Experiences from Implementing a Face-to-Face Educational Game for iPhone/iPod Touch

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Abstract—**This paper presents a location-aware educational game for the iPhone/iPod Touch platform. The game, KnowledgeWar, is a quiz game where students can challenge each other in face-to-face or remote knowledge battles. The game contains a game lobby where players can see all who are connected, and the physical distance to them. The paper describes our experiences from developing KnowledgeWar and results from a user test followed by a questionnaire. The user test focused on usability, and how well the game was suited for learning. The results showed among other things that the game had high usability, it is helpful for summarizing topics, it can stimulate involvement and social interaction, and that smartphones are well suited for such games. The results also revealed that our game did not to stimulate students to attend more lectures or pay more attention during lectures.**

Keywords-component; Educational games, Mobile games, Location-awareness, iPhone development

I. INTRODUCTION

In recent years, smart phones have now become increasingly popular. In Norway with a population of only 4.8 million, close to 400,000 iPhones have been sold. Smart phones are no longer only seen in the hands of businessmen, but more and more students use such phones everyday. The motivation for students to get these phones is in addition to impressing their friends to have better access to mobile Internet and to enjoy a richer mobile gaming experience.

In the Lecture Games project, we want to explore how to use games in higher education to provide variation in teaching and new ways of promoting learning through interaction between teacher and students, and interaction between fellow students. Smart phones open new opportunities to be explored for educational games, including the utilization of location.

Games in education have also become increasingly popular in recent years, especially for children and have proven to be beneficial for academic achievement, motivation and classroom dynamics [1]. Teaching methods based on educational games are not only attractive to schoolchildren, but can also be beneficial for university students [2]. Research on games concepts and game development used in higher education is not unique, e.g. [3-5], but there is an untapped potential that needs to be explored.

By introducing games in higher education teachers can access teaching aids that promote more activity among students, provide alternative teaching methods to improve variation in lectures, enable social learning through multiplayer learning games, and motivate students to work harder on their projects and exercises.

Games can mainly be integrated in higher education in three ways. *First*, traditional exercises can be replaced by games motivating the students to put extra effort in doing the exercises, and giving the course staff an opportunity to monitor how the students work with the exercises in real-time [6, 7]. *Second*, games can be used within a traditional classroom lecture to improve the participation and motivation of the students through knowledge-based multiplayer games played by the students and the teacher [8, 9]. *Third*, game development projects can be used in computer science (CS) or software engineering (SE) courses to learn specific CS or SE skills [10, 11]. This paper focuses on a presentation of experiences from implementing a game that can be used in the first two ways described above. The KnowledgeWar game described in this paper can be used as an exercise to make the students rehearse the theory in a more interesting way. It can also be used as a part of a lecture, where the students get a few minutes to play a game trying to remember what they have been taught during the lecture. We believe that it is important to incorporate games and game technologies into teaching, as it gets more common to also use game technology in serious applications [12-15].

This paper describes the architecture and the design of an iPhone game where the players challenge each other in a quiz-battle. The paper shares experiences from working with the iPhone platform as well as results from a user test that focused on usability and on how the students perceived learning from playing the KnowledgeWar game.

The paper is organized as follows. Section II describes related works. Section III describes the KnowledgeWar game including its architecture and design. Section IV shares some experiences we gained from working on the iPhone platform, and describes the user test we performed to assess usability and whether the game was successful in an educational setting. Section V presents an evaluation and discussion of the results, and Section VI concludes the paper.

II. Related Work

In this section we present some educational games and applications for iPhones and for other mobile devices.

Statecraft X is on a mobile learning game for iPhone, designed and developed to enact a program for citizenship education undertaken by 15-year-old students [16]. Located in the Social Studies curriculum, the game represents one component of a broader learning environment that includes in-class dialogic activity to facilitate student sense-making and identity construction.

