ABSTRACT
We present the design and implementation of a framework for pedagogically controlled modelling of learning games to be played on the mobile phone. The game concepts are grounded in pedagogical theory and adjusted to the technical capabilities of current standard mobile phones. The mobile phone is used for playing the games. Authoring and administration of the games takes place on a dedicated web server, as well as monitoring the progress of individual learner's and learning groups, and the exchange between the learners.

We introduce two game models: the quiz “Fastest First!” and the simulation game “Crisis!”. The game models form the basis for templates which can be filled with concrete content by the game author via an authoring page on a web server. Based on the authored game templates, the game instances for playing on the mobile phone are automatically generated by the system, and can then be uploaded to the mobile phones by the players/learners.

With the presented game concepts we intend to combine learning and game playing so that learning becomes fun. An important aspect of the proposed learning games is stimulating learning through activity. The specific learning goals addressed are: remembering, understanding, applying, judgement and analysing. The simulation game, in particular, targets contextualization of the learning game along the lines of real crisis situations, and models the consequences the user activities have in the game for the user him-/herself and for others.
In the paper, we describe the game models “Fastest First!” and “Crisis!”, and briefly introduce the distributed development and realization of the games on the web server and on the mobile client, and then summarize results from user studies.

INTRODUCTION

In the last years, a number of proposals for mobile learning games have been presented. A concise overview of the work until 2003 can be found in (Trifonova, 2003). The main characteristics identified for mobile game-based learning applications in Trifonova are still relevant today. These are: (i) learning applications should be self-explaining and support a playful way of learning, (ii) the learning contents should be split into small units which require only a reduced span of attention so that game play and learning can take place during pauses, (iii) the learning contents should be available any time, and the games should be integrated in the situational and local context of the learner. The games described in the current paper meet those requirements in the following ways. Learning is integrated with playing quizzes and simulation games; small, self-contained learning units (question-answer cards) are presented to the players/learners; the learners can process the learning units any time as they carry their games on their mobile phones. Game play is independent of a mobile connection as the games are self-contained single player games that can be downloaded from a web-based game server to the mobile phone using the infrared ports of PC and mobile phone. Even though integration of the actual location and situation of the player is no genuine property of the games, game authors are free to design games that can be employed in location and situation dependent learning scenarios.

Mobile learning games are developed for a broad variety of learning contexts such as role play and multiplayer games (Mohamudally, 2006; Sanneblad & Holmquist, 2003; Lonsdale et al., 2004; McAlister & Xie, 2005), covering such different applications as role-based foreign language learning (Harriehausen-Mühlbauer et al., 2005) or game-based learning of C++ (Hamid & Fung, 2007). Other games aim at collaboration (e.g. Sanneblad & Holmquist, 2004; Sanchez et al., 2006). Our games, on the contrary, are mainly played individually. The community of learners comes into play a) when learners compete with each other in the quiz game trying to be the fastest to finish a game in order to be admitted to the next game level; b) after the simulation game when the players discuss among each others on the web server their self-assessment of how well they have done in mastering the crisis compared to what they have achieved according to the judgment of the system.

Our work also relates to eLibera (http://www.elibera.at: eLibera), a toolset for developing quiz-like content on the web server which is then presented to the user on the mobile phone. A fundamental difference in the approaches, however, is that authors of our games are strongly guided how to develop their games and what the underlying pedagogical foundations are, whereas eLibera is more a classical e-learning application, and lacks any game playing aspect.

The majority of mobile games so far have been developed for PDAs, Tablet-PCs, or Pocket-PCs. From a technical point of view this has great advantage over developing for mobile phones, as with the former the full functionality of a PC environment is available for application development including sufficiently large memory, powerful CPUs, advanced programming environments, platform independence, full access to multimedia, large displays and keyboards, etc. These are all properties that do not (yet) hold for mobile phones leading to radically different requirements on application development, programming and testing of mobile learning games (Holmquist et al.; Sanchez et al., 2007). A major advantage of developing learning games for the mobile phone, however, is the market penetration of mobile phones. Thus almost anybody can play the learning games any time they want.

PEDAGOGICAL BACKGROUND

Our game concepts are amongst others inspired by work of Fabricatore, in particular his notion of ‘edugaming’ which focuses on intertwining learning and gaming (Fabricatore, 2000). They also relate to Prensky’s views on game-based learning (Prensky, 2001), who requires learning games first of all to be fun and then encourage learning. An important aspect of our learning games is stimulating learning through activity. In particular, the specific learning activities the user undergoes when playing are based on Bloom’s and Krathwohl’s learning goals — remembering, understanding,
applying, judgement and analysing (Anderson & Krathwohl, 2001). The simulation game “Crisis!” targets contextualization of learning along the lines of real crisis situations (Klein, 1996), and models what consequences the user activities have in the game for the user him-/herself and for others (Senge, 1998).

