Abstract—Students beginning their studies at university face manifold problems such as orientation in a new environment and organizing their courses. In contrast to a conventional scavenger hunt, mobile pervasive games, bridging in-game and real world activities, have the potential to provide help in a motivating manner using new technology which currently becomes more and more common. Thus this paper presents the implementation and evaluation of the pervasive browser-based learning game “FreshUP” which aims at helping to overcome the initial difficulties of freshmen.

Index Terms—pervasive game, campus, freshmen, e-learning, mobile devices, SOA

I. INTRODUCTION

Freshmen at universities often face diverse problems which can affect their performance in the first weeks or months of their studies. Additional to orientation problems on campus, they often move to other cities and own apartments, have to make new social contacts, and have to cope with a new form of learning, living and responsibility for their own lives. Of course, university beginners should gain their own experiences, but in order to increase concentration on the first semester and to decrease the number of dropouts, some help seems sensible.

As computer games are very popular among young people and mobile devices become more and more common, mobile games have the potential to provide effective help in a motivating manner.

As the subject of such a game is a real world context – the university with its campus, administration etc. –, the use of a pervasive mobile game is adequate.

Pervasive games are defined by an expansion of the game context to the real world in terms of spatial, temporal and social dimensions [1]. Using mobile phones, this means to acquire real life information using the current context, e.g. position, sensors, real world objects, and communication with other persons. Unlike traditional computer games the designer is challenged to dissolve the borders between the game and the physical environment while taking care that the distraction by the game can cause hazards for players in the real world and can disturb uninvolved people.

This paper presents a pervasive game for freshmen. In section II related pervasive learning games are described. Section III gives an overview of the game concept and idea. The implementation of the game (section IV) was realized as a student project. Section V describes the evaluation of the game and compares the performance of freshmen who did and did not participate in the game. The final section VI draws a conclusion and gives an outlook on future activities.

II. RELATED WORK

Diverse pervasive mobile games exist for campus navigation systems or city tours (see [2] for more examples). In the following, some games are described:

- A location-based campus navigation game at Dublin City University for mobile devices [3] is designed to offer support for freshmen for finding places on the campus. The players perform certain virtual activities during their first days on campus. Each task affects four commodities – happiness, education, energy and money – in order to develop the gaming experience.
- REXplorer [4] is a serious game which aims at helping tourists to learn about the history and culture of the city of Regensburg, Germany. The players use a remote control, consisting of a mobile phone and a GPS receiver in order to communicate with spirits and to cast spells by performing gestures with the device.
- Chawton House [5] is a manor used for literacy field trips for children. The house is equipped with location-sensitive devices. Children perform tasks posed in form of cards on PDAs in and around the house, putting them into the place of historic writers.
- A game-based mobile learning system of the Shandong University [6] is intended to enable students to perform learning activities without having to travel to seven different campuses. The game consists of virtual campuses, where the player moves to different locations in a 2.5 dimensional environment, where he/she can access learning materials and lecture recordings and perform tasks designed by teachers. The players can communicate via chat and take notes.

An evaluation of the pervasive mobile game Mythical [7] showed that the design of a mobile pervasive game should not only rely on context information as these may be inaccurate. Furthermore, every player should have equal opportunities to access context information. The game should consist of short play sessions and allow for leaving the game at any time without decreasing the chances to win, since incidents in real life or connection problems can cause interrupts at
any time. Additionally, evaluation results showed that inbuilt communication and message boards for general information are advisable.

III. CONCEPT

The concept of the game “FreshUP” is based on a survey with 146 computer science and economics students and thereof derived requirements [8]. The goal is to help freshmen to get accustomed to their new environment and tasks in a playful and motivating manner.

The survey showed that students use smartphones as well as notebooks and personal computers. All students were accustomed with Internet usage and the majority had experiences with computer games. The preferred game genres were rallies and adventures. As these genres are very complex in terms of implementation and platform independence, card games, which were also well-liked, were chosen for the freshmen game.

