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Research Articles

"Premierløytnant Bielke":
A Mobile Game for Teaching and Learning History

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ABSTRACT

Developments in mobile phone technology, together with an increased research interest in utilizing computer games to facilitate teaching and learning, are an important catalyst for the emergence of the area of mobile, location-based computer games in schools. This article describes both the design process and an evaluation of Premierløytnant Bielke, a mobile, location-based game for teaching and learning history using mobile phones. We argue that by using the surroundings and milieu that are local to the students in a playful context, we can support the construction of meaning related to the subject of history in a way that is both engaging and worthwhile.

Keywords: Evaluation, Location-Based Games, Mobile Learning, Teaching And Learning History

INTRODUCTION

There is an increasing interest in how computer games impact education, and how they can be utilized to facilitate teaching and learning. In addition, schools are conscious of integrating technology that is in use in the everyday life of students into the learning experience. In a relatively short period of time, mobile phones have become an integral part of the lives of people, including students, all over the planet. From the cumbersome devices of the 1980s, mobile phones have evolved to be highly connective, fast and small computers. These technological developments have made it interesting to explore how mobile technology can be put to educational use, and in particular, how mobile educational games can be designed, developed and adopted. In our research, we developed a mobile, location-based educational game to investigate how the nearby surroundings of the intended users can provide meaning to a subject being studied.

This article describes a mobile educational game, Premierløytnant Bielke (Lieutenant Bielke in English, PB hereafter), played by competing teams, which has been designed and developed for teaching and learning about local history in Bergen, Norway. Through animated geographical surroundings, such as buildings and geological topology, the game gives the students insight into a historical period in

time. The article also describes and discusses a field trial of PB in use. Attention is devoted to whether the game may prove useful in an educational setting, and how the findings relate to our goals and intentions in developing the game. Whether the game has an educational use potential or not has been a guiding light in designing and implementing the field trial, and here our focus lies in the participants' immersion within the game, whether playing it is an engaging experience or not, and whether and how it supports collaboration. We have also been interested in the more imaginative aspects of playing the game in the location-based setting; does the combination of physical surroundings, augmented with textual information, wrapped in a competitive, quest-like location-based game, help the learner imagine the historical period that we are portraying? Since this field trial was the first test with participants other than ourselves, we also focus on evaluation of the usability of the technology.

The structure of the article is as follows. First, we provide a review of relevant research and developments in the fields of computer games and learning, mobile computer games and learning, and location-based education. Then we describe the research methods used in our study. Third, we describe the field trial scenario and the technological infrastructure represented in the PB. Finally a description and discussion of our main findings is provided.

RELATED WORK IN LEARNING WITH GAMES AND PLACE-BASED EDUCATION

Prensky (2001) has described the young generation as digital natives, where the computer is considered a naturally embedded part of youth culture. Several authors (e.g., Fromme, 2003; Gee, 2003) highlight that computer games are a significant element of computer use for the same generation. The impact for society in general is also notable. The first references to the notion that the gaming industry has surpassed the movie industry in annual turnover, for example, are now many years old (Schirra, 2001). The gaming industry and computer games are becoming an increasingly significant cultural phenomenon or an "enculturation force" (Halverson, Shaffer, Squire, & Steinkuehler, 2006, p. 1049). Computer games have also been entering the educational sector on several levels for quite a while. According to Egenfeldt-Nielsen (2006), the first experiments with computer games in the classroom started in the early 1970s.

Mobile Games

The first game developed for the mobile phone, Snake, was supplied with the Nokia 6110 model in 1997. Other games that exceed Snake in functionality, exploiting the possibilities of mobile devices further, have been growing in numbers in recent years. Interesting and pioneering examples include ARQuake (Piekarski & Thomas, 2002), which is a game that has been developed from the Quake platform for PC to an outdoor gaming experience, by using GPS and a head-mounted graphics display. Cheok et al. (2004) have described an augmented reality (AR) version of Pacman, Human Pacman, where game players take the roles of ghosts and Pacmen. This idea has also been deployed on the streets of New York, in the game Pacmanhattan ("http://www.pacmanhattan.com"). Flintham et al. (2003) describes two games: CYSMN? (Can You See Me Now?) and Bystander. CYSMN? is a game where 20 online players seek to avoid being caught by 3 real-life players on a shared map of an actual location. The real-life players' positions are represented by GPS data, which is transmitted through an Internet radio channel, and shown as icons on the map available to the online players.

These games are often labelled as Augmented Reality (AR) (Klopfer, Squire, & Jenkins, 2002) or Pervasive (Magerkurth, Cheok, Mandryk, & Nilsen, 2005). They often rely on displays that make digital content available relative to the players' geographical position in the real world, wireless technology to facilitate communication, and sensing technology that captures limited elements of the players'

context (Benford, Magerkurth & Ljungstrand, 2005). Klopfer, Squire, Perry, and Jan (2005) have argued, from the perspective of teaching and learning, that through using the 3D characteristics of the real world, and augmenting them with layers of data, thus bridging the real and the virtual world, students are offered the opportunity to interact with compellingly rich pedagogical environments.

