Mobile Learning with a Mobile Game: Design and Motivational Effects

Gerhard Schwabe, Christoph Göth, University of Zurich

Abstract

Mobile technologies offer the opportunity to embed learning in a natural environment. This paper describes the design of the MobileGame prototype, exploring the opportunities to support learning through an orientation game in a university setting. The paper first introduces the scenario and then describes the general architecture of the prototype. The main part of the paper focuses on the evaluation of design issues and the effects observed in two trials. Design issues include: Supporting work on the move poses difficult interface questions, the accuracy of current outdoor, and indoor positioning systems is still problematic and the game requires near real-time response time. The evaluation of the effects shows that features such as 'map-navigation' and 'hunting and hiding' lead to excitement and fun. The participants immerse into a mixed reality that augments both physical and social space. The game success is based on the motivating design of the game itself. The paper concludes with open issues for future research, especially with the need to thoroughly evaluate the learning benefits.

Keywords: Mobile & Wireless Games, Mobile Learning, E-Learning,, Computer Supported Cooperative Play, Positioning Systems, Computer Supported Cooperative Learning

1. Introduction

Currently, there is an increasing number of efforts to apply mobile technology to learning. These efforts can be technology driven, such as the idea to broadcast a lecture on the cellphone (Lehner & Nösekabel 2003) or they can be pedagogically driven, such as the idea to support students' field data collection with mobile devices (Roschelle 2003). Sharples et al (2002) point out that there may be a particular opportunity for mobile learning outside the traditional formal learning settings. The objective of the Mobilearn project (www.mobilearn.org) is to explore the potential and the architectures of mobile learning both in formal and informal learning settings. Specifically, there are three application scenarios: 1. health, 2. museum and 3. executive education. The work presented here grew out of the executive education scenario. For executive students as for all other students it is a particular challenge to get acquainted with the university as a learning environment in order to make best use of its resources as fast as possible. This includes team building with fellow students. Our idea for supporting their initial learning is based on the concept of game learning.

This paper has two objectives:

1.) we want to discuss design issues of a mobile game system with a focus on those design issues specific for mobile learning and having a clear relationship to its motivational value added.

2.) we want to present first data on the effects of the mobile game on participant motivation and on the features causing those effects. This data focuses on motivational effects (fun, excitement etc.).

The next section will review the related literature. Section three will introduce the mobile game learning scenario and the mobile game system. Section four will introduce the general research design. Section five presents the results of two trials. Section six discusses technical design issues and section seven the effects observed in a user trial. Section eight closes the paper with some conclusions and an outlook to further research.

2. Literature review

Computer science, information systems, and educational research contribute to knowledge on mobile learning games. As is typical for information systems research, this paper strives to discuss these areas in an integrated way, but due to space limitation the literature review focuses on the educational aspects.

Lepper and Malone (87) propose a relationship between learning and intrinsic motivation. Their research is based on an investigation of students who played computer games. They identify seven key factors for creating an intrinsically motivating instructional environment: challenge, curiosity, control, fantasy, cooperation, competition and recognition. In a set of experiments Lepper & Cordova (92) show that computer games raise the efficiency of learning if they increase the intrinsic motivation and link the goals "winning the game" and "learning the material". In these games, mathematical problem solving is embedded in an *artifical* game context. With the new mobile technology it is now possible to situate problems in their natural context without losing the motivational benefits of games.

How do computer games engage players? Prensky (2001) proposes that six structural elements characterise games. There are 1) *rules*, that organize the game, 2) *goals and objectives*, the players strive to achieve 3) *outcome and feedback*, which measure the progress against the goals 4) *conflict, competition, challenge and opposition* leading to players' excitement, 5) *interaction*, the social aspect in the game, and 6) the *representation or story* exaggerating interesting aspects of reality. These elements need to be carefully designed and combined to create an interesting game. The *play* of such a well designed game lead to *fun* and *engagement*. We will use those factors later on to discuss design issues and the effects of the MobileGame.

In a thorough literature review on game based learning Mitchell and Savill-Smith (2004) show that these elements can be used to analyze games played on desktop PCs, e.g. on games for teaching basic skills, like reading and foreign languages (see Schwartz 1988 or Herselman 1999), teaching society skills, like self-efficacy in HIV/AIDS prevention (Thomas et al. 1997) and social learning such as encouraging successful dialogue (Ravenscroft and Matheson 2002). It should be possible to use these elements to carefully design and analyze mobile games, but so far this has not been done yet.

