for devices have been created in small groups in the classroom, and the whole group is familiarising itself with those ideas and validating them at the classroom level. These discussions take place in the playground:

The teacher: . . .*and what is this device? The Spinning Mill* (the real name of the device).
Students all start to talk excitedly and in unison: *It's one of those Naluk language machines*. . .
Girl 1: . . .*This is one of those Naluk language learning machines, so that when you spin in it, it teaches you the Naluk language*.
The teacher: *Oh really, so this is like*. . .*a language studio? Yeah, a language studio for learning Naluk* (with excitement). . .
(Continues) *What else could it serve as?*
Girl 2: *Well, when you get to that Naluk planet, then you could go inside that and when it spins around like it does, then you could come out from the other side*. . .
Girl 3: *Like a planet ring.*
(The children demonstrate with the device.)
The teacher (specifies): . . .*So that when they come from there to this planet they learn the language at the same time*. . .
The children nod.
The teacher: *Well, what is this?* (Presents another device, the Wave Platform)
The children step and walk on the Wave Platform (see Fig. 3).
The children exclaim in unison: *It's one of those black hole doors*
The teacher: *Wow!* (with interest)
Boy 1: (continues). . .*so that when someone shakes it from the middle, you have to go fast*
Girl 4: (continues). . .*So that if you step in here* (demonstrates). . .
Boy 2: *then you fall*. . .
Girl 4: *then you fall into a black hole*.

This example shows that the entire process was based on imagination, a fictional representation of the planet Naluki. However, to promote understanding of the space-related terms, it was important to elaborate and reflect on the learning content after the planning and play phases, and to consider differences between fact and fiction in the classroom. The fact-based knowledge was dealt with and further co-created quite successfully at the classroom level by offering children an opportunity to ask related questions, which varied depending on the children's class level and age.

Emotional potential and challenges. The teaching experiment showed that the children could express a variety of feelings regarding their play worlds during the learning and design processes and both in the classroom and in action while playing in the PLE. However, playfulness, humour and joy were predominant. Positive feelings were associated with the active way of learning and involvement, designing imaginative things, group working, collaboration, and the opportunity to share the fictional game world with others in the playground. Designing a common game world was regarded as an enjoyable, fun, and "tops" experience, and playing in one's own world in the playground was considered especially rewarding and cool. Younger children seemed to enjoy the play phase more than older children did, who in a few cases regarded it as somewhat frustrating and childish. The children felt that filling in the templates and completing writing tasks in general were the most tedious tasks. In addition, as mentioned, turning fact into fiction caused difficulty and frustrations in some cases, although the overall result was worthwhile.

Physical potential and challenges. One of the main goals of creating the "what if" world was to get to play the game in the playground, which provided numerous opportunities for physicality. Running in the playground while playing the technology-enhanced mini-games was a very sporty phase. In addition, during free play children ran, jumped, and climbed in the outdoor playground that represented their own planet, with its novel places and tasks. The Wave Platform, which consists of wobbling steps to walk on, was envisaged by one group as a "the Lava Ocean of space", because moving on the steps required good balance. For the children, the game phase was motivating since, as one student commented, "You can play there. . .and you don't need to listen to the lesson. . .or take notes".

6.2. Creative and playful learning potential and challenges—the teachers' view

Since the idea of the intervention as a whole was new to all concerned, and was largely based on the children's free narrative and creativity (Juujärvi et al., 2005; Kangas et al., 2006; Kultima, 2006), it required a different type of instruction and tutoring from the teachers than that used in mainstream teaching. While they involved some individual and traditional working methods in the orientation phase, the learning activities mostly drew on creative collaboration and common decision making at the group and classroom levels. The teacher's role was felt to be challenging because precise planning of lessons, learning and play processes beforehand was not possible. Challenges were also linked to the fact that activity in the CPL is fairly pupil-centred and requires a lot of tutoring and guiding for the knowledge co-creation. Accordingly, the teachers

felt that they had to "stay very much on the alert" and that it was constantly necessary to be "105% wide awake", as one of the teachers put it. They felt that their role was very important, especially during the planning and elaboration phases, when dealing with cause-and-effect relations in the factual and fictional worlds. However, the teachers felt challenged when faced with the task of drawing a boundary between sufficient over-tutoring and tutoring when engaging and feeding the children's imaginations.

