Characteristics of Pervasive Learning Environments in Museum Contexts

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ABSTRACT
There is no appropriate learning model for pervasive learning environments (PLEs), and museums maintain authenticity at the cost of unmarked information. To address these problems, we present the LieksaMyst PLE developed for Pielinen Museum and we derive a set of characteristics that an effective PLE should meet and which form the basis of a new learning model currently under development. We discuss how the characteristics are addressed in LieksaMyst and present an evaluation of the game component of LieksaMyst. Results indicate that, while some usability issues remain to be resolved, the game was received well by the participants enabling them to immerse themselves in the story and to interact effectively with its virtual characters.

Author Keywords
Pervasive learning environment, museum learning, learning model, pervasive game, mobile learning

INTRODUCTION AND BACKGROUND

Museums are rich repositories of information to be shared with visitors. This information can often remain partially hidden despite efforts of curators in designing cues, labels and tours. This is also the case in the Pielinen Museum, which is the second largest outdoor museum in Finland. It is renowned for its authentic atmosphere, and as such most exhibits have been left intentionally without tags, labels and information boards. The challenge of conveying the hidden stories of objects and of the past lives is tackled by an innovative pervasive learning environment (PLE), LieksaMyst, which consists of a set of learning tools including, for example, an intriguing, story-based pervasive mobile game. In the process of designing and implementing the system, we derived a set of characteristics that effective PLEs for museums should conform to. In this paper we present the background to our work, the LieksaMyst PLE, the set of characteristics, and an initial evaluation of the PLE based on the feedback from a group of learners using LieksaMyst's pervasive mobile game component.

Pervasive Learning Environments

Firstly, we make a distinction between the terms *pervasive* and *ubiquitous* which are often used inconsistently and interchangeably. Lyytinen and Yoo (2002) have proposed a division of different learning types along the axes of embeddedness and mobility (Figure 1), according to which, *pervasive* implies less mobility than *ubiquitous*. However, we do not see it only as a matter of place – pervasive learning also relates to time and activity, hence a pervasive learning experience is bound to vary according to place, time and a learner's activity. Despite the differences at the conceptual level, the same technologies (e.g. mobile devices, sensors, smart tags) can be applied to both ubiquitous and pervasive learning.

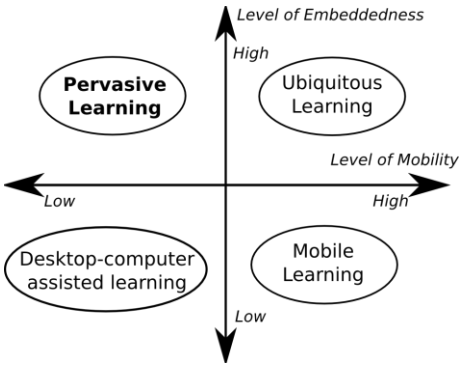

Figure 1. Types of learning according to levels of mobility and embeddedness (Lyytinen and Yoo, 2002)

From another perspective, pervasive learning can be considered as an extension to m-learning with an emphasis on the roles of an intelligent environment and of the context. The physical environment is central as it provides salient resources for learning (e.g. museum objects). According to Syvänen *et al.* (2005), a *pervasive learning environment* (PLE) is a setting in which students can become totally immersed in the learning process. They further note that pervasive computing is an immersive experience which mediates between the learner's mental (e.g. needs, preferences, prior knowledge), physical (e.g. objects, other learners) and virtual (e.g. content accessible with mobile devices, artefacts) contexts, and the intersection of these contexts is the pervasive learning environment. Syukur and Loke (2007) regard a pervasive learning environment as a collection of mobile users, mobile services, mobile devices, contexts and policies, while Ogata *et al.* (2006) state that in pervasive learning, computers can obtain information about the context of learning from the learning environment in which embedded small devices, such as sensors, pads and badges, communicate together. Common factors in these definitions include the interplay of intelligent technology and the context in which the learner is situated (i.e. context-awareness).

Currently there is a lack of a theoretical learning model on which effective pervasive learning environments can be built (Laine and Joy, 2008). In this paper we establish foundations for such a model by deriving a set of key characteristics of pervasive learning environments for museums.

Learning in Museums

There are many reasons why people visit museums. For some it is a leisure activity while others may come together with a school group. Most visitors come to museums in order to learn something new or to continue refining and refreshing the knowledge gained from previous visits. Children and young adults can be an exception as their motivation for the visit can be the authority of school and not their own choice. Just as there are many reasons for visiting museums, there also exist reasons for *not* visiting them. One particularly strong reason is a negative attitude towards museums which only increases the unwillingness for free-choice visits (Black, 2005). Therefore it is important to work towards improving and maintaining positive attitudes of potential visitors towards museums.