There are already a few mobile systems that integrate playing and learning, such as the Cooties Game or Geney (Savill-Smith & Kent 03) or Savannah (Facer et al., 2004). They focus on role-play or simulation. Prototypes and commercial products of location-based games in a real life environment, like CYSMN (Benford et al. 03), Pirates (Björk et al 01) or Mogi (Hall 01), show that people like to play with the new options, but these games focus purely on entertainment.

With mobile game learning still being in its infancy a deeper understanding of its design principles as well as of arising opportunities and limitations is paramount. We therefore started to develop the location-based learning game MobileGame in 2002 (Göth 03).

3. The mobile learning scenario and system

This chapter introduces the MobileGame through a usage scenario and then briefly describes the system architecture. The usage scenario is needed to understand the effects, and the system architecture is needed as a basis for the discussion of design issues.

3.1. Mobile learning scenario

The MobileGame is used to support the orientation days at a university. The traditional orientation rally is electronically supplemented with handheld devices. The orientation rally is a fun event intended to get to know the university and its surroundings. Therefore, the rally will lead all participants through a parcours with several tasks to carry out at certain spots. The students play individually or in small groups (1-3 persons) against other individuals/groups[1]. Each group receives a handheld computer.

During the orientation rally, each group gets different tasks referring to significant places, people and events (explained below). The handheld device shows the current position of the group on the digital map of the university. When the group enters a building the outdoor map switches to an indoor map of the building the group just entered. The whole rally is structured as a cooperative and competitive game. Competition is based on hunting rules: Each group tries to catch another group and, equally, is hunted by a third group[2]. The handheld device shows each group where its hunter and its prey are located. Cooperation rules force group members to meet members from other groups as well as teachers and to exchange information with them - again they are supported with location based information on their displays. The tasks given to them provide them with basic information on University live. There are the following types of tasks:

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1 In order to simplify the text, this scenario assumes that a there is a group of players.

2 The didactic reason for hunting rules is to keep the groups moving. Of course there need to be hunting free areas and times, e.g. during courses.

- *Significant place tasks:* The students have to find important places such as the library, the cafeteria or the laboratories. At each location, they have to perform a typical task (find a book, have lunch, etc.). The specific tasks are context-dependent (they depend not only on the location, but also on the time of the day or they build on the activity of some previous group). The task execution is supported by the handheld device (e.g. serving as a frontend to the library information system or providing them with needed information).

- *Significant people tasks:* The students have to find important people of the university and have to interview them on their activities (the president, the study coordinator, the caretaker…These people either participate in the game or are played by elder students). If those people are typically mobile they can be located by a mobile device.

- *Significant event tasks:* The significant events can be scheduled or come as surprise. Scheduled events include introductory lectures and courses. Here, tasks relate to the organization of studies (e.g. set up a course schedule or how to find important information) and some initial content. Unscheduled events include "spontaneous" welcome parties by student groups, but also the signup of each group member to important University services (e.g. computer account, library card).

Each task requires the group to answer one or two simple questions displayed on the handheld device. For example, one task might be to find the cafeteria. There they get the question "What is the price of an apple pie?". They won't get the next task until the correct answer is given.

In addition to the game, the students can annotate real objects with virtual “post-it’s”. Other groups can read these short messages and answer with their own post-it’s.

3.2. Mobile Game System

The MobileGame prototype implements the system described in the scenario. The scenario itself describes a sort of synchronous collaboration between the playing people. Thus, the architecture of the mobile game prototype is derived from a generic architecture for synchronous collaboration (Schümmer & Schuckmann 2001) (a more detailed discussion can be found in Göth et al 2004).

The architecture proposes clients with their own private state of the ongoing game: All relevant data is stored on the client side so the player can act even if there is no connection to the server available, e.g. when playing in an offline area. The server works as the central coordination point for the whole game. Any changes in the game are transferred to the server which distributes the data to all clients.

The architecture integrates three components: the mobile client on the PDA[3], the web client for a browser, and the server. PDA and server communicate over a Wireless LAN (WLAN). The web client exchanges data with the server over HTTP. The positioning information is provided by the Ekahau positioning engine. This engine calculates the position of each client from the strengths of the WLAN-signals it receives from several WLAN base stations. The accuracy is from one to three meters, if the Ekahau client can “hear” four access points. The Mobile Game prototype can also use GPS for positioning

[3] PDA: Personal digital assitent: A small handheld computer.

information. However this positioning information is too inaccurate and only works outside buildings.