The paper "Using a PDA for Mobile Learning" [17] provides a learning space based on a Role Play Game (RPG) and quiz model which is good at supporting high level social interaction, progression by incremental tasks, continuous player feedback, and reward systems. The architecture consists of two PDAs running the game application. Information from one application is passed to another via an infrared connection. An exchange manager defines how data objects are passed between two Palm OS handhelds. The user model as defined in the database is used to control the operation of the game from the learner's perspective by relating information from a number of components with which the learner interacts.

Schwabe and Göth used handheld computers running a mobile learning game to support the orientation days at a university [18]. The orientation rally is a fun event intended to get to know the university and its surroundings through doing various tasks at certain spots. The students play individually or in small groups against other players. Each group receives a handheld computer. During the orientation rally, each group gets different tasks referring to significant places, people and events. The handheld device shows the current position of the group on the digital map of the university. When the group enters a building the outdoor map switches to an indoor map of the building. The whole rally is structured as a cooperative and competitive game. The architecture integrates three components: a mobile PDA client, a web browser client, and a server. The architecture provides clients with their own private state of the ongoing game so the game also works offline. The server works as the game's central coordination point. Any changes in the game are transferred to the server, which broadcast the data to all clients.

The Sotto Voce project [19] is a PDA mobile companion for Museum co-visiting that provides audio content of artwork descriptions and acts as an audio media space between visitors providing a mean for awareness and sociability. The authors have identified four kinds of activity: (i) *shared listening* to promote interaction and communication between companions; (ii) *independent use* to enable temporarily or entirely the switching off of the shared listening for visitors that do not want to engage social interactions; (iii) *following*, when a companion is in charge of driving, implicitly or explicitly, the tour; and (iv) checking in, which is a short activity to maintain and update the shared context.

The City project [20] takes place at the lighthouse in Glasgow. The system considers three kinds of technologies: (i) a real visit using a PDA; (ii) a virtual reality visit in a 3D world; and (iii) a Web visit. With this system, visitors are able to share their museum experience visit and navigate jointly through mixed realities: the Web, the virtual and physical reality. Information is provided about each visitor location and orientation. In addition, they may communicate through audio channels. The authors have observed that voice interaction, location and orientation awareness, and mutual visibility are essential to the success of co-visiting between remote users.

The paper "Using mobile phones in English education in Japan" [21] proposes an application that create a Web site explaining English idioms. Student-produced animation shows each idiom's literal meaning; a video shows the idiomatic meaning. Textual materials include an explanation, script, and quiz. Thirty-one Japanese college sophomores evaluated the site using video-capable mobile phones, finding few technical difficulties, and rating highly its educational effectiveness.

TAMALLE (television and mobile phone assisted language learning environment) [22] describes the development processes for a cross-platform ubiquitous language learning service via interactive television (iTV) and mobile phone. The aim of the system is to support advanced learners of English as a second language in their television viewing, as just one element in their language learning activities. As the focus of the learners will be on media consumption rather than on conscious language learning, this environment is designed to be as discreet and non-intrusive as possible. The system provides support for captions and other on-screen displays for comprehension of specific language (or sometimes cultural) items for viewers as they watch English language programs. The mobile phone can further support learners' understanding of the program by enabling them to access the summary of program as well as difficult language and cultural items that may appear. Viewers are also able to add, search for and remove items from/into their personal spheres. Even without television, the mobile service is useful for learning the new language items and as a tool for managing personal knowledge.

Lecture Quiz is a multiplayer game where students can play a quiz game using their own mobile phone and the teacher moderates the game using his PC and a video projector [8, 9]. The game provides two game modes: *score distribution* – the 3D animated presentation of the students answers distributed on the various alternatives, and *last man standing* where the players have to answer correctly to make it to the next round.

Mobile Game-Based Science Learning [23] describes a pedagogical methodology based on interactive games for mobile devices (PDAs). The methodology is oriented to developing problem-solving skills in science classes for 8th graders, by including pre-classroom activities with the teacher, classroom activities, and a central activity using an interactive game for a mobile device. The core problem they have to solve through the game consists in preserving and evolving different biological species from the animal kingdom, in an unknown and varying environment, by modifying some key factors for evolution of the species.