The type of learning that takes place in museums is a hybrid or continuum between informal and formal, and the degree of (in)formality depends on the purpose of the visit. For example, a school group may have a slightly more formal learning agenda than a senior couple. Furthermore, a school group's visit to museum is often connected to more formal learning that takes place in an ordinary classroom environment.

In addition to why people visit museums, we should also consider how the visits should be organized in order for them to be effective in terms of learning. There are two basic visit types: free and guided. It has been suggested that neither of the extremes is optimal for learning but that we should choose something in between instead (Bitgood, 1989; Linn, 1980). Indeed, it has been suggested that curators and guides have a tendency to communicate one-directionally (Durbin, 2004) which reminds us of the behaviorist monologues familiar from formal classroom environments. For first-time visitors it may be beneficial to run an orientation program prior to the visit (e.g. teacher tells about the museum to children before the visit). Orientation can also be facilitated with cues which guide an (unguided) visitor (Rennie and McClafferty, 1995). Finally, visitors should not be voiceless in the museums but they should rather be encouraged to interact with the environment (Hall and Bannon, 2005) and with each other.

There exists substantial evidence on positive outcomes related to museum visits. For example, Falk and Balling (1979) reported the development of positive attitudes and cognitive learning; Koran and Koran (1986) suggested that a museum visit is an interesting experience which raises curiosity, affects psychomotor development, interest, appreciation, motivation, and generalization; and Wolins *et al.* (1992) reported affective/emotional experiences. These outcomes relate to all three dimensions of learning in Bloom's taxonomy: cognitive (knowledge), affective (attitude), and psychomotor (skills). These are also emphasized in the evaluation of Hooper-Greenhill *et al.* (2003) which concluded that museums, archives and libraries impact learning in the following dimensions: (1) increase in knowledge and understanding (cognitive); (2) increase in skills (psychomotor); (3) change in attitudes and values (affective); (4) evidence of enjoyment, inspiration and creativity (motivational); and (5) evidence of activity, behavior, progression (conative). Given this support for a variety of learning types, museums are a useful context for investigating a wide range of learning activities from theory to practice.

Mobile and Wireless Technologies in Museums

Using technology in museums is not a new phenomenon as various technologies have been utilized over forty years – from reel-to-reel tapes to cassettes, and from digital players to mobile devices (Proctor and Tellis, 2003). Our focus is on mobile and wireless technologies as they are key elements of pervasive learning environments. Typically mobile devices are either PDAs or mobile phones, but Ultra Mobile PCs and Tablet PCs are also used. In the future we also expect to see more wireless *netbooks* (small and inexpensive laptops).

In addition to mobile device portability, personality, intuitiveness, and ubiquitousness, pervasive learning environments should also support location- and context-sensitiveness. Context-sensitive mobile-based systems have been used in museums and science centers before, including Xsplot (Hsi and Fait, 2005); Via Mineralia (Heumer *et al*., 2007); Tate

Modern's Multimedia guide (Proctor and Burton, 2003); and the MOBIlearn application in Nottingham Castle Museum gallery (Lonsdale *et al*., 2005)). Existing systems often utilize RFID or other smart tagging to implement context-sensitiveness. Positioning technologies (e.g. WLAN positioning, GPS) have also been used to make the system aware of the user's location (e.g. Wang *et al*., 2005).

PERVASIVE LEARNING ENVIRONMENT FOR A LIVING MUSEUM

Pielinen Museum

Pielinen Museum in Lieksa is the second largest open air museum in Finland, hosting over 70 old buildings and structures containing over 100,000 objects from different periods of time. Pielinen Museum is a *living museum* as it depicts how life used to be in Eastern Finland in the past. In 2007 and 2008 the museum attracted 8968 and 8692 visitors respectively. Figure 2 shows the Virsuvaara house exterior and interior, where our work has so far been concentrated.

Figure 2. House exterior (left) and interior(right) – the right half was used in the first experiments.

Authenticity is one of the strengths of Pielinen Museum and in order to keep the atmosphere authentic the buildings, structures and objects have not been equipped with tags and labels. Until now, the only way to know more about the objects and buildings has been through guided tours where information has been mostly one-directional and schedules of tours have not always been convenient. We sought a solution to these challenges in user-centered design workshops with museum visitors during summer 2008 before implementing the LieksaMyst pervasive learning environment described in below. Workshop attendees wished to know more about life in specific periods of time and how particular items were used and connected to other items. Some attendees also suggested that it would be interesting to hear authentic sounds (e.g. old master's snoring). A deeper analysis of the workshop data will be presented elsewhere.

