Designing Mobile Games for Learning – The mGBL Approach

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Abstract
This paper describes the technological environment and pedagogical frameworks underpinning the development of mobile game-based learning (mGBL) mobile games. A detailed description is given of the pedagogical and technical basis of the three game templates developed within the project, plus design and trialling details of each associated game. Finally, we discuss the development of our game authoring tool, which allows users to customise mGBL games, and locate and develop new games.

1 Introduction
The mGBL project taps into the zeitgeist of 21st century learning by engaging with the ubiquitous mobile technologies that students already possess. The project is based on the proposition that young people's motivation to engage with education can be maintained through the development of pedagogically sound games, delivered in a manner that is both accessible and approachable. Young people engage with mobile technologies as a normal and natural part of their daily lives and many cannot imagine a world in which these are absent (Prensky, 2001) and we propose that their learning needs can be met within this perspective as well.

At the outset of the project, the majority of mobile games had been developed for PDAs, Tablet-PCs, or Pocket-PCs. From a technical point of view this is a great advantage, as most of the 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, keyboards, and so on. 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 (Sanneblad and Holmquist, 2004; Sanchez et al, 2007).

However, the introduction to the market of the iPhone and its clones indicates the pace and direction of the development of mobile technology. The expansion of the capabilities of mobile devices provides the technological framework that permits the construction and distribution of sophisticated learning-oriented games and offers the user the opportunity to engage with learning in a non-threatening and familiar environment.

The mGBL project involved a collaboration between eleven partner organisations from Austria, Croatia, Italy, Slovenia and the UK, led by evolaris Privatstiftung, Graz, Austria. Our challenge: to design exciting learning games for young people (i.e. aged 18-24) who use mobile technologies, which are fun and fit their lifestyles.

The learning focus: the development of decision-making skills for use in critical situations, a key area of concern in the EC. As Mitchell notes, the mGBL project 'operates within a social-constructivist pedagogical framework where the learner takes centre stage: we are concerned that our innovations are user-led, not technology driven' (Mitchell, 2007).

2 Designing Mobile Learning Games

Mobile learning games have been developed for a broad variety of learning contexts, such as role play and multiplayer games (Mohamudally, 2006; Sanneblad and Holmquist, 2003; Lonsdale et al, 2004; McAlister and Xie, 2005), covering such different applications as role-based foreign language learning (Harriehausen-Mühlbauer et al, 2005) or game-based learning (of computer languages such as C++, for example) (Hamid and Fung, 2007). Other games aim at collaboration (e.g. Sanneblad and Holmquist, 2004; Sanchez et al, 2006).

Whilst a number of proposals for mobile learning games have been presented in recent years, the main characteristics identified for mobile game-based learning applications based on Trifonova's (2003) concise overview of work prior to 2003 remain relevant today. These are:

- learning applications should be self-explanatory and support a playful way of learning,
- the learning content should be split into small units which require only a reduced span of attention so that game play and learning can take place during breaks,
- the learning content should be available any time, and should be integrated in the situational and local context of the learner. Thus, integration of location-based services becomes relevant.

From surveys of eventual users during an early phase of mGBL, we identified some basic rules to be considered when developing mobile games, which concurred with Trifonova's work:

- Do not focus on learning content – instead provide problem-solving activities that require ingenuity. An important aspect of a learning game is the stimulation of learning through activity. Simulation and strategy games should provide a risk-free framework for experiencing critical situations, trying out strategies and thereby offering the potential of arriving at better skills, self-knowledge. In mGBL games, the specific learning activities the user undergoes when playing are based on Anderson and Krathwohl's learning goals – remembering, understanding, applying, judgement and analysing (Anderson and Krathwohl, 2001).
- Mobile games should be real games, not learning contents 'dressed' as games. Exploit the fun and informality of games. Provide challenge, excitement and feedback – use short tasks with rewards built-in. Within mGBL, the game concepts were primarily inspired by the work of Fabricatore, in particular his notion of 'edugaming', which focuses on intertwining learning and gaming (Fabricatore, 2000). The concepts also relate to Prensky's views on game-based learning (Prensky, 2001), who argues that learning games should firstly be fun and then encourage learning.
- Reflect how learning has developed: peer to peer, agile, project based, collaborative, built around communication and project-based activities requiring ingenuity. Real-life interaction, not just role-play – players in different locations exchange/trade information, ideas.
- Create learner-centric games. Keep games relevant to the learner's social and learning needs, 'just-in-time' information needs, capabilities and level. Put the learner in control – and keep it simple. Exploit aspects of community learning with activities set up by, not for, users. Game results should be given also after short

