Developing a Mobile Game Environment to Support Disadvantaged Learners

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This paper reports on the development of *WeBuild*, a mobile learning game designed to engage learners difficult to reach with IT learning. The development is based on a mobile game engine for the Android smart phone that was devised to support the required multiplayer and location based services. We played and tested the mobile learning game in a training facility of the building industry. The results indicate that the learners accepted the game for the low entry barriers and were motivated to use the game in an educational context. This paper describes the *WeBuild* prototype and the underlying game engine. Eventually, it presents results from the game session that was carried to assess interface and gameplay usability, technical functionality and motivational aspects of the game design.

mobile learning; game based learning; IT learning; learners difficult to reach

I.   INTRODUCTION

People with a lower educational background are increasingly difficult to reach by formal teaching and learning. Their limited motivation to learn is often caused by negative learning experiences, a low frustration tolerance and poor stamina. Mobile learning environments seem to respond to the particular needs of learners difficult to reach. Studies have shown that mobile devices help them to recognise existing abilities and to develop and to improve confidence, autonomy and engagement (cf. [1], [2]). Norman [3] emphasises that learning with mobile devices supports training measures because there is no stigma attached to carrying a mobile device around instead of a self-study manual for example. Learners are more readily prepared to use these devices for learning because mobile devices are a cool thing to use [4].

Also, game-based learning scenarios are often referred to as motivating learning environments that meet the younger generation's needs [5], and particularly those of learners difficult to reach [1]. The emerging concept of "gamification" also argues along these lines [6]. Although this concept is mainly used to describe the improvement of user experience and user engagement in digital marketing [7], it is increasingly recognised by educational scientists. They have started to conceive it as a powerful means to make education more fun and to boost students' interest in otherwise rather dry content [6]. Thus, the development of

learning environments that combine mobility and gaming with learning seem to be a promising approach and first results of handheld game studies have shown positive effects on the learning outcomes (cf. [8], [9]). Comprehensive empirical evidence on the motivational potential and learning effects mobile game environments provide is missing though. We therefore developed the mobile learning game (MLG) *WeBuild*. It was designed to further scrutinise how mobile game scenarios impact motivation and knowledge for disadvantaged learners, i.e. learners who are difficult to reach, hard to access or hard to engage (e.g third chance education).

WeBuild is based on a generic mobile learning game engine. It enables location-based and Google Maps Actions, Client/Server Communication, Multiple Choice Question Management and User Management. The combination of these features was required but not found within already existing game engines.

According to Adam's approach of player-centric game design [10], the user interface (UI) of *WeBuild* was developed in several iterative cycles with the enduser being involved in the design and development process as early as possible.

In the following, we describe the mobile game engine. We then present the pedagogical framework, the game design and the technical infrastructure of *WeBuild*. As a concrete realization of the game engine, it uses almost all of the functions the game engine provides.

II.   THE MOBILE GAME ENGINE

The large diversity of platforms on the market makes it increasingly difficult to support all of them. In the context of this research, we decided to develop for the mobile operating system Android Version 2.1 (API Level 7) and higher which can be executed on more than 98% of the currently active Android devices (http://developer.android.com/resources/dashboard/platform-versions.html). As Software Development Kit (SDK), we chose the Android SDK in combination with eclipse.

Game engines for the Android operating system are already available. They usually focus on the display of graphic objects or the handling of touch gestures. Only a few existing game engines provide a multiplayer feature (usually implemented by HTTP polling of the client). None of them can parse and natively handle QTI questions. This

was one of the main requirements for the MLG though. We therefore developed a game engine that reflects these features.

The game engine consists of five Java package folders. The four main features are split into separate folders each. They comprise location-based and Google Maps Actions, the display of Multiple Choice Question (QTI format), Client/Server Communication and a User Management. The fifth folder contains useful tools to ease the implementation process.

A. Location-based and Google Maps Action

1) Handling of Overlay Objects

The game engine provides a data structure called POIContainer that can be used to group POIs together. Beside group operations the POIContainer can be also attached to a MapView.

2) Handling of Proximity Alerts

If a proximity alert is set to a POI, an alarm is triggered if the user gets close enough to this POI. Additionally, it is possible to activate a vibration alert to inform the user that he is close to a POI.

3) Displaying Positions

A Google Map displays a specifc overlay object that represents the players' location. This object can be replaced by a custom user graphic.

B. Multiple Choice Question Management

Because the SpITKom project has chosen to integrate questions by way of the Question and Test Interoperability specification (QTI), the MLG had to enable this standard too. QTI is based on XML and can be used to describe assessment records.