As the requirements ask for platform independence, a browser-based card game following the principle of a foursome was developed. In equal teams of two to five students of the same course of studies, the students answer questions and obtain cards for correct answers. In order to provide for fair chances, the available mobile devices with Internet access should be divided equally on the teams. Additionally, the assignment of tasks to the teams takes place according to the players’ technical possibilities, i.e. to their available devices (e.g. personal computers, notebooks, smartphones, mobile phones without Internet access).

The questions consist of diverse types (e.g. text input, single and multiple choice, GPS positioning, selection of points in images), derived from IMS QTI [9]. The task types require different actions, ranging from answering a question to visiting certain locations to transmit the GPS position or to obtain a code word. Some of these tasks necessitate the use of a smartphone.

Basically, the questions address four knowledge types: factual, orientational, actionable knowledge and practical skills (see table I). Four cards of the same topic (e.g. campus, course of studies, library, city, public transport), each of them addressing one knowledge type, form a deck and result in one point for the team. After a predefined game duration, the team with the most points wins.

In order to add a motivating factor and to promote interaction between the teams, the principle of the game foursome is amplified by a market place and rally tasks. On the market, teams can swap cards in order to complete their decks. Rally tasks are assigned to all teams at the same time. The team who solves the task first gains the corresponding card.

IV. IMPLEMENTATION

We implemented the “FreshUP” concept in a software project with more than 20 computer science students. As students, they knew the important aspects of student life at our university as well as challenges and problems for freshmen. The implementation took one semester including concept refinements, task definitions and several unit tests as well as overall test runs.

The following presentation focuses on architectural aspects, component interaction, and potential extensions of our implementation.

A. System Architecture

As illustrated in figure 1, the “FreshUP” system architecture consists of a central game engine, a server with all potential tasks and a web server that provides the web interface for player clients. Furthermore, the architecture utilizes the university LDAP to authorize student players. Except for the database, all components are independent from each other and loosely coupled as web services. As each component can be refined and replaced without affecting the whole architecture, we are able to:

- change the task set for other scenarios than freshmen training by replacing the task server,
- change central game mechanisms like group organization and messaging by replacing the game engine (without changing tasks and interface),
- change the interface from web to native by replacing the web server, and
- update a component without affecting other components.

Furthermore, the use of web services and SOAP messages between components enables component developers to choose their platform as well as programming language concerning the functional and personal demands. The current task server and game engine are completely implemented in Java and make use of MySQL databases to store tasks, player data, and group progresses. The interfaces on the web server (Apache) are implemented in PHP and JavaScript.

Figure 2 exemplary illustrates the interaction between all components and a player for the task solving process. The process has been simplified for reasons of visualization. In fact, players are for instance allowed to retry some tasks a certain number of times. Furthermore, they may swap tasks they cannot solve.

In the following, each component will be explained in detail.
### Task Matrix

<table>
<thead>
<tr>
<th>Knowledge type</th>
<th>Sample questions for the registration to a course</th>
<th>Task type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual knowledge</td>
<td>Where do I register for a course? [Examination office/online/professor/tutor]</td>
<td>Single choice</td>
</tr>
<tr>
<td>Orientational knowledge</td>
<td>Select on the map where the course “Programming Basics” will take place.</td>
<td>Select point</td>
</tr>
<tr>
<td>Actionable knowledge</td>
<td>Which information is necessary to register for the course webpage? [Matriculation number/university account/password/e-mail address]</td>
<td>Multiple choice</td>
</tr>
<tr>
<td>Practical skills</td>
<td>Enter your registration number for the course “Programming Basics”.</td>
<td>Text input</td>
</tr>
</tbody>
</table>

Table I: Task matrix composed of exemplary activities relevant to course of studies and knowledge types

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**Fig. 2:** This simplified process of task solving illustrates the interaction of all three components and the human player.