sessions, which correspond to the travel paths to work/study by bus or train. Provide a sense of audience, give them space to grow and adapt, to follow own passions – use a phone-based approach, e.g. incorporating phone calls, messaging – build around communication, tacit learning, ambient learning.

- Generally, do not replicate PC-style games. Games should be specifically designed to meet the specific affordances and limitations of mobile devices. The battery life of mobile devices is a very important consideration, for example, as is the length of games: the shorter the better. For young users, critical features are the costs of mobile devices, whilst for adult users there may be technological barriers.

The small screen size and limited computation capability of mobile devices, along with the particular nature of mobile games themselves, mean that, at present, the content delivery of m-games is somewhat restricted. From this point of view, the real potential for mobile game-based learning lies in providing flexible access to information through the mobile technologies, in an appealing form represented by the game approach.

In response to this challenge we developed three Game Templates and example games in the fields of e-commerce, e-health and e-career guidance, which are areas of strength within the consortium:

1. Game Template 1 'AHEAD OF THE GAME' (Games: a] *Fastest First!* b] *e-Business* and c] *Crisis!*). Game Template 1 contains two modules, a quiz module and a simulation module.
2. Game Template 2 'MOGABAL' (Game: d] *e-Career Guidance*). Game Template 2 uses an adventure game template to allow ultimate outcomes.
3. Game Template 3 'Get Real' (Game: e] *Digital Economy*). Game template 3 can be used to model games reflecting real world problem finding and problem solving.

Overall, the game activities facilitated by the three game templates include:

- SMS (text messaging) for communicating in team games, eg. passing on information to team members and the game system and collecting feedback from these;
- Java quizzes and simulation game components to download to colour screen phones;
- Media collection and sharing by teams of students, using a camera phone;
- Mobile blogging using SMS, MMS (picture and audio messages), camera phones, e-mail and the web.

3 Developing and Integrating Content for mGBL Game Templates

Game Template 1 'AHEAD OF THE GAME' (Games: a] *Fastest First!* b] *e-Business* and c] *Crisis!*)

Game Template 1 contains two modules – the quiz module, on which the example games *Fastest First!* and *e-Business* were designed, and the simulation module on which the example game *Crisis!* was designed.

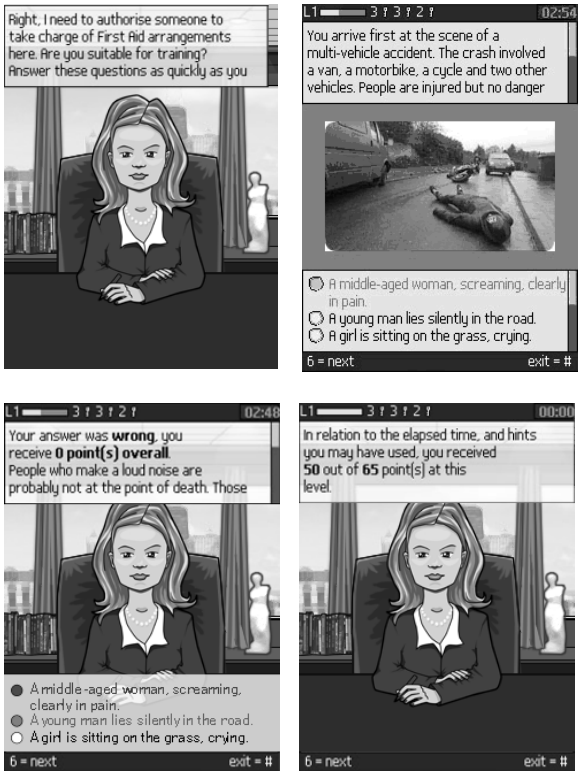
The games are aimed at training the decision-making capabilities of the learners, both on a cognitive and an emotional level. In *Fastest First!* and *Crisis!*, players are forced to make their decisions quickly: in *Fastest First!*, because only the fastest players have a chance to win and reach the next game level; in *Crisis!*, because the situation rapidly deteriorates in the absence of appropriate interventions.