With our games we aim at training the decision making capabilities of the learners, both on a cognitive and on an emotional level. While the quiz “Fastest First!” supports learning at a cognitive level, the simulation game “Crisis!” creates very specific, emotionally loaded contexts in order to apply the already learned. Players of the crisis game are confronted with critical situations such as an accident with differently injured people, the break down of a computer system, a crisis on the stock market, etc. The player now has to master the situation as good as he/she can. Depending on the skills to do the right things at the right time, the crisis will be mastered or will gradually deteriorate. At the end, the player is responsible for how the situation develops, and what consequences one’s own activities have for oneself and for others. In both games, “Fastest First!” and “Crisis!”, the players are forced to make their decisions quickly: in “Fastest First!”, because only the fast ones will have a chance to win and reach the next game level; in “Crisis!”, because the situation rapidly changes to the worse, if no appropriate interventions are made.

Summing up, the games are played by a single learner on his/her mobile phone. While the quiz supports learning and remembering of factual knowledge, the simulation fosters a deeper understanding of the previously learned and its application in situational contexts. At the end of the simulation, the player is asked to give a self-assessment on how well or bad he/she has been doing. If the player agrees, his/her self-assessment will be sent to the game server and then can be further assessed and discussed with other members of one’s learning group.

BUILDING THE GAME MODELS “FASTEST FIRST!” AND “CRISIS!” BASED ON QUESTION-ANSWER CARDS

Fastest First!

The quiz component “Fastest First!” is inspired by TV formats such as The Apprentice and Who becomes a Millionaire. From the former, the bad-tempered boss character is borrowed, from the latter the style of presenting multiple choice questions including joker options. Some of the key aspects of “Fastest First!” are show in Figure 1. Screen 1 is an example of an introduction of the general topic of a specific quiz, in the example case a first aid quiz. At the beginning of the quiz the boss tells the player to be quick in order to get the chance to proceed to the next game level. Screen 2 is an example for a multiple-choice question. The system gives immediate feedback to the user about the correctness of his/her answers. On screen 3, the boss informs the player that the given answer was wrong. Both, wrong and right answers are highlighted in red and green, respectively. Color coding alone, however, is not sufficient. In case of color blindness of players wrong and right answers may be indicated using icons such as thumbs-down or thumbs-up, respectively. Screen 4 shows a simple summary given at the end of a game level, where the player is informed how much points he/she made from a total of points that could have been achieved.

Crisis!

In the “Crisis!” game, the player is confronted with a situation that stepwise changes from bad to worse. The simulation starts with a description of the initial situation including a multiple choice part where the player needs to decide which action to set first, in our example whom to treat first (Figure 2). The player has opted to treat the unconscious person first (screen 1). After the player has made his/her selection, he/she is presented with a question related to that choice. In the given example the question is how to treat unconscious ones. Again, the player has made the right choice by selecting “Recovery position” (screen 2). The situation proceeds step by step until all injured have been treated. In Figure 3, an example is given where learner’s self-assessment and the system assessment do not match. In addition, the learner may also write a small text assessing him-/herself. If the system gets clearance from the player, the text is sent to the server, and may then be further discussed within one’s learning group.
1. Introduction of Topic

Right, I need to authorise someone to take charge of first aid arrangements. How are you available for training? Answer these questions as quickly as you can.

2. Question-Answer Card

You arrive first at the scene of a multi-vehicle accident. The crash involved a van, a motorbike, a cycle and two other vehicles. People are injured but no danger...

3. Immediate Feedback on Correctness of Answer

Your answer was: wrong. You received 0 points overall. People who make a loud noise are probably not at the point of death. These...

4. Summary at End of Game Level

In relation to the elapsed time and hints you may have used, you received 50 out of 65 points at this level.

Figure 1. Quiz game “Fastest First!” sample screens

1. Initial Situation 2. Question elaborating on the player’s choice

You arrive first at a multiple car accident. Whom do you help first?

What’s essential with unconscious ones?

1. Simulation game “Crisis!” sample screens
Editing new games

New games can be authored on the game server based on specific editing templates. Each template covers information for one screen. As regards the quiz game, we distinguish the following type of editing cards: introduction cards for setting the scene, information cards for providing the player with background information, reward cards for editing rewards and penalties to be presented to the learner during game play, and last but not least the cards for editing questions and answers. The latter are the central units through which learning contents is presented and assessed. Templates for different answer types are available: single click, multiple click, ordering. For each question, the author may upload background pictures that provide contextual information, edit hints, and define a point system of rewards and penalties. Each answer can be accompanied by an explanation why it is right or wrong, and how many points are gained or lost when selecting the particular answer.

Editing a “Crisis!” game requires a more complex editing scheme, representing the phases of the crisis and the individual cases that must be treated. The specific questions related to the individual cases are edited similar to the questions in the quiz game, except that no explanations are given whether a learner’s choice has been right or wrong.

FEEDBACK FROM USERS

In accordance with a user-centered approach to application design, where users are involved in the design process from early on, we iteratively made usability tests for developing the mobile client with small user groups up to five people, cf. Höök (2004), in particular page 137, summary of methods.

Based on an initial slide show, the functionality of the quiz game and a first interface design were assessed involving colleagues from the Research Studio who did not participate in the development of mobile learning games. Results were incorporated into the first prototype of the quiz component implemented on a PC emulator of the mobile client. This version went into a focus group test in different countries assessing how people liked the application. Summing up, people found the game concept interesting and liked playing.