The teachers reported that they perhaps should have offered more tutoring and guiding for the children's group work. Only in the course of the process did they realise that they could have directed the children's groups somewhat differently, linked the ideas of the children's imaginary world more explicitly to the real world and, for example, sought logical explanations together with the children for the "threats". More time should have been allocated for this guidance, especially in the elaboration phase. As teachers reported, the elaboration phase should have been longer and more intensive in the classes, whereby it would have provided a better forum for transforming ideas and exploring and developing explanations relating to the factual and fictional worlds of the planets. In the next phase, when the structure and script of the game idea were more under control, the teachers stated that they could better predict the use of their time and could devote more of their attention to tutoring the groups. Having said this, they doubted whether they would have the time to incorporate such a learning method in their future educational practice.

The orientation phase was considered important for learning and planning the fiction-based play world. In this phase, the teachers were of the opinion that the children learned at least the topics that were dealt with during the teaching experiment, that is, the basics elements of the concepts of space and time; they believed these were made "different" in the process in that the children had to contemplate them from different angles. Although science learning or children's thinking skills were not measured in this study, it was important for the teachers to assess these learning outcomes in some way. At the beginning of the process, teachers asked the children to make a mind map to ascertain what they knew about space, the planets and the Solar System, and how they understood the relationships between these concepts. The pupils had been asked to note all of the things that came to mind and to write and draw them on the mind map. At the end of the teaching experiment, the children added to the mind map, in different colours, the new concepts, topics or relationships they had acquired. Examination of the concept maps revealed that learning at least had taken place at least in quantitative terms: the teachers reported that some children's concepts and topics had increased as much as tenfold. The teachers were satisfied with these findings, although the results of the mind map tests did not clearly reveal how children's thinking skills had developed or the extent to which qualitative changes had taken place in their understanding of the topics. With regard to the fact-and-fiction-based teaching method, the teachers stated that if the students were able to deliberate facts and explain them in collaboration, it could then be said that they had co-created knowledge and understood the subject matter, or at least that part which was covered in their plans and explanations.

The teachers reported that it was important that the children had learnt to negotiate and make decisions and to face the challenges related to participation. For example, they considered it important for children to learn to compromise on their own ideas while collaboratively planning the game. Another positive element reported was that the children had to give up on some of the ideas generated in their own group in order to create a common world: "Children ought to learn that not all their own ideas necessarily enjoy the support of the class as a whole". According to the teachers, the composition of the group was also important for knowledge co-creation: "In each group there was someone whose imagination could fly. . .when those whose feet are firmly planted on the ground could break loose a little." Here the teacher identifies a meaningful learning space where one child's imagination feeds another's and nurtures the possibility of thinking.

Although the experiment (around 20 h) only allocated 1 h in the playground, the teachers reported that the game play phase was the most important and rewarding for the children. The teachers reported that imagining was particularly successful in the playground environment, as it provided activities that embodied successful immersion into the co-created play world. However, the teachers thought that their role there should have been more active, as this would have engaged better with the classroom's imaginative world and participated in play with the children. According to the teachers, the technological gaps in the playground implementation did not significantly affect children's role-play and game playing,

7. Conclusion: a model of creative and playful learning (CPL)

In order to frame these emergent findings, and because the PLE is an innovative physical, virtual, formal and informal, indoor and outdoor learning environment, it became necessary to outline a theoretical and practical model for the use of PLE in curriculum-based teaching. The CPL model is based on physical and technological affordances provided by the PLE and the earlier pedagogical models related to PLE studies (Hyvönen, 2008; Hyvönen & Ruokamo, 2005; Hyvönen et al., 2006; Kangas et al., 2006, 2007) and is depicted in Fig. 4.