Mobile Games in Education

There are several examples of mobile games that are explicitly directed at education. One is Environmental Detectives (Klopfer et al., 2002). This game operates on a location-aware hand held computer, and puts the student in charge as an environmental detective responsible for investigating a toxic leak at a real geographical location. While Environmental Detectives facilitates intra-group collaboration, two further games have been designed to facilitate inter-group collaboration; Charles River City, a game about environmental science and epidemiology, and Mad City Murder, which uses the principles from Environmental Detectives to create a mystery investigation (Klopfer et. al, 2005). Another example of an educational game that is based on location-awareness and collaboration is CatchBob, which is aimed at students in higher education (Nova, Girardin, & Dillenbourg, 2005). Experiments with Catch-Bob have attempted to explore how location awareness impacts socio-cognitive processes. Another example is the natural science game of Savannah (Facer, Joiner, Stanton, Reid, Hull, & Kirk, 2004), in which children take part in a safari with the twist that participants take the role of the animals (lions) themselves. Opportunity for reflection is provided in the second part of the dual space of the Savannah and the Den, where the game players are encouraged to reflect on the contingencies of being a lion on the savannah.

Like many of these games, PB also incorporates an element of role play, but differs in the notion of place vs. position. PB is tied to a specific place, the area of Sandviken in Bergen,

Norway, and is only meaningful while being played there. Games like Savannah could in theory be played anywhere; it is the position of the players that triggers game actions. An example of a mobile educational game that has some similarities with PB is Frequency 1550 (Admiraal, Raessens, & van Zeijts, 2007), a mobile history game where students learn about medieval Amsterdam. PB is similar to Frequency 1550 in that it is a competitive location-based game with a quest-like nature, but the games are also different in some ways. Frequency 1550 has a control-room metaphor where parts of the team take the role of a HQ, and the other part is on the streets of Amsterdam. In PB, the entire team plays together for the duration of the game, making the team members' experiences more consistent. Another difference lies in the organisation of the technology, which we have designed so that it is possible to rapidly implement new game ideas using the same technological infrastructure. PB in this way can be seen as an instantiation of the available technological infrastructure that can be used, for example, in a school history-teaching endeavour, but also in a teaching endeavour about creating games themselves.

Mobile Devices, Motivation and Learning

Mobile devices are not designed explicitly to facilitate learning, but rather as personal devices to support private and professional communication and information management. Educational technology research has extended their use into the areas of learning (Kukulska-Hurme & Traxler, 2005), for example by enhancing and augmenting exhibitions at places such as museums. Walker (2007) describes a project about letting visitors to a botanical garden create personal learning trails by capturing the presented material using mobile phone technology for later visits, in order to personalize and enhance the learning processes. O'Hara et al. (2007) similarly focus on collecting content in their study of using 2D barcodes to be interpreted by mobile phones, as a way of enhancing the

visitor's experience of the exhibits at London Zoo. From our perspective, we have tried to create an *outdoor, ad-hoc museum,* within the context of a game. The museum appears within the boundaries created by the textual information presented on the mobile phones, the physical surroundings of building structures and their placement, and the students' engagement with these, in a social context.

One of the main reasons for designing the game activity as a competition between teams is that we hope that it will have a motivational effect on the learners. In their meta-study, Qin, Johnson, and Johnson (1995) conclude that learners competing in teams outperform competing individuals when solving problems, both linguistic and non-linguistic, with well or ill-defined problems. Hämäläinen, Manninen, Järvelä, & Häkkinen (2006) are also optimistic about the pedagogical potential of computer games in supporting collaborative activities, and how these collaborative activities in turn can facilitate learning. Their focus is on higher-order thinking skills such as problem solving or spatial skills, in addition to social skills. Järvelä & Salovaara (2004) point out that while social and collaborative learning practices are becoming increasingly popular, more research on the motivational aspects of recently developed technology-based classrooms is needed. The authors take the position that that competing in a playful game-like situation is potentially both more motivating, and less dangerous, than competing for good grades in a classroom setting, for example.

Through the design of our game, we have intended to support learning processes in a number of different ways. By creating a game to be played in teams, we intend for discussions between team members to take place about the possible courses of action, which in turn can create engagement in the learners. Possible learning outcomes of this can be both social and more factual. We envisage that the competitive setting will help create engagement in the learner, without wanting to imply that learners are inherently unmotivated. Furthermore, we are getting at the learners' capabilities for

imagination, which in this setting is to picture the historical events represented in the game, in a setting where they actually took place. Finally, we use text to provide both a set of facts and game information, interwoven.

Place-Based Education

One source of influence for the work reported in this article is the educational philosophy of place-based education (Sobel, 2004). The main ingredient of place-based education is to base education on resources and problems found in the students' own community, such as local history, culture, and local environmental issues. The origin of place-based education can be found in Dewey's ideas (1915) of bridging the gap between classroom learning and the world that we live in, by letting learners experience real phenomena in context rather than abstract ideas about phenomena out of context. This is also related to the educational tradition of experiential learning where the focus is on learning and meaning making from first hand experiences with phenomena.