The quiz component then was realized on three selected mobile phones (with and without touch screen and varying screen sizes) and again presented to a small group of colleagues. Their remarks on game flow and handling on the different phones were taken into account when implementing the simulation component. In a further iteration, both game components were tested on a Sony-Ericsson M600i with touch screen. Game instances were presented to participants of a learning conference. After a brief introduction, the subjects were left to play the games. They were asked to spontaneously verbalize what comes in their mind when playing. After people had finished playing,
they were again asked to summarize what struck them when playing. Again, the games were considered to be entertaining.

Player comments from the various rounds of assessment can be summarized as follows:

1) **design elements and functionality of the user interface**: critical issues were font size and readability, the distribution of text and supporting picture over the screen, the variation of pictures especially excessive recurrence of boss images had an annoying effect on the players, players had high expectations on the functionality and responsiveness of the touch screen which the mobile device did not always fully meet.

2) **story line and appropriateness of system feedback to the user**: players got irritated when the game did not proceed as expected and the system did not respond in a coherent way.

3) **interplay of game software and device capabilities**: people mainly got irritated when loading took too long (different devices had different loading times), and when the response time of the touch screen and the speed of the user touches were asynchronous.

While the usability tests focused on the user interface and device handling, focus group tests on a medical quiz application were conducted with students (age 18-25) and teachers in Austria, Great Britain, Italy, Slovenia and Croatia. Results from 137 students and 13 professors were collected, addressing aspects such as the game’s user friendliness, the usefulness of the information presented, the appeal of the game, player satisfaction with the interface, clearness of the game objectives, and enjoyment.

Overall, it was found that teachers assessed the quiz game clearly more positive than students did. See Table 1. However, teachers were not amused by the boss character, whereas students did not care. Teachers also requested that more advantage should be taken in the games of the multimedia features of phones. Students were especially interested in improved graphics and acceleration of speed, whereas teachers wanted the system to signal when the player was running out of time.

<table>
<thead>
<tr>
<th>Game Characteristics</th>
<th>Students</th>
<th>Teachers</th>
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</thead>
<tbody>
<tr>
<td>user friendliness</td>
<td>32% sufficient</td>
<td>90% sufficient, 40% of which excellent</td>
</tr>
<tr>
<td>usefulness of information</td>
<td>26% good, 23% sufficient</td>
<td>30% excellent, 30% good, 20% sufficient</td>
</tr>
<tr>
<td>appeal</td>
<td>25% sufficient</td>
<td>20% excellent, 40% good</td>
</tr>
<tr>
<td>interface</td>
<td>21% good, 24% sufficient</td>
<td>60% good, 20% sufficient, 20% poor</td>
</tr>
<tr>
<td>clearness of objectives</td>
<td>23% good, 22% sufficient</td>
<td>30% excellent, 30% good, 10% sufficient</td>
</tr>
<tr>
<td>enjoyment</td>
<td>24% sufficient, 19% poor</td>
<td>25% excellent, 40% good, 30% sufficient</td>
</tr>
</tbody>
</table>

Table 1. Teacher and student assessment of game characteristics

**CONCLUSIONS**

We have presented a concept for pedagogically grounded learning games, the quiz “Fastest First!” and the simulation game “Crisis!”, and their implementation on a web server and on mobile clients. The web server is employed for authoring and distributing the games, as well as for organizing and monitoring the learner groups and the learning progress of the individual learners. The web server is also the place where the learners discuss their learning progress with others. The learning games are played on the mobile phones. Their goal is to train the decision making capabilities of the players at a cognitive and an emotional level. “Fastest First!” supports learning at a cognitive level (learning and rehearsing of factual knowledge). “Crisis!” creates very specific, emotionally loaded contexts for the learners to apply the already learned.

The development of the game templates has been accompanied by constant user involvement including the assessment of interfaces and device handling, as well as the assessment of learner and teacher opinions. Usually people found the games interesting and liked playing them. Interestingly, teachers assessed the quiz game overall more positive than students did.
Being a research project, we aimed at a generic implementation of the game templates that suits different mobile phones. User feedback, however, made clear that for the user experience the game technology must be well adapted to individual phone models. For instance, important issues were: font size and readability, and the distribution of text and supporting picture over the screen. Moreover, players got irritated when loading the games took too long (different devices had different loading times), and when the response time of the touch screen and the speed of the user touches were asynchronous. Especially students were interested in improved graphics and acceleration of speed in the game play.

The responses clearly show that learning games are of interest for both students and teachers. However, especially the students measured the look and feel of the learning games against other games, seemingly PC games, whereas teachers wanted to see the multimedia capabilities of their phones being employed in the games.

Given the current state of development of the programming environments for mobile phones and the limitations in memory and multimedia capabilities, the development of appealing learning games for a broad range of mobile phones is challenging and resource intensive. The speed of technical developments for mobile phones, however, gives hope that applications which are now developed in research projects will be more easily realized on new generations of mobile phones in the near future.

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REFERENCES