LieksaMyst

LieksaMyst is the name for a pervasive learning environment (PLE) that we have developed in the Pielinen Museum together with a group of museum visitors and the curators of the museum. Rather than merely replacing the human guides, LieksaMyst offers possibilities for versatile interaction with the museum environment. LieksaMyst's core is a story-based role-playing game which takes the learner back in time to meet people who lived in the old houses and used the authentic objects for various activities. Together with these authentic albeit fictional characters, the learner experiences daily routines of the respective period of time. Interaction between the learner and the fictional character is done through the mobile device and the system supports text, images, sound and video. One game session can last from 20 minutes to several hours, depending on how much content is available and how motivated the learner is.

Currently we have created a story for one character living in one of the largest buildings in the museum, Virsuvaara. The character is Anna, the 40 year-old lady of the Virsuvaara house. She lives together with her husband, children, grandparents, servants and lodgers, in total 18 persons in a single room. Among her daily activities Anna tells and shows the learner for example how butter is churned, how carpets are made, and what kind of food was eaten in her house in 1895. The learner is also presented with various challenges ranging from intriguing queries to finding a specific object needed to complete an activity. These challenges are part of the interaction with Anna – she requests the learner's help in order to complete her daily chores. Object recognition is currently performed manually by typing in a short numeric code that is carved on an authentic-looking wood piece next to the respective object.

The learner is given the chance to select from various alternative story branches. At the end of the day as Anna wishes farewell, she prompts the learner to sign her guest book. This entry, together with the learning experience (story path) of the learner is stored on the server so that it can be presented later, for example on the homepage of the game for reflection purposes. In terms of social interactions in the game, learning situations often involve several learners using a single mobile device and several groups exchanging ideas with each other without explicit encouragement.

In addition to the role-playing game, LieksaMyst has also other learning tools available. Currently we have implemented a database discovery tool which allows context-sensitive access to pictures and text located in the museum database. We are also currently creating a learning tool through which the learner can retrieve context-sensitive information about any object and its usage via RFID tags. Rather than mere information retrieval, this tool will also allow recording of related

evidence and posting comments in the form of text, pictures, voice and video. Additionally, in the near future we will release an easy-to-use editor tool for curators to create and edit content for LieksaMyst.

CHARACTERISTICS OF PERVASIVE LEARNING ENVIRONMENTS

Currently there is no learning model established and tested to support the design and construction of PLEs (Laine and Joy, 2008). As the first step towards building such a model we have derived a set of characteristics based on inherently constructivist principles of situated learning, authentic learning, contextual learning, group-based learning, exploratory learning, problem-based learning and museum learning. We chose a hybrid approach as none of the existing models would alone suit PLEs for museums. Table 1 presents these characteristics together with references to supporting literature, rationale for inclusion, and analysis on how each characteristic has been implemented in the LieksaMyst PLE. The characteristics (15) have been organized into five categories: User profile and perspectives; Interaction and collaboration; Ownership; Authenticity and relevance; and Support and assessment.