III. The KnowledgeWar Game

This section presents the KnowledgeWar iPhone/iPod Touch game as well describing the main architecture and the design of the game.

A. *The Game*

The initial idea behind the KnowledgeWar game is the notion that students spend a lot of time walking around socializing. Sometimes students even skip classes to just spend some time together. The social interaction among students can be both face-to-face and electronically using mobile devices such as smart phones and laptops. With the KnowledgeWar game, we would like to offer the students an opportunity to spend this social time both entertaining and educational.

A major challenge for educational games is to create games that can be used in several courses but still can be fun. Single player quiz-games fits very well into this category, but they can be a bit tedious and repetitive. By adding a social component, such games can be much more competitive and engaging. Figure 1 shows four screenshots from KnowledgeWar.

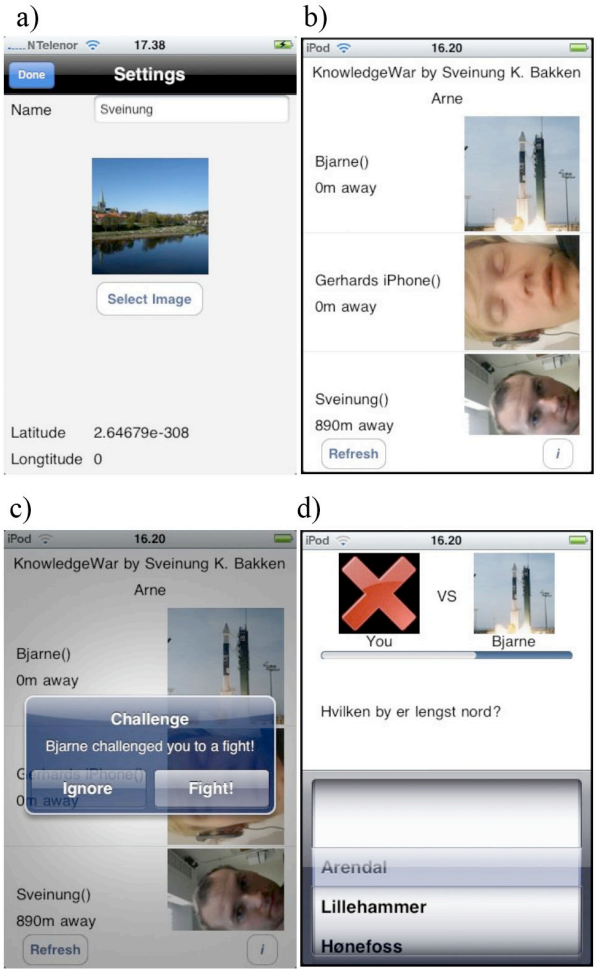

Figure 1. Screenshots from the KnowledgeWar game

The game is interesting, but not very complex. When the user starts the game application on his iPhone/iPod Touch, the player can set a nickname and choose a picture if it has not been done before (see Figure 1a). The lobby screen of the game shows all the available players with names and pictures, and how far away they are (see Figure 1b). In this way, a player can choose to have a face-to-face game or to play remote. Since the game does not enforce the players to be on the same spot, our game supports players with different social preferences. To play the game, the user simply touches the player to be challenged (see Figure 1c). If the other player agrees to start a knowledge fight, the game is on (see Figure 1d). The game itself is a quiz game where the player can choose among a set of alternatives using an iPhone selector (roll selector). The alternative chosen when the timer runs out will be evaluated, and the players get points if their choice is correct. After playing through several questions, the winner is announced to both players. The game application will then take the user back to the game lobby, where the user can challenge more players to fight. The quiz questions used for the game are stored in a database on the game server. The main restrictions regarding the questions are that there must be two or more answer alternatives that can be described in a short sentence (maximum 30 characters) for every question and that the time limit for giving an answer and the correct alternative must be specified. This format makes the game perfect for rehearsing theory in a course to test students' theoretical knowledge. The game is not suitable for testing certain skills or techniques. Many textbooks provide teachers with multiple-choice assignments ready-to-be used for testing students' knowledge. These multiple-choice assignments can directly be used in the game as long as the description of alternatives is not too long. When a player challenge another player in the KnowledgeWar game, the game server will randomly pick five questions from the database to be used in a game session. A natural extension of the game would be for the teacher to be able to bundle questions at different difficulty levels, to let students get questions that are appropriate for their level of knowledge. The difficulty level could also be related to the score you get from winning a knowledge fight.