The orientation phase consists of framing the topic, the learning process, the methods and the tools, and collecting and creating the knowledge base. Students orient themselves to a given academic topic and this forms the knowledge base for the process. The present study has shown that ground rules for group-work and collaboration have to be elaborated carefully beforehand. For instance, the ground rules for exploratory talk (Wegerif & Mercer, 1997) or dialogical reasoning (Wegerif, 2006) can be incorporated into teaching to enhance the quality of knowledge co-creation. Similarly, orientation activities need time and careful planning and the use of well-known technological and other tools in the learning environment. *The game co-creation phase* emphasises imaginativeness, possibility thinking, and negotiation skills corresponding to the levels of narrative construction and collaboration. Students work together in small groups and create academically oriented or fact-

Fig. 4. The model of creative and playful learning (CPL).

and-fiction-based games or other content that can be implemented within a technology-enriched playground. For example, students might create a PLE game with geographical content by using first game development tools with Paint Brush, digital pictures and multimedia voices, and then go to the Internet to gather more information about the topic. Hence, in the game co-creation phase, various game creation tools and other media applications make learning more visible to others by shaping and sharing materials such as narratives, graphs, figures, thought maps, games and content for playing and evaluating.

The play phase involves physicality, active play and game playing in the PLE. Students might play both self- and peer-constructed games that can be non-technological or technology-enhanced. It is also important to offer a child an opportunity to reflect on and improve his or her game and play outputs if needed. *Elaboration* is an important phase for understanding, enabling the assembly and review of knowledge that has emerged in the earlier phases and to ask what, how and why questions. It affords the opportunity to reflect on, elaborate and transform knowledge and experiences. Each of the phases can be used for different learning purposes. For instance, the game co-creation phase or the play phase can be applied as orientation to a topic, for revision purposes, or to test understanding. In addition, technological tools and digital technology provide tools for knowledge co-creation in this phase. Applying the CPL model in PLE settings can support a variety of learning outcomes: academic achievements, physical skills, participative skills, skills of knowledge co-creation, thinking skills and media skills.

According to the CPL model, learning takes place through knowledge co-creation in an environment of imagination, playfulness and "media richness", which are essential for *proficiency as future citizens* (Claxton, 2002). The term "media richness" illustrates the use of media and new technology as a natural part of all curricula, such as those for mathematics, foreign languages or physical education. The term refers to a learning environment that caters to the needs and skills of today's children regarding media and new technology (e.g., digital cameras, ICTs, social media channels, the Internet, videos, mobile phones, iPods, computer games) and that emphasise a media production approach to learning. In the present study, technology did not play a large role, because game design and media production by computer were not available to the children, but the current version of the PLE did afford a variety of opportunities to create varied content. In fact, PLE use has recently been studied in a cross-cultural teaching experiment in which 331 Finnish and Dutch students used the game creation tools and new technology to produce and play games centring on a variety of subject matter (e.g. Kangas et al., 2009).

CPL is designed to integrate curriculum, subjects, environments, processes and methods. The teacher's role during the process can vary depending on how much the teacher emphasises the children's own contribution and activity both in the classroom activities and on the playground. CPL promotes knowledge creation for play and games as well as for meaning making: explicit reasoning, exploration, inventing, proposing and validating ideas. The alternation of working in small groups and at the classroom level is a good way of promoting the individual's and the group's collaborative understanding (cf. Wells, 2002). In keeping with Wells' (2002) idea of 'community of inquiry', the CPL model allows each group to present and explain

its thoughts and ideas to others. The other groups and the teacher pose questions for co-creating a common understanding of the focal game. The teachers have a special role as constructors of the groups and as tutors: they give emotional support, allow the children's imagination to run free, and encourage thought experimentation to flourish during the process of knowledge co-creation.