Characteristic	Supporting literature	Rationale	In LieksaMyst
User profile and perspectives			
Multiple roles, perspectives and skill levels	Hall and Bannon, 2005; Kelly, 2002; Herrington and Oliver, 2000; Herrington *et al.*, 2003; Thomas, 2005; Falk and Dierking, 2000; Johnson and Quin, 2004; Csikszentmihalyi and Hermanson, 1995	In order to support visitors of various backgrounds, skills and interests, the PLE should provide access to various roles, perspectives and skill levels in an adaptive manner.	Multiple roles are provided through various fictional character and activities performed with them. As each fictional character can have several stories to share, it is possible to create a hierarchy of skill levels. Alternative learning tools offer possibilities for those who do not enjoy gaming.
Consideration of background, prior knowledge and experiences	Scanlon *et al.*, 2005; Kelly, 2002; Falk and Dierking, 2000; Schmidt, 1983; Sharples, 2003	Prior knowledge and experiences should be taken into account in learning activities. For example, a first-time visitor has different needs to a regular customer who visits the museum frequently.	Learners' prior experiences are currently considered through free choice of characters and stories that are based on feedback from design workshops. We are also planning to include personal profiles for learners who visit the museum often.
Interaction and collaboration			
Social negotiation and collaboration	Scanlon *et al.*, 2005; Hall and Bennon, 2005; Kelly, 2002; Csikszentmihalyi and Hermanson, 1995; Herrington and Oliver, 2000; Herrington *et al.*, 2003; Mims, 2003; Falk and Dierking, 2000; Savery and Duffy, 1994; Thomas, 2005; Sharples, 2003; Hein, 1990	Sharing experiences and facing challenges together facilitate effective learning.	Learners have the possibility to play together using the same device or interact with each other in a shared physical space. More collaborative activities are under development.
Multimodal exploration of the environment and objects	Mims, 2003; Johnson and Quin, 2004; Csikszentmihalyi and Hermanson, 1995	By exploring the environment through various senses the visitor becomes more attached to it.	The game encourages the learner to explore the environment through story-telling and various activities. Both visual and aural modalities are currently used. Some players also reported “old scent”.
Ownership			
Ownership of the learning process and outcome	Kelly, 2002; Csikszentmihalyi and Hermanson, 1995; Mims, 2003; Herrington *et al.*, 2003; Falk and Dierking, 2000; Savery and Duffy, 1994; Thomas, 2005; Sharples, 2003; Johnson and Quin, 2004; Hawkey, 2001; Hein, 1990	Ownership affects directly to motivation to learn. Furthermore, having control over one's own learning process is necessary for effective learning.	The learner is in control of the story in terms of pace and choices made (story branches). Learning paths and any recorded “evidence” are owned by the learner.
Ownership of the technology	Scanlon *et al.*, 2005; Thomas, 2005; Sharples, 2000;	In addition to increased motivation, owning the technology has direct consequences on the ability to use the technology effectively.	Although in the testing phase, a set of the museum's mobile devices are used. In the future the learners can use their own devices as the mobile technology is general and portable.

Authenticity and relevance			
Authentic context	Herrington and Oliver, 2000; Schmidt, 1983; Grabinger *et al.*, 1997; Falk and Dierking, 2000	Solving real world challenges cannot be taught effectively in an unauthentic setting. Authentic context is also important for deep immersion of the learner.	Exhibits in Museum of Pielinen are in a very authentic state due to local preservation policy. The look and even the smell of old objects seem authentic.
Authentic activities that have relevance to the real world	Scanlon *et al.*, 2005; Kelly, 2002; Herrington and Oliver, 2000; Herrington *et al.*, 2003; Mims, 2003; Savery and Duffy, 1994	Connecting learning activities to the real world is an important part of making the meaning of concepts. Without real world relevance, the concepts remain abstract.	Activities have been designed to be authentic with curators who possess expert knowledge on local history and old traditions. Real world relevance stems from the relation of the activities to the modern life of the visitors.
Compelling narrative to facilitate immersion	Hall and Bennon, 2005; Falk and Dierking, 2000	The PLE should employ a compelling narrative that helps the visitor to immerse quickly into the authentic context.	Stories are compelling and interaction with authentic characters helps in the immersion process.
Gained experiences integrated and applied across different subject areas	Herrington *et al.*, 2003; Mims, 2003; Sheppard, 2001; Hooper-Greenhill *et al.*, 2003	Knowledge can and should be transferred across disciplines. The PLE should allow generalization and linkage of the knowledge to other contexts and subject areas.	Due to the nature of the museum (living museum), the knowledge can be easily transferred to other "living contexts" to be reflected and compared. Furthermore, stories may have intersecting aspects for making connections.
Personal relevance	Scanlon *et al.*, 2005; Mims, 2003; Grabinger *et al.*, 1997; Thomas, 2005; Falk and Dierking, 2000	Learning activities in the PLE should have personal relevance, so the learner is able to construct a personal meaning of a concept.	Learners can relate learning activities performed with authentic characters to equivalent activities in their own lives, hence the personal relevance.
Support and assessment			
Scaffolding techniques	Hall and Bannon, 2005; Kelly, 2002; Csikszentmihalyi and Hermanson, 1995; Herrington and Oliver, 2000; Mims, 2003; Savery and Duffy, 1994	Support should be available when the learner needs it the most, and it should be faded out when the learner can face the challenges themselves.	Scaffolding is something that could be improved. Currently, authentic characters and guides give hints and suggestions to the learner but the learner's skill level is not measured so as to adapt the given help.
Support for reflection	Rennie and McClafferty, 1995; Kelly, 2002; Herrington and Oliver, 2000; Herrington *et al.*, 2003; Falk and Dierking, 2000; Savery and Duffy, 1994; Johnson and Quin, 2004	The PLE should offer possibilities for reflection during and after the museum visit. During reflection new knowledge is linked to existing mental models and prepared for future linkages.	Currently post-reflection activities are not explicitly supported but in the near future a website will be launched which presents stored learning experiences for further reflection and commenting.
Immediate feedback	Csikszentmihalyi and Hermanson, 1995	Immediate feedback is necessary to promote reflection and maintain intrinsic motivation.	The learner is provided with immediate, choice-dependent feedback after each activity.
Integrated, authentic assessment if applicable	Herrington and Oliver, 2000; Herrington *et al.*, 2003	Sometimes assessment is wanted. In such cases the PLE should offer a possibility to perform assessment integral to the learning process.	The application is not being used for assessment purposes as we aim to raise intrinsic motivation rather than extrinsic. However, there is a currently disabled feature that counts points for players according to their performance.