The game engine integrates a QTIParser that translates a QTI string into a QTIQuestion object. The QTI string can be either produced by reading from a local file or by a web request. Currently the game engine supports single choice and multiple choice questions.

C. Client/Server Communication Handling

The game engine provides an object called XMPPConnectionManager. This object can be used to establish an XMPP connection to an XMPP server. In addition, it provides methods to create or join a MultiUserChat and to send messages.

D. User Management

The user management is realised by two data structures. The object User that contains all information neccessary for a user and the object UserGroup that extends an ArrayList and can handle a group (or team) of users. It implements several methods to simplify the user group handling, e.g. displaying of team members only.

III. THE WEBUILD –APPROACH

The game engine was developed in order to realise *WeBuild*. The game is targeted at participants of state funded professional qualification programs offered by the Education Centres for the Building Industry (Bildungszentren des Baugewerbes e.V.). The target group consist of predominantly male participants aged between 17 and 25 years. Only few of them have a school leaving certificate. Also, their capacity to concentrate on something is rather low. They are not used to learn at all and they are not willing to actively participate in learning activities. Furthermore, they have strong personal and social deficits that hamper or even inhibit finding an apprenticeship in companies.

Nearly all of them possess a mobile phone. Their ability to use a computer as a tool for information and/or work is comparatively low though. By now, most jobs however require at least basic skills and knowledge in the professional use of common computer applications (e.g. word processing programs). This also applies to the building industry which increasingly relies on the use of computers for day to day communication or logistic matters for example.

The MLG therefore aims at supporting the acquisition of IT knowledge as one of the key competencies and requirements of today's labor market [11]. It is based on the European Computer Driving Licence (ECDL) (www.ecdl.org) as a standard that reflects and certifies up-to-date skills and knowledge in the use of a computer and common software applications. By providing IT knowledge, *WeBuild* aims at improving the employability skills and prospects of learners difficult to reach.

WeBuild is the mobile version of the multiplayer browser game *BauBoss* which was developed in the course of the German BMBF-project SpITKom [12]. Prior to the development of *BauBoss,* a study was carried out that assessed the players' computer game preferences and their competencies in playing computer games. The results of this study also influenced the design of *WeBuild*.

We use the combination of both, the MLG and the multiplayer browser game, to analyse how coupled games impact motivation and knowledge gain. The research is based on the hypothesis that for the target group, a coupled game is more effective than the desktop version of a learning game only. We imply that for the target group, mobile devices enable exiting and low-threshold learning opportunities that are in line with the target group's leisure time activities (cf. [13], [14]) thus supporting the acquisition of knowledge. Therewith, this approach addresses a fundamental need in European education, i.e. offering new chances to those who were not able to benefit from traditional obligatory education and training, or who were not able to perform at school (cf. [15], [16]).

A. Game Design

1) Learner View

The concept of the location-based mobile learning game *WeBuild* is that of individuals or teams competing against each other while solving tasks. By adding virtual objects to places the target group is daily in touch with, it includes a simple augmentation of physical objects.

For example in the course of *WeBuild*, players have to go to the real stocks (see Figure 1) in order to get the material necessary for building objects (garage, houses, etc.). The
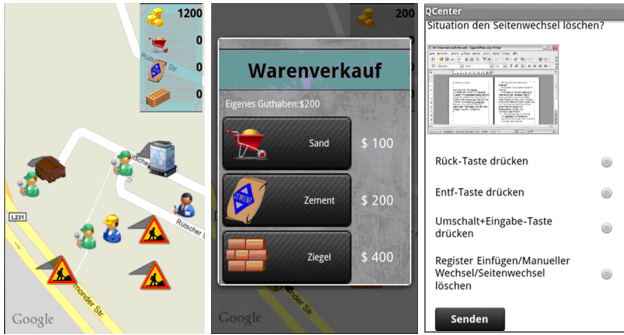
Figure 1. Game screen, warehouse and question template (Draft)

objects are virtually placed on the map and have tasks or questions attached to them. Once a player comes near them, the electronic attachment becomes visible. The player picks them by being close enough and clicking them on the map. Complementing the Mulitplayer Browser Game *BauBoss*, *WeBuild* also addresses multi-user and social interaction of the target group as one of the major objectives.

To start playing, the learner has to sign in. After that, he can choose from different types of objects (e. g. houses, garages, bus stops, etc). The choice of what he can actually build is restricted by his score and/or his money available. The learner has to find places marked on the map, go there and mark them as "construction site". Building grounds can be taken only once. As soon as one player has claimed a certain spot, it is closed to other players and they are denied to take it. For each construction site, the player can select the type of building he wants to build there. Learners can ask friends to help them building an object (e.g. subscribe as helpers), thus working in teams. For the study, this aspect was pre-arranged due to time restrictions.