Place-based education is popular in learning about multidisciplinary issues (such as environmental issues), often carried out as teamwork, and builds on connecting students with community resources such as local government, parents, and local businesses. Besides learning about the subject matter using this model, place-based education aims at turning students into informed citizens so that they can participate in community processes "asserting that children are as much citizens as adults and need to be given opportunities to share their knowledge, perspectives, and insight with regard to important community issues" (Smith, 2002, p. 591). For our project we have collaborated with the local City Inspector of the Inspectorate of Ancient Monuments and Historical Buildings ('Byantikvaren'). Together with them we have the vision that this will be an activity that raises the student's awareness about local cultural heritage, which may in turn lead them to care more about their local community, and in addition, be more knowledgeable about

the importance of preservation work. There is a risk of becoming too introverted in place-based education, by exclusively focusing on local issues instead of larger global issues. However we see our effort as a way to illustrate for the students what global moments meant for the local community of Bergen. In particular we provide a perspective on what the Napoleonic Wars meant for shaping the community of Bergen, an event that altered its living conditions in many ways. As a way of understanding the global, our point of departure is the local.

Although the approach of place-based education is often more comprehensive and encompassing in scope than our work, as far as it involves community participation, we are inspired by this concept. By playing PB, we hope that participants will experience parts of the local history of Bergen in a concrete yet imaginative manner, believing that place-based education can create engagement and enthusiasm (Liebermann & Hoody, 1998). In particular we see our contribution in creating motivating and engaging activities for the learners using mobile games as a fun way to learn about local history and cultural heritage.

DESIGNING MOBILE GAMES FOR LEARNING

The following sections contain an account of the design process of the game at hand, including characteristics of the game user interface and game administration. The technological infrastructure consists of several integral parts, and the computing that is done is highly distributed. The background of the historical period that the game encompasses is also introduced.

The game PB is a location-based game for the mobile phone, designed to support teaching and learning of history. It builds on developments undertaken as a part of the MOTEL project (Baggetun, 2009). A single player can play the game, but we envisage the typical game play to be organised as a competition between groups, sharing a phone. The historical theme is the town of Bergen, Norway, during the pe-

riod of the Napoleonic Wars. With background and context from the event of "The Battle of Alvøen" in 1808, the game player is asked to organize and control the building of small vessels for the protection of the marine trade routes to and from Bergen. The player is given tasks, displayed on the screen in text, dependent on his or her geographical position. The tasks are to find a place or location, relevant to the building of the vessels. The player navigates the town using a scrollable map displayed on the screen, and a distance meter that displays the distance to the relevant places in meters. When the relevant location is found, an icon indicating that the task is completed is displayed, and the text for the next task is displayed. The goal is to complete the game with the lowest possible score. Points are gained one for each minute played, in addition to number of hints used. Geographical position is determined by GPS, either internal to the phone or connected by Bluetooth.

The Technological Infrastructure in Support of PB

Web administration interface: Game data and parameters are set through the Web-based game administration interface. The game administration interface is written in Django (http://www.djangoproject.com/), which is an open source framework for developing Web applications, written in Python programming language. The storyline, or what happens at each location, is also added to the game using this interface. By separating the game from the game administration interface, and making it accessible on the Internet, we allow for the rapid implementation of future game ideas, using the same technological infrastructure. The information is then packaged in a zip file that can be transferred to the phone by Bluetooth or other means.

From the game administration interface, a user can add a game name, start and stop times, participating groups, and a map to be displayed on the mobile phone, with relevant zoom and section. The game consists of several locations, each accessible by clicking the markers on a

map in the administration interface. Clicking anywhere on the map adds a new marker, and thus a location in the game. For each location, information such as a name, text, an icon and hints are added. The GPS-coordinates are added automatically when clicking the map. The map that is used is openstreetmap.com, which is a community-based, open source and Web-accessible map (http://www.openstreetmap.org). Figure 1 depicts the game administration interface.

Mobile Phone client: PB is written in PyS60 (Python for Symbian 60), which is a version of Python customized to work for mobile phones. It works for Nokia phones, in addition to a limited selection of other brands (Samsung, Panasonic, and LG). PyS60 is aimed

at rapid development of prototype applications (Scheible & Tuulos, 2007).