4. Research design and framework

The overal design of the MobileGame research follows the pilot study research approach (Schwabe&Krcmar 2000). Its basic idea is to develop socio-technical innovations in close collaboration with the field site and to iterate between development and evaluation activities. Sharples et al (2002b) adapted these ideas to the educational area and refined them. Both approaches leave the starting point of the development activities somewhat vague. While it is easily possible to gather requirements to support an established (educational) activity, it is difficult to gather those requirements for a radically new activity as there is nothing to observe. It was, therefore, decided to use a scenario as a starting point (for scenario based design see (Carrol 1995)). This scenario has been described in section 3. Such a scenario should be coherent enough to allow a shared understanding and to guide the development process. It should also be general and colourful enough to allow the developers to creatively interpret and advance the scenario. The basic design and architecture of the MobileGame and its design issues, as the result of the first evaluation, are described in section 5. The main objective of the evaluation was to inform design and to understand the educational value of the game as an example of mobile learning. This requires a rich environment reducing the control we had over the variables.

As many components of the MobileGame are leading edge technology we have evaluated the system in several steps: We based our evaluation on Taylor's (2003) recommendation. In the context of the Mobilearn project (www.mobilearn.org), she proposes to first test the usability of the technology and in a second step the pedagogy. After each step, the software is adapted to the newly surfacing requirements. The first test of October 2003 focused on the usability and only offered a few insights into pedagogic questions. After this test, we noticed how large the step is from a basically usable software to a system that allows a thorough evaluation of its pedagogy and its pedagogic value. It appeared not advisable to leave the development of the software without guidance for such a long time, as some usability questions were (also) open. We then decided to split the future development and evaluation process into two parts: First, we focused on the motivational aspects of the game and its relationship to the usability of the system. In a second step, we will include the well-designed content and systematically test the effects on learning. This final test of the learning benefits is still outstanding. In retrospection, this two-step approach turned out to be very helpful: although we did not focus on content issues we now know much better how to prepare appropriate content than before.

4.1. Method of evaluation of the first trial

The first version of the software was evaluated in a user test at the University of Koblenz in October 2003. The test was integrated in a presentation day by the faculty of computer sciences. The first evaluation only tested the technology in a very crude game: We just hid a PDA in a room of a university building and asked 7 interested visitors (mostly students) to find it with the help of the game. Then they completed a short questionnaire concerning their experience. There was a closed section in which the participants evaluated technical aspects of the game and an open section where the particiapnats provided feedback regarding the game. The complete questionnaire is available in the Internet[4] or by contacting the authors. Additionally the participants were observed during the game.

4.2. Method of the evaluation of the second trial

The second evaluation of the MobileGame was located at the Koblenz Campus of the University of Koblenz-Landau in Germany. The location was chosen because Koblenz as a partner of the Mobilearn project has a campuswide wireless LAN and both authors have very good knowledge of the environment (one used to study there and the other was a professor there). The game covered two office buildings, the central campus facilities (cafeteria, lecture halls, library) and the space in between, all in all an area of about 150.000 m^2.

Participants: A total of 22 students volunteered to participate in one of the two games (one with 13 participants and the other with 9). Eighteen participants played the game on their own and each participant was equipped with their own device. Four participants played the game with a partner and shared one device. The participants were videotaped while playing the game. Six participants were in their first year, 9 participants were in the second year and 4 participants were in the third year or above. They were aged between 19 and 25 years old (average age 21,6 years). There were 17 male students and 5 female and most of them considered themselves experienced computer users.

Procedure: The students were given 10 tasks, each consisting of a location they had to find and a location related question. The question was answered by filling in a multiple

[4] http://www.ifi.unizh.ch/im/imrg/index.php?id=194

choice question or using sliders to specify a number. The task was given to each student (specifically: to each PDA) in a random order. Below the ten questions:

1. What is the first word on page 396 in the book with the code INF/Wi 1999-93? (Multiple Choice)
2. What is the number of the room of Prof. Ebert? (Slider)
3. What is in this room? (Multiple Choice)
4. How many secretaries work for the institute of IS research (Multiple Choice)
5. How many computers are in this room? (Slider)
6. When does this office close on Tuesday? (Multiple Choice)
7. What is the correct link to the web form for getting a network access? (Multiple Choice)
8. In this room you can return your re-registration. What is the number of the room? (Slider)
9. What is the Menu 1 on Friday in the cafeteria? (Multiple Choice)
10. How many copy machines are located on this floor? (Slider)