1) **Task Server:** The task server is the repository for all tasks in “FreshUP”. It provides the following functions:
   - store tasks and answer patterns (internal database)
   - provide tasks to the game engine (randomly generated)
   - validate task solutions, given by game engine
   - provide an administration interface for tasks

   Currently, the server stores around 200 tasks covering the different subjects as well as knowledge types (see Table I).

2) **Game Engine:** The game engine is responsible for the overall game logic. It fulfills the following tasks:
   - authorize registered players with university LDAP
   - store player-specific data (e.g. profile, group member)
   - store group-specific data (e.g. open tasks, earned points)
   - route internal messages between players
   - forward messages between task server and web server
   - provide administrative functions for game control

   Authorization of players with the student database happens only once, during registration. After initial authorization, the game engine keeps a local database with game-specific player data.

3) **Web Server:** The web server is responsible for two web interfaces for players. The classic interface depicted in figure 3 can be used with a traditional desktop computer or laptop. Additionally, figure 3 shows the mobile interface that uses the same content but has been optimized for smartphones and PDAs and utilizes these devices’ GPS sensor over JavaScript.

   Additionally, administrators are able to use the game engine’s administrative functions with a dedicated interface.

**B. Extensions**

The described “FreshUP” version has been played in the current semester and the evaluation results will be presented in the following section. Beside the current functionality, we identified several extensions that are currently in development.

In the current semester, we had the first public test run of “FreshUP”. For reasons of manageability, we decided to introduce the game just for computer science students and related branches of study. Furthermore, we decided not to introduce rally tasks and the market place for the current semester. The rally tasks require a large amount of mobile devices as they mostly use GPS features to be solved. Market place functionality shall be realized off-time in a face-to-face meeting in order to further analyze behaviour of players and requirements for the online solution. We plan to introduce both features for the upcoming freshmen generation, that is not limited to computer scientists.

Additionally, we plan to extend the possibilities to solve questions with mobile devices. For instance, we will make use of the device’s camera to answer questions by taking photos of graphical tags (e.g. QR code).
Today’s students are broadly involved in social networks and other media that help to stay in touch with each other [10]. Therefore, we plan a social web interface like a Facebook App to be played directly on those platforms.

V. Evaluation
Subsequently to the student project in the summer semester 2011, the game was tested and improved with the help of student assistants during the summer break. This included, amongst others, bug-fixing, layout adaptations, reviewing tasks, improving the mobile version, and recruiting sponsors for prizes as a motivating factor. In order to attract players for the evaluation, the game was advertised in several introductory events and during an obligatory tutorial for computer science freshmen. Subsequently to this advertisement and a registration phase, the game started.

The game lasted two weeks, starting in the third week of the semester. After one week, the players were asked to answer a questionnaire concerning their experience with games in general, their impression of the game and how “FreshUP” helped getting accustomed to university life. For every group member who completed the questionnaire, the group gained two bonus cards. The bonus cards of all group members added up to one deck and thus the group gained one extra point.

A. Sample
In order to evaluate the effect of the game on the above described obstacles (see I), the questionnaire was distributed to all computer science freshmen, in addition to the students who participated in the game. The sample amounted to 34 students (that is 12 percent of all computer science freshmen), age 18 to 33, whereof 85 percent were male.

Despite of the comprehensive advertisement, 35 percent of the freshmen did not know of the game and 73 percent of them would have been interested to participate because of the possibility to get to know other people, the quick gain of information concerning the university and interest in the game.

Nine male students, respectively 3 percent of all computer science freshmen, participated in the game in the winter semester 2011/2012. They were divided into three groups of two and one group of three players.

1) Comparison of Players and Non-Players: 67 percent of the players used smartphones and 33 percent of the players used a notebook for the game. Overall, “FreshUP” players seem to be more technophile than other freshmen in terms of mobile technologies, since they own more smartphones (see figure 4).