Game a] *Fastest First!* Each question in the quiz module requires the answer options, which of these are right or wrong, the feedback for both right and wrong answers, any hints, and the number of points available. Once all the questions for one level are entered the author can proceed to the next level. A few additional control options are available for each level. The teacher can, for example, specify a level introduction, a mastery score, and feedback for the level as a whole.

Fastest First! is inspired by TV formats such as *The Apprentice* (i.e. the bad-tempered boss character) and *Who Wants to Be A Millionaire?* (i.e. multiple choice questions including joker options). Figure 1 (see below) shows some of the key aspects of *Fastest First!*

- Screen 1 is an example of the introduction of the general topic of a specific quiz, the example shown is a first aid quiz. It is also at this stage where the boss tells the player to be quick in order to get the chance to proceed in the game.
- Screen 2 is an example of a multiple-choice question – the system immediately informs the user whether the answer is right or wrong.
- On screen 3, the boss informs the player that the given answer was wrong – right and wrong answers are highlighted in green and red, respectively. Colour coding alone, however, is not sufficient, as colour-blind players may be disadvantaged. Consequently, right and wrong answers may be indicated using icons such as a thumbs-up or a thumbs-down, respectively.
- Screen 4 shows a simple summary given at the end of a game level, where the player is informed of his or her score and the total of points that could have been achieved.

1. Introduction of Topic 2. Question-Answer Card



3. Immediate Feedback on Correctness of Answer

4. Summary at End of Game Level

Figure 1. Sample screens for the quiz game *Fastest First!*

Game b] *e-Business*. Covered areas: basics of ICT and e-Business; problems and issues of users using e-Business applications; Information Systems (IS) development and e-Business applications; security and privacy of e-Business; e-Business strategy.

Scenario: At the first level the learner applies for a job and the first activity represents a job interview where the student has to demonstrate basic ICT and e-Business knowledge. If the learner shows enough knowledge, s/he is employed as a helpdesk specialist.

In the second level the learner has to deal with problems and issues that users experience using ICT and e-Business

applications. Sometimes this job can be very irritating and demanding but sometimes can also be very amusing.

After successfully finishing this task the learner becomes an IS and e-Business developer or a development project manager. In this level the learner faces more technical aspects of ICT and e-Business application development.

The subsequent promotion and difficulty level focuses on e-Business security and privacy. In this level the learner meets an external IS auditor and has to deal with questions about security measures and privacy issues.

The final level covers strategic decision-making about e-Business in a selected organisation.

The game consists of five levels with ten questions each. The total number of optional answers is 200, with feedback provided for each answer. Hints have also been developed for each question. The mastery score increases from level to level, so level one is the easiest and level five is the hardest. The learner is awarded points for each answer but must achieve the mastery score in order to progress to the next level. If the mastery score is not achieved, the learner must repeat the level from the beginning.

Level	Role	Questions/Points	Mastery
1 Basics of ICT and e-Business	Candidate at job interview	10 (2) 20	15
2 Problems and issues of users using e-Business applications	Employed as e-Commerce helpdesk	10 (3) 30	20
3 IS development and e-Business applications	e-Commerce developer	10 (3) 30	25
4 Security and privacy of e-Business	Head of IT department	10 (3) 30	27
5 e-Business strategy	Board of directors	10 (3) 30	28

Table 1. *e-Business* game levels and scoring

Game c] *Crisis!* While the quiz module supports learning at a cognitive level, the simulation game module creates very specific, emotionally loaded contexts in order to apply prior knowledge. The simulation module targets contextualisation of the learning game along the lines of real crisis situations (Klein, 1996), and modelling of the consequences the user activities in the game have for the user personally and for others (Senge, 1998).