Before the game, the students were given a short training session with the PDA. They also received a short printed information document. One game lasted aproximately 40 minutes, the other aproximately 30 minutes. In this time, the students had the opportunity to answer the questions and to catch other groups. At the end of each game, each player was given a questionnaire. The questionnaire contained 12 questions that can be clustered into four sections: the first section asked the students how satisfied they were with their introduction to the game; the second section collected data on the motivational aspects of the game; the third section focused on the usability of individual functions and the final section collected data about the users. The completed questionnaire is available in the Internet[5] or by contacting the authors.

4.3. Discussion Framework

We will use Prensky's structural elements (see section 2) to organize the discussion of the results. The MobileGame can be described in terms of Prensky's 6 structural elements. The scenario describes the global *rules*. The players have the *goal* to solve the tasks (and ultimately learn). The real time technique gives you direct *feedback* on the current status in the game and on the *outcome* achieved so far. *Conflicts and competition* are realised through the opportunity to gain points (by solving tasks or catching others). By playing in groups there is *interaction* in the game. This effect is additionally supported by the chat function. The *representation* is realized through the orientation on the digital map and the augmentation of the reality with digital objects (e.g. the task or the virtual post-its). These structural elements characterised our game and should engage the player.

5. Results

5.1. Results of the first trial

This section contains the major results of the first trial. This trial focused on the technology of the first prototype. The test persons have to rate seven technical issues of the game and the general impression. The scale ranged between 0 = unserviceable over 3 = acceptable to 5 = excellent.

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[5] http://www.ifi.unizh.ch/im/imrg/index.php?id=194

Table 1: Rating of the technical aspects of MobileGame

	M	SD
Size of screen to read while walking	**2.9**	**1,1**
Weight while carrying in hand	**3.9**	**1,1**
Size of device to hold in hand	**4.0**	**1,2**
Display of maps	**3.3**	**1,1**
Handling of software	**3.3**	**0,9**
Accuracy of display of own position	**1.9**	**1,1**
Input of text with pen	**3.6**	**0,8**
General impression of functions	**3.7**	**1,4**

Screen size and accuracy of the position scored least. A number of participants commented that they liked the idea but would have liked a better technical realisation of the game. They would have liked to have a zoom; auto-scroll and an improvement of the update time of the client. These features were built into the system for the second trial.

5.2. Results of the second trial

This section contains the major findings from the second trial. Since the experiment was designed to test the motivational aspects of the game we will present most data on this issue.

We asked the participants whether it was fun to play the game. A large majority of students (17 of the 22) indicated that they liked it and would play it again any time. Five participants liked it, but thought playing it once was enough. Nobody chose the options "It was ok", "No, but it could be fun if some details were changed" or "No, it was a waste of time”. Positive (sometimes even enthusiastic) comments in the open questions supports these findings. So the game is entertaining and students like to play it.

Afterwards we asked, which elements of the game the student liked best. Each of the 22 students were allowed a maximum of two choices. Two students had to be taken out of the evaluation because they had selected more than two choices. However, this does not change the overall picture as these two had similar preferences as the others. Nine students selected “Hunting and hiding”, seven “Orientation with the map” and six “Playing as a group experience.” “Solving the tasks” and ”Technical aspects of the game” were selected by five participants, and four chose “Own position on the map”. Only one students selected “Learn something about the university”, “Collection of game points”, and “Orientation on maps by icon links”.

Each participant was asked to rate how often he used key features of the game ( ). The could respond 1 = not at all, 2 = rarely, 3 = normal, 4=often and 5=very often.

Table 2: Usage of key game features

	M	SD
1.Orientation on map	4,5	0,5
2.Look-up questions	3,7	0,8
3.Chat	2,0	0,8
4.Catch others	3,3	1,2

"Orientation on map" was used most often. In response to the open questions, many students asked for the map to be simplified.. As we used architects' maps of the building, they included irrelevant information (such as numbers or outdated plans for furniture). They wanted this information to be replaced by relevant information, such as more information concerning other players and the location they were currently at (e.g. the name of the building) and their achievements in the game in comparison to others (achievements = correctly answered questions). However, there were quite a few students who were happy with the map as it was.