In the course of the game, the player gets messages on the mobile device that invite him to answer a question or to tackle a task. Both, the questions and the tasks are meant to involve him with IT learning.

Also, game-based tasks and questions are integrated to motivate collaboration and to bring about commonly achieved results. For example, in the course of the construction phase, material necessary to build an object is missing at the construction site. The player thereupon receives a message with the request to get the missing material, e.g. "*We are running out of bricks. Get us three more packages*". He then has to go to the warehouse, find the requested material and pick it. The virtual objects such as wheelbarrow, shovel, cement, mortar, etc. are virtually placed on the map. The player picks them by being close enough and clicking them on the map. If the task is finished successfully, points are granted and the object status on the virtual map updates. The social interaction in the game is assumed to attract the target group, who is very keen on playing with or against other people [12].

2) Teacher/Game Editor View

The game provides an easy to use map editor for teachers. With the editor, it is possible to set up a new game for a specific location and/or a specific target group. After logging in, the teacher can start the map editor. A Google Map shows. The respective location can be reached by pinch and pan touch gestures. From the taskbar on the top of the screen, the teacher can choose a point of interest (POI) type (e. g. building site, warehouse or bank) and place it on the map by tapping on the selected location. Tapping on the POI again, removes it.

The menu enables specific game settings such as (a) defining the name of the game or of teams, (b) enabling the compass and the satellite view or (c) saving and/or loading the game. The save and load functionality allows to save the created game template to the internal storage of the Android device. After the game is created, the teacher can start the game at any time. The waiting room activity then opens in which the teacher has to wait for the players to join his game.

B. Technical Infrastructure

The MLG *WeBuild* complements the Multi-User Browser Game *BauBoss* that was developed in the course of SpITKom. The SpITKom architecture comprises two main components: the front-end community platform and the OICS learning service component. The community platform is based on the LifeRay open source community server and contains the flash-based game front-end. Additionally, the open source QTIEngine (http://www.qtitools.org/landingPages/QTIEngine) is integrated to visualise and evaluate assessments [17].

The SpITKom components are addressed by a web service that wraps the four basic components: the Liferay User service which handles the user management, the QTIEngine which provides an XHTML representation of a question, an OICS Connector which is responsible for storing (and loading) learning outcomes and assessment records and a GameDB Connector that stores (and loads) game data. A HTTP connection is used to contact the SpITKom web service. Figure 2 represents the *WeBuild* infrastructure and points out the relations and connections between the individual components.
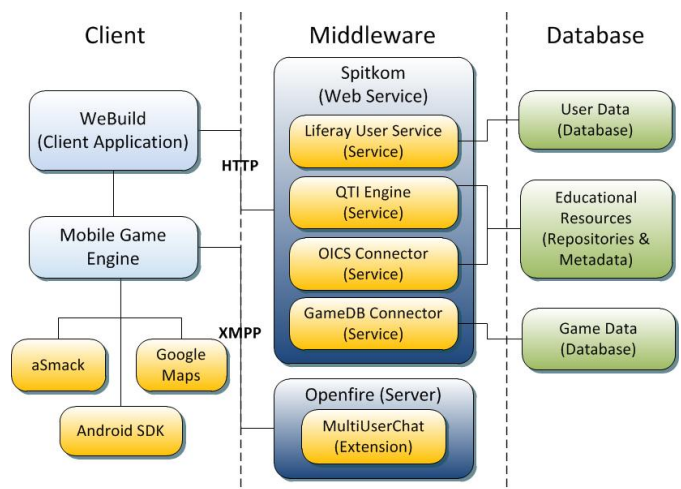

Figure 2. *WeBuild* technical infrastructure

The mobile application is based on three Java libraries: (a) Google Maps for realizing the location-based feature, (b) Smack for realizing the multiplayer feature and (c) the mobile learning game engine developed in the course of this project. The mobile game engine serves as base and provides most of the functionalities, i.e. (a) location-based features build on the Google Maps API, (b) the Question Management to handle questions in the QTI format, (c) the User Management to realise a simple user object or a complete group/team of users and (d) an XMPP Connection Manager that establishes and manages the XMPP connection.

The pilot uses GPS for positioning with a resulting accuracy of three to five meters. The players are located and displayed as overlay objects on a Google Map. Initially, an accurate location of the player is required to open building sites, to answer questions (bank) or to get construction material from the storage.

Because *WeBuild* is a multiplayer game with chat functionality, we decided to use a Client/Server architecture with the XML-based messaging protocol XMPP (www.xmpp.org) handling the chat and application communication [18]. Compared to the HTTP protocol, XMPP it is not stateless. This way, the established connection allows a bidirectional communication between client and server. Furthermore, XMPP already provides several protocol extensions, called XEPs which the game engine makes use of, thus opening a new Multi-User Chat (MUC) (http://xmpp.org/extensions/xep-0045.html) for each created game.