Players of the *Crisis!* simulation game are confronted with critical situations, such as an accident with differently injured people, the breakdown of a computer system, a crisis on the stock market, and so on. The simulation module contains a special scenario, which consists of four critical situations. The students have to prioritise which of the four critical

situations is the most important and than select one of the optional treatments. The player then has to master the situation to the best of his or her ability. The simulation has four steps and in each step the critical situations become increasingly severe. The players' skills will determine how well they are able to do the right things at the right time, and the crisis will either be mastered or will gradually deteriorate. Decisions made at one stage influence all other situations in the subsequent stages. Ultimately, the player is responsible for how the situation develops, and the consequences of their actions for themselves and others.

At the end of the simulation, the player is invited to assess his or her own progress. Points are calculated based on selected situation and treatment option. If the player agrees, the self-assessment is sent to the game server and is then available to be further assessed and discussed with other members of the learning group.

In *Crisis!*, the player is confronted with a situation that changes incrementally from bad to worse. The simulation begins with a description of the initial situation and a multiple choice question, where the player needs to decide which action to take first, in the example, who to treat first (see Figure 2 below). Here the player has opted to treat the unconscious person first (Screen 1). After the player has made a selection, the game asks a question related to that choice. In the example below, the question is how to treat unconscious people. Again, the player has made the right choice by selecting 'Recovery position' (Screen 2). The situation proceeds step by step until all the injured people have been treated.

1. Initial Situation 2. Question Elaborating on the Player's Choice

Figure 2. Sample screens for the simulation game *Crisis!*

Figure 3 shows an example where learner self-assessment and system assessment do not match. In addition, the learner has the option to submit a short self-assessment via SMS. If the system receives clearance from the player, the text is sent via SMS to the server, and can then be further discussed with the learning group.

1. Self-Evaluation 2. System-Feedback

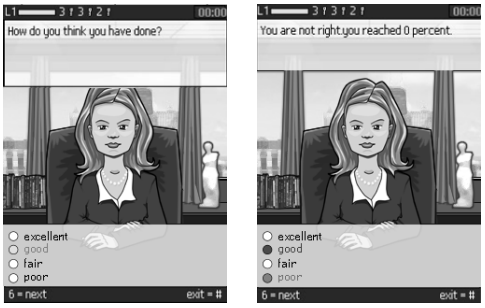


Figure 3. *Crisis!* player self-evaluation and system feedback

Fastest First! and *e-Business* support learning at a cognitive level (learning and rehearsing of factual knowledge), *Crisis!* creates very specific, emotionally loaded contexts for the learners to apply prior knowledge. The games meet Trifonova's (2003) criteria, as they present small, self-contained learning units (question-answer cards), which can be processed by the learners at any time, as they carry their games on their mobile phones.

Game Template 2 'MOGABAL' (Game: d] *e-Career Guidance*)
The challenge, from the technical point of view, in programming a Java 2 Platform, Micro Edition (J2ME) game in the mGBL framework is that the objective is not to create 'one' game, but the potentiality for an abundance of games. Key issues:

- the game type and style may be highly variable
- the game pedagogical content is highly variable
- both the game type and its pedagogical content are to be created, modified or customised by users (the teachers creating the game as support to their courses) in a relatively easy way.

The solution was found in the simple game concept of movement on a rectangular map, having different graphical layers: background graphics, active elements ('sprites') and possible 'fog of war'.

The player's avatar roams the map. If 'fog of war' is present, initially the map is obscured and revealed only during map exploration. A collision with one of the sprites launches an 'event'. Each sprite is tagged with a code to which a list of '1 to n' events is associated. According to game construction rules, sprites can be programmed to 'disappear' from the game after being collided with, or they can be 'permanent' and launch a random event taken from the list of events with the same code at each collision with players' avatars.