Table 1. Characteristics of pervasive learning environments for museums

EVALUATION AND DISCUSSION

As evaluation we present part of the results of experiments conducted in the Pielinen Museum during November-December 2008. Participants used only the role-playing part of the game – the database discovery tool was not part of the agenda although some players voluntarily explored it. These results show the first impressions and attitudes of the players, and represent only a subset of the entire study.

Test scenario

In total 49 test participants were included in this test. Participants were of various nationalities: Finnish(31), Polish(4), Korean(4), Nepalese(2), Russian(2), German(1), Chinese(1), Pakistani(1), Latvian(1), Czech(1) and South African(1). The game had two language versions (Finnish and English). Testing was conducted in the Virsuvaara house from the 19th century which is one of the largest buildings in the museum. For the experiment we designed a two-part questionnaire – the first part to be filled before playing (demographics, previous mobile usage, attitudes, media preferences) and the second part after playing (after-game experiences, perceptions). Observations of the participants were also recorded.

We ran four test scenarios with different groups: (1) a group of local children from 7th grade; (2) a group of local senior teachers; (3) a group of foreign exchange students; and (4) museum staff and visitors from South Korea. The first three groups were selected to represent different ages and cultural backgrounds, and the last group was used as to receive the museum staff's perceptions as well as more international perspectives. Before participants were taken to the test location, they were given a short presentation of the museum and of our educational technology research in general. After the presentation, the first part of the questionnaire was filled and then followed the actual game play in Virsuvaara. The amount of time spent for playing varied from approximately 15 minutes to 45 minutes, and participants were either playing individually, in groups of two (most cases), or in groups of three. After the game play the participants were asked to fill in the second part of the questionnaire. Nokia N95 and N80 phone models were used in tests.

For the first test group (local 7th graders) we (accidentally) did not remove object codes from the user interface as we used these codes for internal testing previously, hence locating objects was not a challenge for the participants. This was the major complaint heard in the questionnaires of the first group. Some players in other groups also noticed that the codes are in sequential order, thus guessing the next code was easy.

Evaluation results and discussion

The average ages of males (49%) and females (51%) were 28.73 and 30.28, respectively. All test participants owned mobile devices, even the school children, thus penetration of wireless communications amongst them was very high.

In the pre-test questionnaire we asked for participants' perceptions of museums in general. We compared these answers with the answers to a question which measured participants' perceptions towards the test day experience in Pielinen museum in the post-test questionnaire. In the pre-test questionnaire the statement was "In general, I think museums are:" and the answer options with respective results were: *Boring* (4.1%), *Interesting* (75.5%), *Exciting* (20.4%), *Unexciting* (2%), *I have no opinion about them* (6.1%), and *Other* (4.1%). The two participants who answered *Other* gave further explanations as *Interesting* and *Something*. In the post-test questionnaire equivalent statement was: "I think today's visit at Pielinen Museum was:" and the answer options with respective results were: *Boring* (6.1%), *Interesting* (89.8%), and *Other* (14.3%). *Other* answers were amended only with positive comments such as "exciting", "quite ok", "interesting and enjoyable", "wonderful" and "really, really nice and interesting". Those who answered *Boring* were from the first test group and it is possible that the presence of object codes in the user interface affected their experience. The sum of percentages in these answers exceeds 100% as some participants checked (against instructions) more than 1 option.