The main challenge when implementing the iPhone client was to learn Objective C and the interfaces in the iPhone OS.

B. *The Arhictecture*

The implementation of the KnowledgeWar game is based on a service-oriented client-server architecture. An overview of the architecture is shown in Figure 2. A game server takes care all services shared by users such as player profiles, question database and game sessions. Apple's Push Notification Service is used to push events to the iPhone/iPod Touch clients.

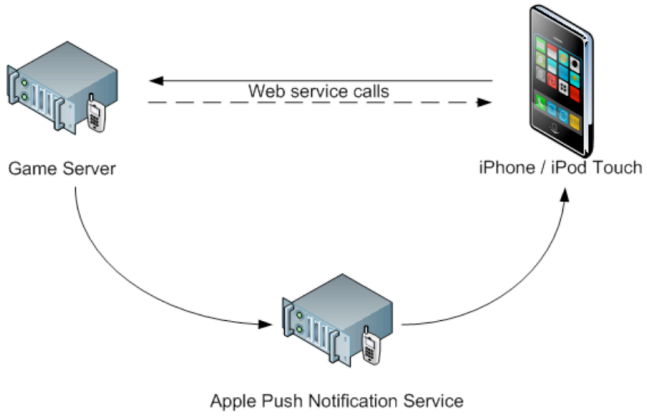

Figure 2. KnowledgeWar architectural overview

Figure 3 shows the game server architecture. We used several free and open source libraries for providing the main services of the server to make the server as flexible as possible. The server is Java-based and all of the components are tied together with Maven, Spring XMLs and custom Java code. This enables a flexible plugin interface to the server. The architecture shown in Figure 3 is divided into three main parts.

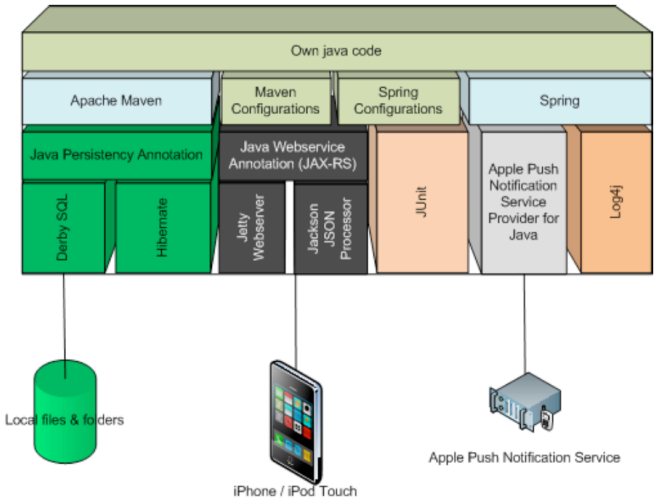

Figure 3. KnowledgeWar Game Server Architecture

The left part in Figure 3 takes care of the data management and data persistence. The middle part consists of a web server and a framework for providing web services to the client. The right part takes care of pushing events to the client via Apple's Push Notification Service. The architecture also includes JUnit use for testing and Log4j for providing logging when running the server. The domain model shared between the server and the client consists of *Challenge* – a challenge from one player to another, *Heartbeat* – position processing, *Opponent* – contains a *Player* object and the distance to this player, *Player* – containing unique identification, nickname and avatar image, and *Round* – containing questions, possible answer and correct answer. Services provided by the server are a game service, a location service, a player service, a persistence service, and a push notification service.