The different 'events' supported include:

- Quiz: A text and one or more options to choose from
- Decision Tree: Similar to Quiz, however, various choices have no immediate reward but link to a subsequent event (which can be any event type). This allows construction of complex simulations of chains of choices or decisions
- Conditional Decision Tree: Similar to Decision Tree, but some of the possible choices are available and visible to the player only under particular conditions
- Simple: Text message that can be used as a 'leaf' of a decision tree or as a simple random event
- Multimedia: Opens a multimedia resource then links to a subsequent event. Can be used to enhance the graphic aspect of the events or to insert audio/visual elements in decision trees
- Null event: Game contents logic may require an 'empty' event
- Game Over: Event overriding the normal 'game-over' rules

Another important concept in the game which we have borrowed from role-playing-games (RPGs) is that the player's avatar is personalised by a set of four to six attributes, or 'characteristics'. The names of these characteristics are fully configurable, so that for a 'typical' RPG they could be Strength, Intelligence, and so on. Alternatively, they may be Linguistic, Logical-mathematical, and Interpersonal for a career guidance game. Players can choose between different 'characters' with varied skills. The player's choices and game events will have an impact on the values of these characteristics.

The Java code runs as a 'game engine', while everything else is contained in 'resource files' within the final 'jar' archive file that will be installed on the mobile phone. These files, ie. all the graphic resources (for map or multimedia events) and three text files, contain the:

- Game Setup: Defining names of characteristics, game-over conditions, and so forth
- Graphic Setup: Defining how one or more game maps (one per game 'stage') will be constructed from the resources containing the sprites and graphic elements needed
- Event Content: List of all the events that may happen in a game

Game d] *e-Career Guidance*. mGBL game content development is based on a bottom-up approach, which means that users have been directly involved in the activities from the very beginning of the project. For *e-Career Guidance*, interviews and focus groups were carried out both with users of mobile games and experts in career guidance. Both target groups were invited to share comments and ideas concerning the use of games to support guidance, focusing on the kinds of bias that users may have towards mobile technologies. In this context, content development was carried out, taking into account, firstly, the main suggestions resulting from the surveys and the anticipated benefits of m-games to career guidance and, secondly, that one of the core concepts of mGBL games is to support decision-making in critical situations. Since, in the career guidance field, this concept corresponds to supporting the user's choice in a transitional moment (eg. between school and employment), two specific topics of career guidance were addressed:

- Career guidance and mobility: for support in decision-making in critical intercultural dimensions both for work and study reasons. A specific target could be university students to be selected for EU programmes such as Erasmus or Leonardo da Vinci, for example.
- Vocational guidance: for support in decision-making in critical situations in the work context or in a transitional phase, especially after secondary school but also after university.

In addition, the game design had to take into account factors such as the adaptation of content to one of the available game templates and the fact that the situations created have to amuse and/or thrill the player, otherwise it cannot be considered a game. Moreover, while a quiz-based game was better suited to deliver contents in the other project areas of analysis (i.e. e-commerce and e-health), this was not possible in e-career guidance, since there are no 'right' or 'wrong' answers and every choice must be available. As more interaction was needed to address a 'guidance situation' and to face up to the different possibilities, an adventure game template was selected.

It is important to mention that the specific storyboard outline has been developed by researching critical situations using the analysis of real cases in collaboration with employment centres, youth information centres and guidance counsellors through surveys carried out in Austria, Slovenia and Italy. Based on that information, the game developed into a simulation of a work placement in a foreign country, where the player is free to move in different game areas, facing different situations, with several tasks to carry out and decisions to make. Particular emphasis was given to the emotional process leading to decision-making, and also allowed players access to a guidance centre where they can find help and extra information about the themes they face. Moreover, in order to increase the longevity of the game, the game has been enriched with several optional 'quests' (along the main line of development of the story) with the aim of introducing fun and a wider variety of different situations to be faced.

Finally, as with role-playing games, the aim of this game is not to 'win', but to improve the characteristics of the player's avatar. Specifically, the guidance game has adopted a

scoring model based on Gardner's (1983) theory, characterising the player with a subset of 'Gardner's intelligences'. The game uses those 'intelligences' more suited for a work placement simulation, allowing the implementation of a scoring model which links the performance of the player to the improvement of characteristics through game experience.