The client application, when launched, checks for and installs data from new zip files on the phone memory card when opened. If no new data files are found, it starts the game using the most recently installed data. On the screen, four elements are visible to the user; a map in the background, a distance meter in the top right corner, an icons bar on the left side, and a menu bar at the bottom of the screen (Figure 2). At the current stage of development, the map is scrollable, but not zoomable or player-position centric. The distance meter (initially in red text) displays the distance in meters to the next location, and updates every 5 seconds based on GPS data. When the player is within the specified radius of the location (40 meters)

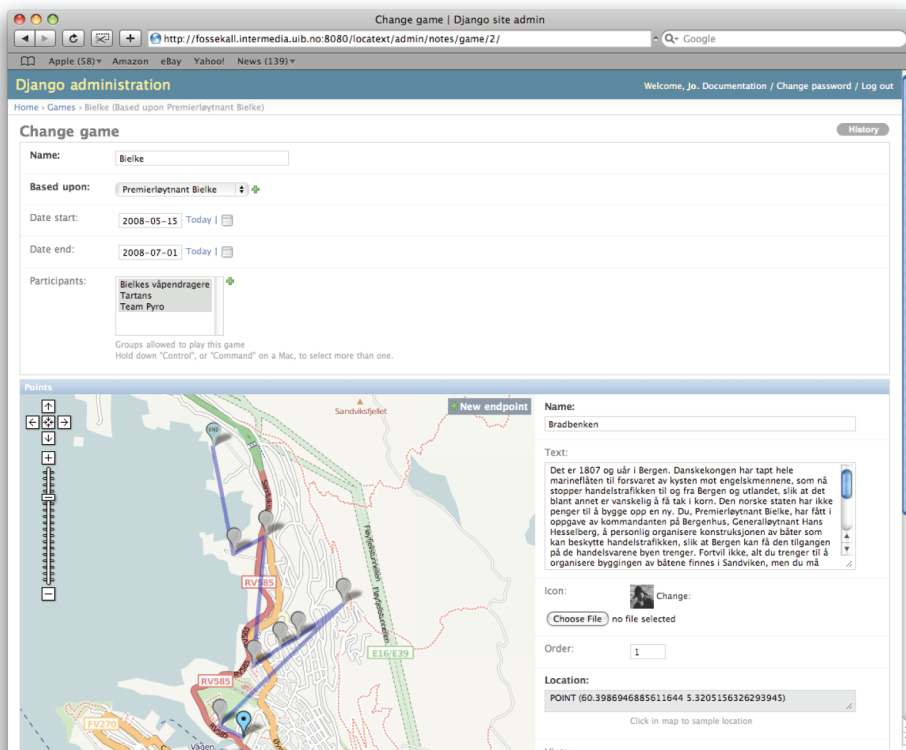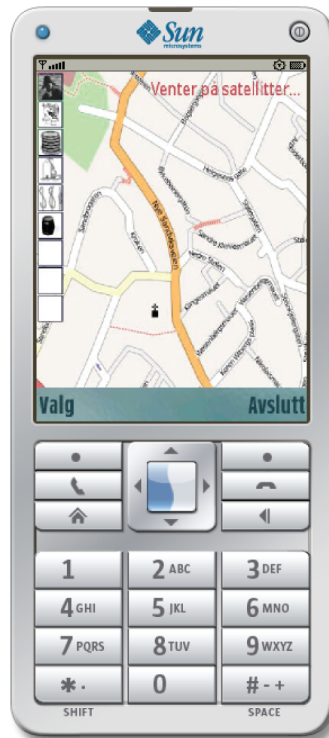*Figure 1. Web-based game administration application*

Figure 2. The PB game as it appears on a mobile phone. For clarity, the screenshot was made on a mobile phone emulator without connected GPS, hence the display of 'Venter pa satellitter…' ('Waiting for satellites') instead of an actual distance.

the text turns green. In the version of PB that was played in relation to this particular field trial, the radius was set to 40 meters, but the radius around each location is easy to change, through altering the code in the phone application. The icons bar displays an icon for each location that the game player has successfully "picked up," and empty spaces indicating how many there are still left to pick up. From the menu, the game player can choose to pick up locations, display and re-display the most recent task assignment and hints, and check the current game score. Interactions are mostly done using the standard Symbian menu system. Figure 2 illustrates the game application on a mobile phone emulator.

Historical Background in PB

The historical period that is portrayed in the game is, as mentioned, Bergen during the Napoleonic wars (1803–1815). Norway was in a union with Denmark, and was drawn into the wars on the French side, after the British confiscation of the fleet belonging to the Danish Royal Navy, located in Copenhagen. This event left Norway in a state of war against Great Britain, and simultaneously unable to protect marine merchant trade routes. This in turn led to famine in Bergen, because the town was, under these conditions, unable to obtain sufficient amounts of grain, which was normally imported from Denmark. This nurtured a need for amending the situation. However, the state

of the Norwegian economy at the time excluded the public building of any large navy ships. The solution was to build a number of small and low-cost gunboats, financed by private means. The task of organizing the new approach to naval defence in Bergen (both organizing the training of seamen and operation of the boats) was left to a young officer, Premier Lieutenant Bielke, who was brought in from outside Bergen. His arrival in Bergen is also the starting point for the computer game, where the players are asked to take his role, and organize the building of the gunboats. Bielke later became something of a celebrity in Bergen for his role in the "Battle of Alvøen," where he used 5 of these boats and favourable weather conditions to defeat an English frigate in 1808, despite being at what must have been understood as very much unfavourable odds.

The decision to base the score system in PB on time was mainly made to draw a connection to aspects of the actual historical situation portrayed in the game. The state of famine needed to be amended as quickly as possible. Also, Premier Lieutenant Bielke's personal diary from his time in Bergen, reveals that he received the first of the boats available to him just months before the Battle of Alvøen took place, leaving him very little time to train the crews and get to know the boats. By basing score points on actual time used, we hope to inspire a sense of urgency when playing the game.