The frequency of looking up question was rated "normal" or "often" by the majority of the participants. There were a lot of positive comments concerning the multiple choice questions; the comments on the slider-based questions were mixed. The tasks were presented in a random order. Ten participants rated that the order of the tasks was „very good", twelve rated it as "good, but some more intelligence in the ordering would be desirable" (nobody chose "Useless. The uncoordinated distribution of tasks was very demotivating").

The use of the catching function varied widely. In the open comment questions quite a few students reported difficulties in handling this function, mainly due to difficulties with imprecise navigation and a somewhat confusing interface. Chat was rarely or not at all used by most participants.

Only one of the 22 participants agreed with that opinion "that the game could have been played without a PDA") and even s/he was unsure as s/he made two selections (the other was with the majority). The other 21 thought the electronic support increased the excitement of the game; ten of these thought the electronic support significantly added value to the game experience, eleven thought the electronic support increased excitement but thought the technology was not mature enough and

Table 3 shows the most important positive and negative aspects of the game in the eyes of the participants[6]. Each student could select up to three positive and three negative items. Many students selected only one or two aspects.

Table 3: Most important positive and negative aspects of the game

Most important positive aspects (maximum 3 choices)	
The dynamic position tracking on a map is a significant value added for an orientation game	17
The game is a considerable value added compared to a traditional guided tour	11
The opportunity to independently explore the university is a significant value added	8
The opportunity to send messages to annother group is a significant value added for an orientation game	7
The clarity of the user interface helped to play	4
I got to know the university better through the game	0
Most important negative aspects (maximum 3 choices)	
The display of the position on the map was so imprecise that the flow of the game and the motivation to play has considerably suffered.	9
The 3 second delay in the position tracking was very irritating for me	8
The difficult typing of text on a PDA has effectively hindered me to send messages or make annotations/notes	8
In unfavorable conditions (e.g. in the direct sun) the display on the screen could not be read	7

[6] The list was created on the basis of the results of the first trial.

The control of the game software has interfered with the flow of the game and the motivation to play	2
I consider it extremely hindering that the PDA cannot be used when I am walking or running	2
I had great difficulties to keep an overview over different maps.	2

The majority of the participants selected the navigation as a major positive aspect. Half the participants saw a considerable value added to a traditional guided tour. A third selected the opportunity to individually explore the university and to communicate over messages with other groups. A small minority regarded the interface as a major positive aspect and nobody selected the s/he learned about the university.

The four most frequently selected negative aspects are related to the interface design (each selected by a third of the participants): imprecise display of the position, delay of position tracking information, difficulties in typing text and difficulties in reading the display in unfavorable conditions. Only a small majority selected the control of the game flow, difficulties in using the PDA when moving or keeping an overview over different maps.

6. Technical Design Issues for the MobileGame Prototype

An appropriate game design cannot be reduced to individual features. Rather, general technical design issues need to be solved and an appropriate infrastructure set up. This section discusses four key technical design issues: Accuracy of positioning, play on the move, offline areas and response time and interface design.

6.1. Accuracy of positioning

Other mobile games like "Can you see me now?" (Benford et al 03) already reported problems with inaccurate position information, particularly with GPS. Our prototype uses WLan for positioning with a resulting accuracy of three to five meters. An accurate location of the player is required to solve the task, to hunt other groups and to orient on the digital maps. The players in the first trial told us that the accuracy was quite good as long they only needed to know their approximate position. As soon as they had to know the exact position of an object the accuracy was not sufficient. They had to search in up to three rooms to find the hidden PDA in the first trial and the participants reported difficulties catching and solving location dependent tasks in our second trial. In the second trial, the low accuracy of the location information was reported as the single most important negative aspect. There were two parts to this problem: The low precision of the location information and the representation of this low precision on screen. The first issue could be tackled through better infrastructure. The second problem could be solved through better representations of the imprecision of the location rather than the jumping arrow provided by Ekahau position engine.

6.2. Play on the move

In the first trial, even in straight corridors the participants reported difficulties in moving and navigating at the same time. If they wanted to check their current position they had to stop and look at the PDA comparing the map on the screen with their surroundings. The size of the maps does not appear to be the major problem, as they covered half the PDA screen and the participants did not have problems reading when standing. Rather, they did not succeed to synchronize their heads to the movements of the device in the hand. Furthermore the cognitive load of translating an abstract two-dimensional map to into a three-dimensional building was high.