We also asked in the post-test questionnaire if the participants would be happy to come back to Pielinen museum (91.8%) or if they would not be interested in coming back anymore (8.2%). From four who were not interested in coming back, three were from the first test group and one from the exchange student group. In order to discover participants' perception of LieksaMyst, we presented them two statements with scale Strongly Agree(SA) – Agree(A) - Disagree(D) - Strongly Disagree(SD) with weights 1, 2, 3 and 4, respectively. The questions and the respective answers are presented in Table 2 together with average and standard deviation values. Sum of the percentages on the first statement exceeds one hundred as one of the participants answered both D and SD.

Statement	***SA(1)***	***A(2)***	***D(3)***	***SD(4)***	***Avg***	***StDev***
I think I would like to try the game again here next summer.	44.9%	44.9%	8.2%	4.1%	1.68	0.74
I think I would like to try the game also in another museum.	40.8%	53.1%	4.1%	2%	1.67	0.66

Table 2. Participants' perceptions of LieksaMyst

Analysis of these tests regarding pre- and post-conceptions of museum visits and the game reveal that a good majority of the participants considered museums exciting and interesting places before trying the game. This could be due to fact that the participants came to test the application to the museum voluntarily, thus they might be representatives of the general population that prefer museums. After playing the game, the visitors' conception of the visit was very positive and a strong majority expressed their willingness to return back to the museum and try out the game again in Pielinen Museum and other locations as well. We consider this a strong indication that the game was well received by the audience.

Finally, we asked the participants open questions about their likes and dislikes about the game. Table 3 presents the most common and interesting answers. Where applicable, we have included in parentheses references to the characteristics

presented in Table 1. This was an interesting result as we did not explicitly relate the questionnaire to the table of characteristics and these aspects were articulated by the participants. Usability issues were reported mostly by the group of senior teachers, thus there is a clear need to improve the game to fit all ages. These results suggest that we should improve image quality, screen size, add audio narration and provide other tools in addition to the game to explore the museum, as not everybody favors games.

What did you like/enjoy about playing with Anna?	***What did you dislike or find difficult about playing with Anna?***
I could find out new things. Anna's intermediate comments were good, Male 13. (Immediate feedback)	Difficult to see the numbers [because of dark room], for me a little bit too much story telling, Male 26. (Multiple perspectives, skill levels)
I was feeling as if I was helping her and knowing things like making coffee, butter and know about the Finnish fire place, Male 24. (Authentic context, activities, and immersive story)	Pictures are not reproduced well enough due to small screen size of the client device, Male 55. Character keys are too small so I made errors unintentionally, Female 75.
The nice thing was that it was possible to get information through playing and action. It was nice to kind of discuss with Anna, Female 30. (Immersive story)	Most of conversations are just text. I think sometimes it should be better [if] the text will be explained on voice, Male 29. (Multimodal exploration)
Getting to know how Anna's typical day looked like, Female 23. (Authentic activities)	That the object numbers were already visible, Male 13.
It was a good simulation and I felt as if I was actually involved in the situation, Male 22. (Authentic context, activities and immersive story)	Before playing with Anna, it would have been better if I had an introductory guided tour about the house, Male 46. (Prior experiences)
I liked it when I had to start searching for objects, Female 13. (Multimodal exploration)	Anna's comments were sometimes annoying, Female 13. (Multiple perspectives, skill levels)
I could control the pace of game; I got to know how those old objects were used in the 19th century, Female 21. (Learner's control)	Few questions which were quite interesting but being a non-Finnish I found them difficult, Male 22. (Consideration of prior knowledge, background)

Table 3. Participants' likes and dislikes regarding playing with Anna

CONCLUSIONS

LieksaMyst PLE solves the problem of unmarked objects and information in the Pielinen Museum. At the same time, the museum visit becomes more exciting and engaging, thus having a potentially positive effect on visitors' attitudes towards museums. As the system was developed together with museum visitors and curators, the end result was highly compelling and met many visitors' expectations. Evaluation showed that the game part of LieksaMyst was well received and its story-based immersive game play would have potential in other museums as well. We concluded also that LieksaMyst met most of the characteristics of pervasive learning environments that we derived based on a large body of literature on existing constructivist learning models and theories.

In the future we will refine LieksaMyst to fully conform to the characteristics of PLEs and test the technology in other locations as well, not limited to museums. We will continue further our efforts to develop a sound learning model for pervasive learning environments that will fill the existing gap and will therefore be the basis of future PLEs.

ACKNOWLEDGMENTS

We would like to express our gratitude to curators of Pielinen Museum and those visitors who contributed to the design process of the LieksaMyst. Development of LieksaMyst has been partly financed by the National Board of Antiquities.

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