Several of the sites and buildings that were relevant for the construction of the boats still exist today, although they are not in operation. Through game play, students will be able to experience the sites relating to their significance, function and appearance as they were in the early 1800s. Relatively familiar surroundings, some similar in appearance to the 1800s and some completely different, are presented in the new context of a computer game. The surroundings and environment local to the students are thus animated to facilitate a learning experience. Examples of the sites relevant for boat-construction that are included in the game are rope factories, a shipyard and a cooper's shop area.

In the initial phases of the design process, the target user group for PB was students in primary and secondary education, learning about history. Although the game is still mainly intended for school use, we also envisage application in other areas, such as tourism or life-long learning. The mobile phone has become a ubiquitous device, used by members from almost all strata of society (Ling, 2004), and there is no sense in excluding any of these potential user groups. Data from this field trial have helped to convince us that the game can also be interesting to play for other age groups.

Game Play

When starting the game, the player is presented with a text message that pops up on top of the map, and identifies him or her as Premier Lieutenant Bielke, and described the task at hand, which is to build gunboats in the above-mentioned historical context. The player is then asked to obtain construction drawings for the boats, and provided with clues for where they can be found. The next task is raising funds for the boats, which is operationalized by having them seek out the summer residence of a particularly wealthy, named family in the 1800s, which is a well-known viewpoint in Bergen today. The players have the option of using up to three hints for each task, at the cost of score points.

Figure 3 illustrates the interaction process when picking up a spot (location). In the leftmost picture, the distance meter in the top right corner tells the user that they are 138.5 meters away from the next location, (displayed in red numbers.) In the second picture from the left, the user has reduced the distance to 31 meters, upon which the numbers turn green. The icons bar on the left of the screen is empty. In the middle picture, the user chooses "Pick up spot" from the menu, and is given the first game mission, to find the construction drawings for the boats. This must be done by finding the commandant of the fortress of Bergen ("Bergenhus"), as the text in the second screen from the right describes. When the user has read the text, and

*Figure 3. "Pick up spot (location)" interactions in the game*
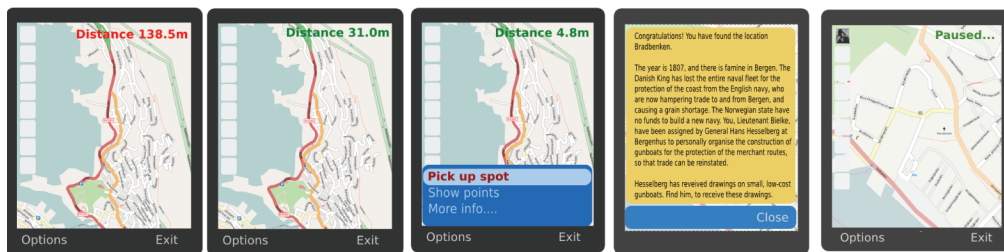
closes the text-overlay, the mode is returned to map view. The distance meter indicates that the game is paused, and the icon for the first location is displayed in the icons bar. The icon is a picture of a man with a uniform that looked like the one Premier Lieutenant Bielke wore. The game is automatically paused so as not to stress the players when reading text, and has to be restarted by the player. The latter functionality has been added since the completion of the user test described here.

Figure 4 illustrates the interaction required for obtaining and displaying game mission hints. The hints are somewhat important, as all the locations in the game have to be visited in a pre-specified order, and missing one will prohibit the player from finding the rest. Three hints are available for each location, and are graded regarding information value and game score. Using one hint adds one point to the score, using the second hint adds two points, and using the third and last hint adds five. The last hint makes the location very obvious. From the menu, the user chooses "More info" as seen in the picture to the left. (The user also can find

the game score from the same menu.) Then, he or she chooses "Give me a hint," as seen in the centre picture. The hint text is then displayed on a similar background canvas as the game mission, as can be seen in the picture to the right. The hint displayed in this example tells the user the general area in which he or she will find the commandant of Bergen, as described in Figure 3. The use of hints is optional, and meant to be used if the group of players is left with no idea of what to do with a game mission. We want to facilitate group discussion about possible courses of action based on the text describing the game mission first and foremost, but at the same time we have to ensure that the locations are actually found.

Jakob Nielsen's evaluation heuristics (1994) of error prevention and control, visibility of system status and recognition rather than recall have been used to cast light on aspects of the user interface. The aim is to highlight aspects of his heuristics that are relevant to the game play. Related to the principle of error prevention, a file, which contains the most recent values of the game state, is constantly saved to the phone.