In the MobileGame, the players have to locate their position constantly, in order to locate their next task or to hunt other groups. A constant stop-and-go hinders the flow of the game. At least half the game players complained about this problem during the first evaluation. In the second trial the participants again reported difficulties with the precision of position information (see Table 3), but the majority did not regard having to stand still while using the computer as major negative aspect of the game.

Still, it would be useful to enable the players to play when walking. One solution could be an audio interface, which gives the user the needed location information through headphones. Björk et al. (2001) have experimented with using audio for providing status information in their game Pirates!. However, the information could often not be heard because the noise level within the gaming area was too high. So therefore transmission of information through transient audio and persistent visualisation on the PDA screen each have unique advantages and disadvantages.

6.3. Offline areas and response time

One of the players reported that updating their position took too long. Their position was updated every three seconds, but in this time the players could move five or more meters. Frequent updating of position is one most important requirements of mobile games. Mostly, you do not have an area-wide WLAN, so the mobile clients are not always connected to the server. But the players want a near real-time reaction of the client, e.g. if they are solving tasks, hunt other groups, chat with others or just walk across the campus and use the digital map for orientation. Game objects, which are changing all the time, like the position of the players, have to be updated by the client as fast as possible. This means, the mobile game has to have both a good caching algorithm, and an efficient data transmission strategy.

In our prototype all static information, such as the game maps, were stored on the PDA. Only the dynamic information, such as a new position or a new task, were transmitted. The PDA receives all the information from the server that was needed for offline work, like the answer of the current task, so that the players could interact even if they were in an area without WLan. Additionally, they received information concerning their network status and the status of other players they wanted to interact with.

6.4. Interface Design

Besides response time, the user interface was the most important design issue of the MobileGame. The interface enables the players to use the game features, enables a group to interact with the system over one device and communicate with other groups.

Figure 1 shows the old interface and the new one, which has been implemented after the test. The first interface used drop-down menus like desktop programs. The basic idea was that the players needed a ‘tool’ (Züllighoven et al 1998) that they could use to call functions in a random order. Observation of the players showed that navigation with the drop- down menu and using the pen of the PDA was not really intuitive. The use of the PDA was much more like the use of an ‘automat’: A player prefers easy access to a

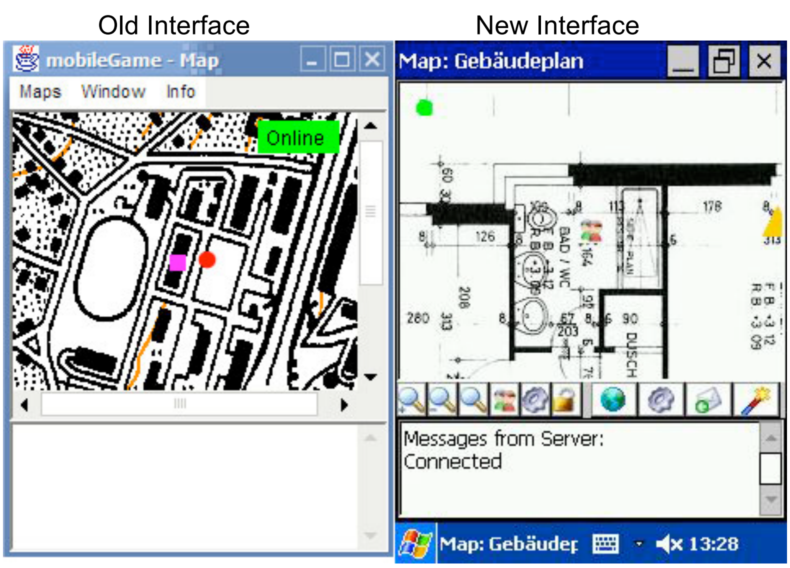

Figure 1: The new and the old user interface

service to the freedom of using the system in an innovative way. So we redesigned the user interface and substituted the old menu with a button bar. Now all functions can be reached by one or two clicks. We also used symbols instead of text because they are smaller than text and the users understand symbols much better.

One remaining problem is the interface for answering the open questions. They offer the game designer a broad range of possible tasks. However, the users have to write down the answer with the pen and a little virtual keyboard on the PDA, which is difficult to use. Multiple choice questions restrict the game design, but users can answer with a simple click. In the tested version we supported open questions, multiple choice questions and questions with sliders for numeric input. We think an audio interface could help here too. A hightech approach would translate audio input into text input; in a simple approach the players just communicate with a human tutor synchronously or asynchronously (voice-mails).