Intelligences	**Capabilities and perception**
Linguistic	Words and language
Logical-mathematical	Logic and numbers
Interpersonal	Other people's feelings
Intrapersonal	Self awareness
Musical	Music, sound and rhythm
Spatial-visual	Images and space
Bodily-kinaesthetic	Body movement control

Table 2. Gardner's seven intelligences (the first four have been selected as player characteristics)

The selection of game contents was based on the learning goals that the project wanted to achieve. People have different thinking preferences, dominant learning styles and natural strengths, and various personality theories help to determine individual learning needs and, therefore, the contents of the game. Gardner's (1983) Theory of Multiple Intelligences, for example, proposes that human intelligence is a mixture of several intelligences. His model is a classical one and widely used in education and industry to understand and teach many aspects of human intelligence, learning style, personality and behaviour. His first seven types of intelligence map against all categories in the applicability of mobile games to different learning situations, depending on target groups, content and learning goals. The theory applies to people in general, regardless of sector, country or culture. Focusing on developing individual natural strengths, by selecting the three types of intelligence in which most people are strongest, it increases learning effectiveness. Similarly, there are four main phases in the learner experience in Kolb's (1984) cycle – 'wanting', 'doing', 'feeding back' and 'digesting'. Feeding back and digesting are also important stages in Argyris' (1976) 'double loop' learning process, where players reflect in action by confronting the assumptions and systems behind plans and procedures to consider how far the theory that they are actually using corresponds to their 'espoused' theory.

Game Template 3 'Get Real' (Game: e] *Digital Economy*)
Game Template 3 can be used to model games with elements of real world problem finding and problem solving. This is why this game template is called 'Get Real'.

The main element of the system structure of Game Template 3 is a back-end platform that enables communication via mobile phones (sending, receiving, and automatically reacting to SMS and MMS), a mobile blog, as well as supervision and administration of the learning game. Game Template 3 games are highly collaborative, as they support competition between groups of learners who are trying to identify a critical situation relevant to their area of study and to investigate and propose possible solutions. They have to do this as quickly and as well as possible, demonstrating critical use of appropriate procedures for dealing with crises and an appreciation of the underpinning norms.

- The groups receive the tasks via team blog/SMS from their teachers.
- The group reports their work and summarises their discussion and findings in the mobile blog.
- The teacher checks the blogs and awards points for relevance, depth, clarity of argument, etc.

The group that performs the best earns the most points and is the winner of the game. Our Game 3 interpretation sees these phases as part of real world problem finding and problem solving, which is undertaken collaboratively, using the phone as a tool. 'Feedback' and 'Digesting' are key stages in a 'double loop' (Argyris, 1976) learning process, where learners engage and re-engage with a real world critical situation, 'reflecting in action' (Argyris, ibid; Schön, 1983).

Configuration possibilities provided by the template. The only technical requirement for the mobile devices is that they must be devices with photographic and MMS capabilities.

This game template and these games cannot be downloaded and installed on mobile devices. The platform is installed by the platform administrators on dedicated server hardware. The low-level configuration of the platform is performed directly in a database.

A web interface is provided for users of the platform, which allows controlled and secure access to the platform functionality via a standard web browser. This administrative interface is designed to be accessed by normal PC clients via a web browser with common screen resolutions and data transfer speeds. Authentication with user name and password is required.

The platform contains inbuilt means for automated interactions between the platform and mobile users. Within the administrative interface it is possible to model interactions based on incoming events. This functionality can be used as a game authoring tool to implement complex server-based collaborative games without any additional programming. In combination with other platform features like user set management and message sending, game play can be prepared and controlled via the platform administrative user interface. The following interactions are currently available for modelling:

- Access Check
- Message Sending
- User Set Assignment
- Log Writing
- Message Content Analysis
- Blogging

Game e]: *Digital Economy*. At the Karl-Franzens University, Graz, Game Template 3 was trialled in a *Digital Economy* course with over 100 students, comparing two learning approaches: conventional case studies versus pervasive games. The group, which was (randomly) chosen to learn the basics of the *Digital Economy* via the use of the pervasive game, was assigned the following task:

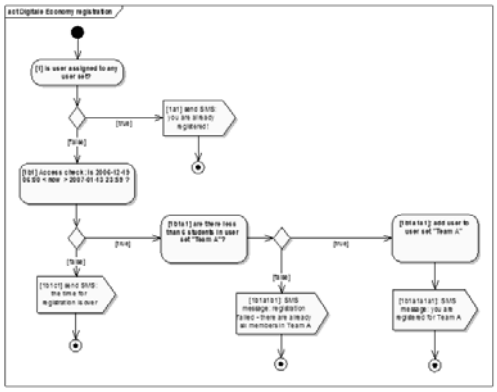
Students had to form ten sub-groups (teams) of six and register via SMS to the game. They then had to identify situations in the real world where certain potentials of the *Digital Economy* are well or badly implemented, and describe them or make suggestions for

improvements using messaging on their mobile phone. Also, a mobile blog was provided by the platform, where students could directly post pictures and explaining text to a dedicated game website via the platform back-end system. The game website was accessible for all participants and, this way, the results of their own and all the other sub-groups could be constantly monitored.