Figure 4. Obtaining and displaying hints
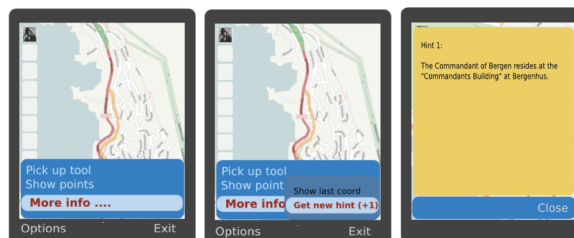
Should errors occur, such as memory overload, or the player inadvertently pressing the exit button on the phone, at game start-up they are offered the choice to "resume last game." This is particularly important, as each location must be visited in a specified order.

The system status changes relative to the players' progress in the game, and the visibility of the system status thus becomes a matter of providing cues about game progress. The overall progress in the game can be inferred from the remaining number of empty spaces in the icon bar. Between the locations, the distance to the next location is displayed by the distance meter, which updates continually. When deciding upon a course of action, which always involves deciding on which direction to walk, the distance meter value will either rise or fall depending on whether the game players are walking away from or toward the correct location. Furthermore, the speed of the value change depends on the angle between the correct location and the direction of the players, in addition to speed of movement. Because the distance meter updates continually, the user can always tell whether the game is running or has stopped. The current score can be accessed from the menu at the bottom of the screen, but since the game is arranged as a competition, the score really only has meaning when compared to other group's scores. This is an issue for future development, as continual feedback on the relative scores of other groups of players at that point in the game would presumably greatly enhance the experience of competition.

The principle of recognition rather than recall is about not relying too heavily on the user's mnemonic capabilities. One way this has been implemented in the game has been for the users to be able to re-display the text describing the task, and the hints from the bottom menu. In a competitive setting, it is very likely that eager players may read the text quickly to save time, and thus forget central key words in the description of the task.

EVALUATION

In this section we will present how we evaluated PB during its development and through a field trial with a group of users.

Methods

As part of our research and development efforts we have carried out various tests of the PB game. During development we have ourselves, as the designers, tested both minor usability issues such as graphics and menu organization, but more importantly we have also fully tested the PB game, testing and playing various release versions of the game ourselves, from start to finish. We regard it as important to conduct these tests ourselves, as we see this as a way for us to establish a reflective practice (Schön, 1983), trying to take the role of a user. While it is certainly problematic, for us as the original designers of the system, to test pure usability aspects of an application (e.g., if the menu organization is intuitive or not), we are ultimately interested in finding out to what extent we have facilitated a particular type of experience. The physical space in which our game takes place is an integral part of the game experience itself, thus we have made a point of self-testing the game within the boundaries of this physical space. One argument in favour of doing this self-testing when developing mobile applications, perhaps in particular when the application is a game, is that the testing of mobile applications is associated with a distinct set of methodological challenges (Isomursu, Kuutti, & Väinämö, 2004), when compared to the evaluation of classical desktop applications (Jones & Marsden, 2006). Evaluating mobile applications can be more difficult and complex, for example in how to follow and observe a moving user.

As a follow-up to self-testing the game we conducted a field trial with a group of nine participants. The data that forms the major empirical basis for the study reported in this article came from this particular field trial. There were two female and seven male participants and we organized the participants into teams

of three. The test participants were between 25 and 35 years old. Each group was given a GPS enabled mobile phone with the PB game set up and configured. Before the game was started we instructed the participants about the functionality and required interactions with the phone, game play/story, and the rules of the game. Each group then completed the route for the game, and was assembled after completion of the game for an informal group interview session.

During the field trial we observed the groups in a highly non-obtrusive way. Observations during the game were mainly undertaken to find out whether they were engaged in the game or not (if they took the game seriously and if we could see signs of immersion). We did not follow any of the groups closely, for example by walking together with them, as we have experience from other projects that this can be too disturbing for the participants. Immediately after completing the game, the participants responded to a questionnaire. The questionnaire was organized around two themes, in two separate sections. The first theme was personal habits and customs regarding their mobile phone use, while the second theme asked them about their experiences in playing the game. The questionnaire consisted of about 50 questions. Some were questions with "yes," "no," or "don't know" answers. Others were scale questions, with six degrees from "totally agree" to "totally disagree" response options. The second section was somewhat more encompassing. Further dissection of the themes and the responses to them are discussed below.

After the questionnaires were completed we carried out an informal group interview session, where positive and negative experiences of the game were discussed together with areas for possible improvement. Several suggestions for potential development of the game were made during this session, and the participants' views on the game were clearly expressed. By organizing the interview right after the completion of the questionnaire it was meant to give the participants and us the advantage that they could elaborate upon or ask about the questions in the questionnaire.

Findings

In the first section of the questionnaire we wanted to ask the participants about what the mobile phone meant to them on a day-to-day basis. The questions were organized around two sub-themes, 1) mobile phone habits and 2) communication and social activity. In the questions about mobile phone habits, we asked them about what kind of mobile phone they owned, including the technical specification (such as WLAN, Bluetooth, and screen resolution), and which of those they used and appreciated. We also presented a set of questions about criteria for choosing phones and service providers, and how often they changed these. In the section about communication and social activity, we asked about preferred modes of communication, how many people they typically used the phone to communicate with, and if they tailored the phone to suit their favourite use (e.g., changing front panel buttons) and personality (adding colour and skins). The overall goal of the first section of the questionnaire was to profile the existing habits of one of our target groups for our application in order to get answers to our assumptions and questions about the appropriateness and potential in using mobile phones as a mobile learning device.