7. Discussion of the Effects

The game was thought to be fun by most of the players. Thus we can conclude from the experiment that this type of game can engage participants. Prensky's structural game characteristics will be used to discuss what features of the game contributed to engaging the participants. This discussion includes implications for designing mobile learning games.

Conflict, competition, challenge, opposition: There were two features in the game which were could be described as competitive:.They were hunting other players and answering the highest number of questions. Almost half of the students selected "Hunting and hiding" as the most interesting feature in the game, which was all the more interesting because there were several complaints in the open section of the questionnaire about this feature: The latency of the positioning software was too long and the interface was regarded to be somewhat confusing: It was not always clear to everybody whom they were hunting and whom they were running away from. On the other hand competing for points answering question was not seen as an important feature of the game. There are two possible interpretations for this evaluation: As the questions were not immediately relevant for the students (they already knew the campus), they may have had little interest to excel in answering them. Thus the these comments could be an artefact of the experimental design. A second possible interpretation was that players were having difficulty competing in two tasks at the same time and chose to compete in the game that provided the more immediate feedback (see the discussion of real-time gaming below). This interpretation is grounded on the personal experiences of the authors with similar conventional games: Participants tend to specialize either on gaining points by hunting or on gaining points by answering questions. If this is the case the hunting feature may even become dysfunctional for learning. A variant of the latter interpretation is that one task is more exciting than the other one.

In a learning environment a careful design is needed to balance the engagement for hunting with the engagement for working on tasks. Possible solutions are:

1. Make the competition for points more visible: currently the hunting feature is visibly dominant as players always see their competitors on the map. A similarly visible game task point counter could balance that dominance.

2. Make the catching itself a learning experience: If hunters do not only receive points from their preys but rather an explanation of some task solutions, both preys and hunters would learn.

3. Turn of hunting for part of the game: If the hunting is turned off for some time or some regions the players automatically get exposed only to the competition on tasks.

In any case, the hunting is a surprisingly useful feature to keep participants interested and moving.

Outcome and feedback: The increased excitement has the potential to support students' learning. The shared experience can also help to achieve "soft" learning goals such as team building. The task-oriented features and its accompanying content have to ensure that the "hard" learning goals are achieved. However, the task oriented features of the game have not (yet) been systematically designed and as the participants were not the final target group (i.e. new students to the university), it is not surprising that the task oriented features received only a medium rating: Five students liked the task oriented features of the game best. But only one person thought thtat the most important feature of the game was that s/he learned something about the university and as nobody claimed that s/he got to know the university better through the game, even this evaluation is questionable. As the participating students were not new to the university, most of the presented information was not new to them.

The provision of immediate feedback is a major difference between an electronically supported game compared to a conventional game. The importance of immediate feedback is supported by the participants' clear statement that the game could not have been replaced by a conventional game. The negative aspects reported as most important (in table 2) also relate to limitations of the feedback mechanism. An interesting improvement in outcome and feedback would be automatically generated learning diaries that allow the players to reflect on their learning.

Goals and objectives: The MobileGame has primary and secondary goals and objectives. The primary goal of the MobileGame was to advance learning: Newcomers to the university would be able to orient on campus, getting to know significant places, events and people. For this purpose a set of tasks was given to each student. The secondary goal of the game was to gain as many points as possible (through answering questions and catching others). As discussed above the set-up of the experiment did not allow us to analyse whether the primary goal was achieved. Therefore this section will focus on the secondary goals, i.e. on design of the tasks required to gain points.

As discussed above, the mobile game was successful in providing good tasks. The design of the tasks was difficult: The questions have to be sufficiently difficult to challenge the participants, but they should not take too long in order to keep the game flowing. As any missed task is a missed learning opportunity, the participants should be able to tackle most tasks. On the other hand there have to be more tasks than participating individuals/groups in order to avoid the sitaution where two groups have the same task at the same time. Together with the limitations posed by technology (particularly a limited play duration due to battery limitations) there was only a relatively small design space for an appropriate number of tasks.

The game presented the tasks to the participants in random order and their feedback indicates that they were happy with that. However the game area was limited. In a larger area or in a game with more advanced learning goals the designers are well advised to allow for a more sophisticated ordering. Either participants are allowed to chose any available question according to their preference, or they should be presented in a geographically or pedagogically meaningful order.