Compared to freshmen who did not participate in the game, none of the players specified an area of university life which they managed bad or very bad (see figures 5 and 6). Concerning the institute of computer science, 67 percent of the players and only 19 percent of the non-players managed very well. Registration-related tasks were managed well by all players, whereas 42 percent of non-players managed these tasks medium and only 29 percent well.

2) Game Evaluation: The part of the questionnaire concerning “FreshUP” showed that all players thought that the
game duration of two weeks was appropriate, whereas 67 percent of them stated that the starting point of two weeks after the beginning of the semester was too late. Furthermore, the players were discordant concerning the evaluation of the group size – it was rated as bad, good and don’t know. None of the players had an opinion to the question whether they would have liked to play in a team or in single player mode. In addition to the mobile devices owned by the players (see figure 4), all players also used a PC to play the game (see figure 7).

Fig. 7: Question: Which devices did you use for the game? (multiple answers were possible)

Overall, the game was well liked in terms of concept, design, usability and implementation (see figure 8). None of the aspects was rated very bad or bad, and usability was rated very well by one player. The level of difficulty of the questions was found appropriate by all players.

Fig. 8: Question: How do you rate the game aspects concept, design, usability and implementation?

The players were asked to sort the task types and task topics according to their preference. The preferred task type was the selection of points in an image. GPS positioning was the least popular task type, perhaps because it required travelling to other locations.

The preferred task topic was campus 2, where the institute of computer science is located. Campus 1 which is farthest away from this campus was the least favourite. The players only agreed concerning organisation which was rated as a medium preference. Concerning the other topics, there was no common preference distinguishable. In contrast, regarding the gained cards of all groups, the number of campus 1 and campus 2 were equal (see figure 9). Organisation and learning methods were the least solved topics. The favourite topic was city with 16 percent of the overall gained cards whereat it has to be taken into consideration that the largest amount of tasks was available for this topic.

Furthermore, the players provided no suggestions or desires for improvement such as additional functionality or different topics.

Fig. 9: Gained cards according to topic

VI. CONCLUSION AND OUTLOOK

Freshmen at universities may be overstrained by diverse aspects of university routines and corresponding changes in their everyday life. Pervasive educational games provide a promising approach to effectively convey learning content like information about the university processes in a motivating manner.

This paper presented “FreshUP”, a pervasive game for freshmen. “FreshUP” confronts, sensitizes, and approaches students with several university subjects utilizing different tasks. The students make use of their smartphones and desktop computers to solve tasks and to communicate with each other. The technical game architecture is based on web services to provide a high extensibility and flexibility for further developments and other areas of application.

The evaluation showed that the game was well liked in terms of duration, concept, design, usability and implementation. Since the players were indifferent concerning team or single player mode, the team concept should not be altered in order to advance student contact and communication.

The results of the questions concerning task type and topic showed a clear preference for tasks which were located nearby the computer science campus and did not require traveling. As group sizes are likely to become larger with more participants in the game, this preference might shift.

The small teams of two to three freshmen had difficulties in gaining enough cards to form decks and thus receive points. Again, larger teams might resolve this problem, but it also
emphasizes the importance of a market place in order to use
the card exchange to complete more decks.

The next game period is planned for winter semester
2012/2013 extending the target group to all fields of study
at the University of Potsdam. Therefore the overall available
task pool has to be increased and special tasks concerning the
fields of study themselves have to be added, ideally in cooperation
with the respective course coordinators. Concerning the
currentness of tasks, it is essential to validate the task pool
before every game start. Additionally, early advertising at the
point of enrolment and multi-language support may also help
to increase the number of participants.

Another future goal is a comprehensive documentation to
ensure portability to other universities, as the architecture
allows for easy adaptation and replacements of single com-
ponents.

The implementation of additional features such as a market
place and racing questions is planned in order to increase the
motivation and intergroup communication. Another motivating
factor might be the integration of communication tools such
as a chat or forum.

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