The following screenshot and activity diagram is an example for the registration process of the game *Digital Economy*.

Figure 4. Registering for *Digital Economy*

The registration is done by sending an SMS with the keyword ‘DER’ + team name (e.g. ‘DERA’ or ‘DERB’), where ‘DER’ means *Digital Economy* registration. A successful registration is confirmed with an SMS.



After an SMS with the keyword ‘DERA’ has been received, the displayed interactions will be processed as follows:

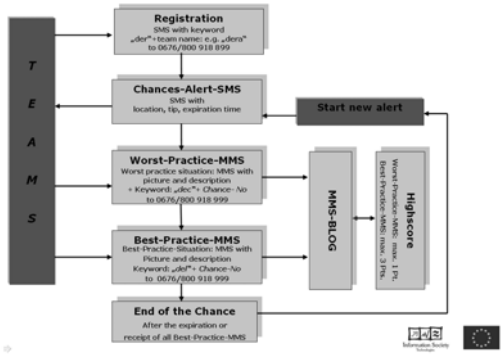
Figure 5. DERA system interactions

[1] The system checks if the user is already assigned to a user set
[1a1] The user is already assigned to a user set. This means he or she is already a member of a Team (eg. Team C) and therefore cannot register for another Team. -> The system sends to the requesting user an SMS with the message ‘you are already registered’.
[1b1] The user is currently not assigned to a team. -> The system checks if the registration request has been received in a valid time range.
[1b1c1] The registration request has been received in an invalid time range. -> The system sends to the requesting user an SMS with the message ‘you couldn’t be reiterated due to the registration time is over’.
[1b1a1] The registration request has been received in a valid time range. -> The system checks if the maximum number of members in Team A has been reached.
[1b1a1b1] The maximum number of members in Team A has been reached -> The system sends an SMS to the requesting user with the message ‘registration failed. There are already six members in Team A’.
[1b1a1a1] The maximum number of members in Team A hasn’t been reached -> The system adds the requesting user to the user set ‘Team A’.
[1b1a1a1a1] The system sends an SMS to the requesting user with the message ‘the registration process was successful’.

All students get an SMS with a task to identify a situation in the real world, where certain potentials of the *Digital Economy* are badly implemented. This SMS is sent by the teacher.

To get points the students have to find a worst-practice situation as soon as possible within a defined time slot. After taking a picture of this situation they have to send this picture via MMS to the server. The MMS must contain a keyword (e.g. ‘DEC1’ for *Digital Economy*

Chance 1) and a description of the situation. Only the first postings and only one posting per team is accepted. If the posting is accepted by the system all team members get an SMS with the information that the posting is valid and that they are allowed to send a solution MMS now. All other students get an SMS with the message that team x has posted a chance successfully.



After a team has posted a chance MMS and the chance MMS has been accepted by the system (only the first posting(s) will be accepted), the team is able to send a solution MMS containing a suggestion for improvement. The MMS must contain a keyword (e.g. 'DES1' for *Digital Economy* Solution 1), an image and a description. Only one solution per team will be accepted.

Figure 6. Game Process

After the time slot has expired or all teams have posted their chances and solutions, the game can be continued with a new chance alarm or can be finished.

The following picture shows the blog created for team A, containing already one accepted chance and solution (newest first).

Figure 7. Team A Blog

The participants and lecturer can constantly monitor the activities of all groups via the gaming platform. The system automatically reacted to erroneous SMS or MMS messages (eg. double registering of a student for different teams, or multiple postings for a certain 'chances alert' by members of the same team) and provided logging and back-up functionalities.