Subsequent design-based cross-cultural studies have proved that a teacher's sensitivity with regard to the pedagogical use of the PLE is an important classroom-level factor which influences student's satisfaction with the environment and methods of creative and playful learning (Kangas et al., 2009; Kangas, Randolph, & Ruokamo, accepted). In addition, children overall seem to be satisfied with learning through creative and playful learning processes in the curriculum-based PLE context. However, it is important to be aware of the dangers of creativity being perceived as no more than having fun or making pretty things, rather than being challenging, and often painful or frustrating, such as "hard fun" and "flow" (cf. Loveless, 2006; Csikszentmihalyi, 1990). This study demonstrated the existence of "hard fun" in fact-and-fiction-based learning processes that offer opportunities to reflectively analyse one's current knowledge and skills.

8. Discussion

The study yields insights into teaching curricular topics at the primary level using an approach that is novel in cultivating creativity and thinking skills in a playful learning environment. The research shows that one way to foster creativity, imagination and group work skills, alongside academic achievements, is to integrate fact-and-fiction and playfulness into teaching. It also provides an approach for meaningfully integrating various curriculum subjects and learning goals. In this study, physics, geography, arts and crafts, students' first language, physical education and media education were seamlessly integrated. The prevailing notion of formal learning – learning at a desk and learning individually about the world through textual reality (Säljö, 2004) – was challenged in a variety of ways, and the results were encouraging. However, teachers encountered many challenges in implementing the teaching methods that draw on CPL: firstly, they realised how their pedagogical orientation changed from teacher-directed to child-centred during the process. This required them to adopt a variety of roles, such facilitator, instructor and afforder, as well as learner. Secondly, they noticed how challenging it was to tutor and guide small group work indoors and outdoors while at the same time giving the children's imagination free rein. The teachers attributed difficulties with effective knowledge co-creation to differences between the individual pupils and to school traditions in which imagination is not always appropriate or allowed. They thought that getting used to various creative and playfulness-based teaching methods would help them and their pupils work creatively. They also found it quite challenging not to be able to plan their lessons beforehand in detail as is common practice in traditional teaching. Despite these misgivings, the teachers perceived no problem in incorporating this kind of method into school subjects, and were satisfied with the teaching experiment. Design-Based Research (DBR) requires that the researcher must systematically engineer the contexts of empirical studies in ways that allow for the advancement of new theory and pedagogical practice that will create an optimal learning environment (see Barab, 2006; Barab & Squire, 2004). Although the research-based evidence is still tentative, the results of the present study indicate that the use of the PLE and various combinations of the creative and playful learning methods are worthy of further research and implementation in educational practices.

Many practitioners have noted that novel learning environments are often received with high enthusiasm by students and teachers, but that this perception rapidly decreases with time and traditional methods reappear (Niemi & Kumpulainen, 2008). Indeed, the teachers in the present study felt that they needed more resources and support for their pedagogical thinking. Thus, further research is needed, as well as improvements in education, to better prepare teachers to implement and sustain instructional methods such as playful teaching (Hyvönen, 2008) or CPL, and to introduce novel learning environments such as PLEs into their pedagogical practices. The teachers' role was challenging during the teaching experiment, as it required a great deal of effort and time to carry out each of the learning phases, which included tutoring the small groups, as well as work with the whole class inside and outside the classroom. Although all teachers are naturally not ready for creating new learning environments based on creativity, innovation and new technology, it is clear that from teachers' perspective many trends of the future learning environments will require them to manage more diverse learning styles and therefore more diverse teaching strategies (see Natriello, 2007). Teachers' thinking usually involves a choice between different pedagogical alternatives (Kansanen, 2004). The CPL model offers tools for creative and playful teaching and the PLE provides a fascinating technology-enriched learning environment for learning through play and games, and for playing with new technologies in the educational sphere. Applying the CPL in the PLE settings requires that teachers have the skills and motivation to use innovative methods and learning environments, and work and "play" with technologies, just as young people today are accustomed to doing.

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