IV. GAME TESTING

In July 2011, a test was carried out that assessed (a) the *WeBuild* interface and gameplay usability (i.e. the integrated features of the prototype), (b) the technical functionality and (c) the motivational aspects of the game design. The six male participants that explored the prototype were aged between 17 and 20 years.

The testing was conducted in order to identify problems that could be addressed prior to the planned larger study. It took place at the BZB Duisburg which are located in the North Duisburg Landscape Park. This area is characterised by vast places without car traffic that could possibly hamper the game actions. The POIs were defined prior to the testing. The real storage depot of the BZB was chosen as warehouse. The bank was positioned at a restaurant. The distance between the warehouse POI and the bank POI was around 300 meters. Also ten construction sites were located in between and around the bank and the warehouse. When choosing the POIs, we had to make sure that they were not too far away from each other. We suspected that in this case players would easily lose interest in the game. On the other hand, placing the POIs too close together would possibly enable them to play whilst standing.

A. Method

There were six HTC Desire mobile phones available for the game play. The phones were equipped with digital compass, Quad-Band UMTS connection, a touch-sensitive screen with multi-touch screen display and 1 GHz CPU Processing Speed. The phones were loaned to the participants for the one-hour gaming session. Before the testing, the game was installed on the devices and SIM cards were inserted in order to set up an online connection.

The participants were equipped with a smartphone each and randomly assigned to two groups of three. Prior to the game testing, the aim of the game was explained and gaming instructions were given. Afterwards the two groups were asked to play for up to an hour. During this time, intervention was kept to a minimum and only made sure that the players got through to all relevant aspects of the game play.

Qualitative data were collected by using a questionnaire and informal interviews (with the teacher and with the students). The researcher's role during the case study was participant observer. The data we collected were analysed with regard to usability, technology use and students' participation and motivation.

B. Results

The game testing showed that the MLG is accepted and that it has potential to motivate the target group. Also, the testing delivered valuable feedback with regard to the features we integrated.

1) Interface and game play usability

Participants think that the game is intuitive. They think that the functionalities are integrated well and that the game play is easy to understand.

2) Technical functionality

WeBuild's complex technical infrastructure proved to run capable. The generic mobile learning game engine, that forms the basis of the application, facilitated to set up a motivating and technically stable game which the players appreciated. They intensly used the feature for social interaction and networking (chat and application communication of the multi-player game).

After the testing, we adapted some functionalities of the prototype. (1) In the future, only teachers can disable the proximity alerts. We adjusted this, in order to avoid that participants erroneously switch off the location-based functionalities (proximity function). (2) The option to enable Google's satellite map view, which visualises the environment, is now integrated to ease orientation. (3) Finally, we implemented a key listener to support learners who are unfamiliar with the Android operating system. The key listener handles clicks on the return key.

3) Motivational aspects of the game design

From the testing it showed that the target group accepted the game. They considered it to be engaging and were motivated to use it in an educational context. Participants agreed that they would like to play the game more often. They liked the concept of the game and had fun walking around outside in teams while using the mobiles, particularly the house building feature and the chat. The distance we chose for the various objects (warehouse, bank, building site) seemed to be fine with the target group (radius of action < 700m).

V. CONCLUSION

In this paper we described *WeBuild*, a mobile learning game designed to support the acquisition of IT knowledge for learners difficult to reach. The game addresses a basic understanding of computers and software applications expected universally in today's workplace. It is based on a mobile learning game engine which enables location-based and Google Maps Actions, Client/Server Communication, the display of Multiple Choice Question (QTI format) and a User Management.

A testing already indicated that the game has potential to serve as an intuitive and low-threshold learning offer for the target group. They accepted the game and enjoyed playing it. Ongoing game testings will ensure that the game ideally meets their needs.

VI. FUTURE WORK

Currently, a larger study is planned to assess the educational potential of the mobile learning game. In the course of the study, the use of the game and its effects on affective and cognitive learning outcomes will be evaluated. The empirical study will particularly focus on (a) the implementation of the game into the instruction of a state funded professional qualification program, (b) the effects of the game-based-learning-approach on the target group's engagement with information technology and (c) participants' knowledge gain. The effects will be compared to a scenario that is based on a multiplayer browser game (*BauBoss*) only.

We expect to obtain information on the long-term effects and practicability of its use. The study will centre on game design elements. It will analyse what game mechanism actually impacts learners' skills and performance and try to reason why. The results from this study will be published in due course.

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