Responses to the first part of the questionnaire indicated that the participants had a relatively high degree of confidence and literacy in using their mobile phones. Although these findings were not surprising, we still interpret these responses in favour of a shift, or evolution, where users are using their mobile phones for more than the two presumed core functions of telephony and messaging. Some reported owning devices with GPS and WLAN, and that they had connected the phone to their PC including installing new applications onto their phone, in addition to customizing the phone with themes, backgrounds, and re-arranging menus.

Several of the participants reported using the phone for playing various games. Further,

applications such as Calendar and "To do" notes were being used to organise and remember daily activities, and mobile Internet applications like Web browsers were also being used to some extent. However, instant messaging clients and media players were comparatively less used. One respondent, perhaps rather curiously, reported using the phone for accessing a TV channel's teletext service, through the channel's Web pages. All reported that using a mobile phone was easy. Although the minority reported owning a GPS and WLAN enabled phone and that they were only in the beginning of using mobile Internet services, we see this as part of a more general development where each person's mobile phone is being used to support an increasingly wide spectrum of activities.

The second section of the questionnaire, about experiences with the game, consisted of three sub-themes. The first theme was about how the participants experienced the competitive elements of the game, whether and how the participants immersed themselves, or accepted the imaginative conditions inherent in the game. Signs of immersion, experience of competition and presence of imagination within the surroundings are important to our study, as we regard these as indicators of overall engagement with a game, which is in turn how we have tried to establish the educational potential of PB. Second, we presented questions about which parts of the functionality were used in playing the game, and to what extent the different functionalities were used. Finally, we asked a set of questions about how the participants experienced the concrete surroundings of the game, the buildings and topology, and whether the gaming experience altered their perceptions in any way. Within this sub-theme we also asked questions about the group dynamics that emerged during game play. The latter sub-theme in the questionnaire is important, as it relates to our overall goal with the technology, to use mobile technology within the context of a game to facilitate learning about history, where the technology and "digital" aspects of the game are combined with elements and aspects of the real world. Whether the geographical

topology and surroundings actually appeared in a different light or not is thus central to our efforts. It should be noted that the participants in this particular field trial were not part of classroom-like social contingencies, and one of the main intentions for the game in the future is to be used as a part of a classroom activity. One possible effect of this could be that their focus on knowledge construction may have been toned down for the preference of learning and winning the game itself.

All of the participants reported a clear impression and understanding of the goal of the game, and that they managed to envision themselves as the main character of the game. Responses also indicate that the interface was easy to use and understand, and that the game was perceived as an overall engaging experience. The participants described the experience of competition as inter-group in nature, rather than as an individual or intra-group competition, indicating the presence of a sense of team spirit. The tasks were reported as adequately challenging, and not placed physically too far apart. The responses to the questions in the first sub-theme seem to indicate a presence of what Suits (1990) calls lusory attitude among the participants, an essential component of game playing. Lusory attitude is a mindset of the players, and can be understood as willingness to achieve the goal of the game (prelusory goal), through voluntarily adhering to the (restrictive and efficiency-reducing) rules of the game. Often, the goal of a game can be achieved by employing more efficient means, such as picking up the ball with your hands and throwing it into the goal in soccer. However accepting the limits on possible behaviours, or the rules of the game in other words, makes game playing possible. A lack of lusory attitude in the participants could cause them to not want to finish the game, not care about winning it, or try to win by breaking the rules or achieving the prelusory goal by more efficient means to use Suits' terms. Breaking the rules could be achieved by, for example, opening the game score data file using a text editor, and typing

in a game score number lower than all the co-competitors.

Regarding the more usability-oriented questions, some aspects or parts of the functionality and user interface were being used more than others. The text interface (describing the game missions) and the distance meters were reported as crucial tools for completing the game. The map and the hints were reported as being substantially less used. That the hints were used sparingly was to some extent no surprise, as using them reduced the chance of winning the game by adding points to the score. There is furthermore no sense in using hints if the players have an idea about how to solve the game mission at hand. The use of the map rated rather low, and this was more of a surprise to us, as it was always our intention to integrate appearances from the map with the game storyline. One possible interpretation is that the groups knew the area of Sandviken well beforehand. Some of the participants were native to Bergen, and all of them had lived in Bergen for a while, so this explanation is certainly viable. A test with younger participants, for example secondary or primary school students, may also have given in a different test result. We have, however, scrutinized how the map appears during game play, and have come to the conclusion that several improvements can be made to make it more informative after this field trial. The distance meter was close to unanimously reported as the main tool in completing the game, from an interface point of view.