The empirical evaluation results reveal that the pervasive game leads to higher energetic activation, more positive emotions and more positive attitudes towards learning content than the conventional case study approach (Petrovic et al, 2008).

4 Customising and Developing the mGBL Mobile Games

The mGBL templates have been designed to allow teachers (and students) to develop their own mobile games through editing and customising the example games.

However, we recognised that despite the usability of the templates, the development of a new mobile game is not simple. For example, for Game Template 1, which consists of two modules – the quiz module and the simulation module – the game content is much more than just questions and answers. Other information, such as answer descriptions, right and wrong answer feedback, hints, jokers, points awarded and so on, must be provided.

Therefore, we have developed an authoring module containing a special authoring tool for each game template. The authoring module is a piece of software that is integrated into the

mGBL platform as a set of web forms. This module helps teachers to develop new games based on their own teaching content and the selected game template. It enables users to become game authors and to focus on authoring the game rather than struggling with software coding. The tool is accessible by web browser from anywhere that teachers would have access to the Internet.

Teachers have to complete two main sections defined in the authoring tool:

- set up a game – specify game characteristics such as game description, the rules, the number of game levels, the number of elements per level, any time constraints, any jokers and so on
- add content to the game structure – the content can either be questions in a quiz format, or a simulation of a scenario, or a task, depending on which element the user selects from the game template

For example, in Game Template 1, the module for the quiz game includes 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 the cards for editing questions and answers. The latter are the central units through which learning content is presented and assessed. Templates for different answer types are available: single click, multiple click, and sequencing. Authors may upload background pictures for each question that provide contextual information, edit hints, and define a point system of rewards and penalties. Each answer can be accompanied by an explanation of why it is right or wrong, and how many points are gained or lost when selecting a particular answer.

The game setup can be edited with a simple text editor. For the graphic setup, a Java tool ('Boardmaker') was developed that presents a graphic user interface to create game maps and the corresponding 'Graphic setup' text file. Events are defined using XML: an ad hoc XML-DTD describes all the possible event structures so that they are forcibly consistent with the game code; an XML-XSL file allows automatic conversion into the text file that must be inserted within the game resources.

A wide range of game styles can be developed using the above elements. Examples include:

- Quiz: Using 'permanent' event-sprites linked each to a long list of random quizzes regarding various topics
- Exploration: Use of 'fog of war' and visible or hidden obstacles/borders can allow creation of labyrinth games for exploration
- Arcade Style: Event-sprites can also be programmed for predetermined or semi-random movement on a map, thus the aim of the game can be to avoid 'negative event' sprites while searching for 'positive event' sprites
- Simulation: An interactive map can 'put' a player's avatar in a situation (eg. a car accident or a similar crisis situation). Interaction with game elements may force the player to try to make the right decision
- Adventure: With some 'plot creation', the simple 'simulation' game above described can be evolved into a complex 'adventure-game', with several stages (maps). By using the 'Set internal variables value' event it is possible for the game to 'keep memory' of players' choices and have the 'adventure world' react accordingly.

Within all these different ‘game styles’ the contents are completely customisable. For example, in a quiz game as described above, the lists of quizzes could be substituted for others with completely different topics by simply changing the ‘event content’ configuration file without changing the game logic and graphic appearance.

In general, both teachers and students will have access to the authoring tool. Consequently, students will also be able to develop their own games, thereby supporting increased interest in mobile game-based learning, creative thinking and involvement in the learning process.

5 Summary

In this paper we have described the development of the three mGBL game templates, their pedagogically grounded learning games and aspects underpinning their implementation on a web server and on mobile clients.

The learning games have been developed to appeal to young people aged 18-24 and their teachers, and to be played on commonly available mobile phones. The games’ ultimate goal is to train the decision-making capabilities of players at a cognitive and an emotional level.

The web server is employed for authoring and distributing the games, as well as for organising and monitoring the learner groups and the learning progress of the individual learners. The web server is also the place where learners communicate with each other and discuss their learning progress with others.

Further, we have described how we developed a game authoring module for each template, to allow the customisation and development of our example games. In addition, we have developed a database to allow users to select a variety of games based on their affordances in terms of learning content, goals and activities, and the number of learning situations and players supported (see elsewhere in this publication).

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