In order to keep the complexity of the game design low, most tasks were presented as multiple choice questions. Closed questions are typically less interesting than open questions and seriously inhibit the didactical design of the game. However, there are two good reasons to stay with multiple choice: first, it is still difficult to type in information with a PDA, particularly when one is on the move or still exhausted by prior movements. Some questions could be solved by using a moving slider, which is a little more difficult than using multiple choice but less difficult than text input. There were significantly more negative comments on this feature than on the multiple choice questions. Second, multiple choice questions speed up the game, as answers are given quickly and the participants can then move on. In a competitive environment, speed is a prerequisite to excitement.

Interaction: The MobileGame offers plenty of opportunities for interaction. Six participants liked the group experience most. The opportunities to directly interact with other participants over the chat were rarely used, because participants reported that typing on a PDA is too difficult. Thus a future system may be well advised to improve the chat input or to include other channels for communication, e.g. a voice channel. The evaluation of the "Can you see me know"-game (Flintham et al 2003) shows how such a voice channel can also contribute to the excitement of the game. However, the high rating of group experience and the low level of electronic interaction raises the question what led to the positive group experience. One answer are intensive discussions between groups. Non-verbal interaction such as observing one another on screen or watching others from a distance may have played an important role.

Representation or story: The game and (!) learning environment were presented to the players on a digital map. The students also liked the navigation with the map (7 choices), although latency and lack of precision of the navigation software was a problem. The navigation features were at the centre of the discussion for the students, receiving the highest numbers of complaints and a very high level of interest. This supports our observation that a navigation system is a very powerful tool for situation learning in a natural environment. The game also included a simple electronic augmentation of physical objects: A task/question was attached to each object and only once a player comes near to an objects (is within its “aura”), the electronic attachment becomes visible to him.

We conclude from the three favourite features of the game that the students liked the mixed reality experience of the game. . Mixed reality means that the participants activities are partially represented in physical space and partially in digital space and both spaces stand in correlation to one another (as exemplified by the orientation with a map). The MobileGame allowed the participants to collectively immerse in such a mixed reality. Furthermore, the MobileGame contains new opportunities for social interaction (e.g. chatting or catching) and they have to adhere to new rules (i.e. the game rules). Thus, participants were not only immersed in a augmented physical environment, but, at the same time, they were immersed into an augmented social environment.

This interpretation is supported by the fact that the participants reported that weaknesses in the technology reduced their experience. This immersion into a mixed reality environment appears to be a major reason why it is not the same to play the game without IT-support, i.e why the students see a significant value added in the game. Immersion is particularly interesting if there is movement and action, both in augmented physical and social space. The students appear to be more willing to accept low performance in augmented physical space (e.g. imprecise navigation) than in augmented social space (e.g. for chatting): In contrast to the group in the first evaluation, the lack of usability of the PDA during walking or running did not appear to be a major issue for participants in the second evaluation. The participants disliked insufficient support for collaborative features. Written communication is difficult with the PDA. So there is still a need for other communication channels.

8. Conclusions and outlook

The design and evaluation of the MobileGame is one more case for the dual role of information technology (Giddens 1986, DeSanctis and Poole 1994): Mobile Technology enables immersion into a mixed reality environment and more motivating learning experience. However it also severely limits some activities. For many purposes, mixed reality environments are much more apt to augment learning than purely physical or purely digital environments. However current technology still has some serious limitations particularly regarding the mobile user interface and the accuracy of positioning systems.

Still, the current state of MobileGame already indicates its potential to enhance learning: The participants enjoyed the game and most would have liked to play it again. We have attributed this finding to their exciting mixed reality experience. The game at least moves them into a state where they are mentally ready for learning, where they are in the right environment for learning and where they also already experience some socially oriented learning. We cannot yet support our claim that the MobileGame will really enhance "hard learning". The tested user group was unsuited for this test. Furthermore, the tasks and the accompanying content have not yet been carefully designed. This will be our next objective. A further challenge will be moving the concept of the MobileGame and the prototype into new domains. We have already run a very simple version of the game in the Zurich Zoological museum and have given it to children. Here we were able to use professionally prepared content. However, the users still liked the gaming features best. There appears to be something in gaming that deeply touches people of all ages and can lead through immersion to fun. We have demonstrated in the MobileGame prototype, how one can embed learning into this experience. If we can systematically succeed in this, the classical dichotomy between fun and learning may be closed. Then one case for the value added of mobile learning is made.

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