The questions about how the surroundings were experienced, the theme of the game and to a certain degree the group dynamics, were aimed at finding out more about the learning experiences we have designed for throughout the development process of PB. The responses support the idea that the participants discussed possible solutions to the game mission before they took any action, and to a slightly lesser degree that they discussed several possible courses of action. This discussion of the game mission is a central part of how we have designed for learning processes to take place, by attempting to create an awareness of the conditions that the

game sets for the participants, by affording the participants the opportunities to vocalize ideas that arise from the text that they read. This is also a central reason why play is organized in groups, and if the game play were carried out in silence, then there would be more arguments in favour of it being played individually.

The participants also reported that they felt they had learned more about Bergen during the Napoleonic Wars after finishing the game. Responses to the questions about the experience of actually picturing or imagining the surroundings during the events that are part of the game are more diverse. The buildings were reported as appearing in a new light, while the city landscape that the buildings are placed in, were to a lesser degree being experienced in a new light. The rationale for asking questions about this was that the placement of buildings in the actual historical period was to a certain degree ruled by logic, logic that we gave clues about in the game. One example of this logic is that mills are placed adjacent to rivers. Another is that *roperies* (where rope was manufactured) are placed on long, straight, stretches of road. Hints about this logic are interwoven with the game task texts.

The interview session brought up several suggestions for improvement, mainly proposals about more adequate ways to use the map. The participants also described in a more concrete manner how the dynamics of group collaboration evolved. The modus operandi seemed to be that one participant read the task text aloud to the rest of the group, after which the group discussed possible solutions. Having decided where to go next, the group then went toward the location believed to be correct. One group assigned a "runner," who would race ahead of the rest of the group, when they came close to the location, in order to save time, and have a higher chance of winning. In general, the participants reported a motivational effect of participating in competing in groups against other groups, rather than on their own.

In the interview session, when being told the story about the Battle of Alvøen, several of the participants responded that knowledge about

this story beforehand would have affected the motivational attitude to the game positively, that is the events that took place there represented an engaging story to the participants. This is informative for future experiments and tests with PB, and leads us to believe that it could be included in a more encompassing teaching scenario, where the historical events are discussed in greater detail beforehand.

Discussion

Our findings gave us some answers about whether what we set out to design actually resembled the experience of the users in our study. Part of the endeavour was to facilitate a motivating and enchanting experience for the participants. In addition we wanted the students to immerse themselves in the historical area, to see buildings and city landscape though a new set of eyes, and through this trigger some learning experiences. It can be argued that parts of the learning experience we have designed for can be traced in the participants reporting of their experiences. They reported, both in the interview session and in the questionnaire, that playing PB is a fun thing to do.

Our design and evaluation process has not provided any clear answers about how to go about building and employing location-aware mobile learning games from a to z. There are several issues, however, that have emerged, and all these we see as a set of dilemmas, or contradictions, that represent future design challenges for us. One dilemma is the contradiction between constructing a situation that allows for reflection and the competition to win the game. The example of the group who divided roles, and assigned a runner to save time can perhaps serve as an illustration of this. Another example can be the reported experience of seeing houses in a new light, but not so much the landscape in relation to the houses, as it requires more thoughtful observation. A prerequisite for reflection is to see and think, perhaps even imagine or hypothesize about the physical surroundings involved in the game play, but a prerequisite for winning the game is being as fast as possible,

and thus not stopping more than absolutely necessary. To find a way to manifest a space for stopping and thinking in relation to what the game players are seeing, without hampering the flow of game play, would be a solution. This could be achieved in at least two ways. One possibility is to provide this space to a larger degree in the game play itself. Another possibility is to let the game be the game, and then design a larger learning scenario, where items and aspects from the game are brought into the classroom for discussion. Further investigation of actual learning effects is necessary, however, and studying these in detail was also outside the scope of this study.

CONCLUSION

This article has described our efforts with the design of the location-based mobile computer game PB, with emphasis on technological infrastructure, historical background and game play, and placed our work in relation to our inspiration in other academic work. It has described our evaluation of the game in a setting of actual use, and provided a discussion of what we see as the most important findings.

We will conclude with some challenges we will face, and what we regard as central contradictions in our research. The first one is the challenge of mixing games and learning. This is an issue that bears comparison to Donald Norman's idea (1993) of both setting up engaging experiences (in an interview he mentioned Hollywood at being good at this), and at the same time facilitating opportunities and tools for reflection that enables learning. Both these aspects are important when designing and tuning an educational game. We can also relate this to the distinction between joy and work, where we, when designing games for educational purposes, need to take into account that we are dealing with what Gaver, Dunne, and Pacenti call "ludic pursuits" (1999). The concept highlights the differences inherent in the motivation between the activities of work and game playing. Research wise, it seems

insufficient to only follow common design methodologies that are made for analyzing work, when analyzing an activity that is based on different assumptions.

There will also be a whole range of usability factors that need to be analyzed. Mobile collaborative game playing concerns a fairly new interaction paradigm where advanced small displays should be an important part in augmenting reality, as well as drive the mixed real-virtual game play forward. Switching attention between the real and the virtual, and ensuring a flow in the game will be a major concern for further technical interaction design. Finally we see a set of new practical methodological challenges. Moving into the streets and fields will demand methods other than the traditional methods associated with Human-Computer Interaction (HCI) design.

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