Figure 4 shows the client architecture. When the client is launched, the application delegate is initiated. The other parts of the architecture is the persistency class providing persistency locally on the device, the domain model similar to the server (Heartbeat, Challenge, Player, Opponent and Round), the backend integration, view controllers consisting of four views (see Figure 1), the view definitions used by the view controllers, and the Utility class providing shared attributes and methods.

The third author of this paper implemented the KnowledgeWar game over 4 months in his master project.

IV. Experiences and User Test

In this section we will share some experiences we learned from developing an iPhone application, describe how we performed the user tests of the game, and present the results from the user tests and the questionnaire.

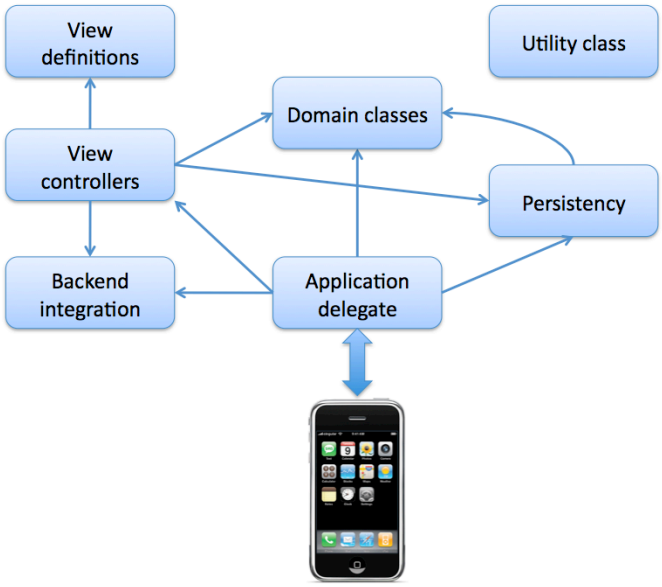

Figure 4. KnowledgeWar Client Architecture

A. Provision of iPhone Apps

The iPhone OS has a built-in security mechanism to ensure that applications have not been tampered with before they are installed. The security mechanism consists of a chain of certificates that must be signed by all applications to be installed on the device. In practice, this means that researchers cannot simply compile and build the code and then deploy it directly on a device. It is important for researchers wanting to use iPhone/iPod Touch as an exploration platform to know about the limitations related to deployment and what options are available. There are four methods for deploying an iPhone/iPod Touch application**:** *1) Use App IDs* that will identify your application and make it related to your provisioning profile; 2) *Use ad hoc distribution* that will allow the developer to distribute an un-approved application to up to 100 pre-registered devices through iTunes; *3) Use a debug install* where the application is deployed to a physically connected device by launching the application directly from the development tool; and 4) Use the *AppStore distribution channel* where the application must be approved by Apple before it is made available on Apple's AppStore.

For many developers, including ourselves, we were not used to the approval process enforced by Apple. Even though we did not plan to release our KnowledgeWar game on AppStore, we were curious on how hard it was and how much time was required to get an application approved and ready for download/sale at AppStore. To test the entire app approval lifecycle, we submitted a four unrelated apps to the AppStore. The applications we submitted were two variants of a time tracking application and two applications for efficient emergency event management. Three out of the four apps were

payable apps. The results of our test on approval time are shown in Table I.

TABLE I. TIME FROM APPSTORE SUBMISSION TO READY FOR SALE

Application	Approval time
App1	4 days
App2	4 days
App3 version 1	5 days
App3 version 2	6 days
App4 version 1	5 days
App4 version 2	6 days

Our experiences from submitting apps to AppStore approval were that we did not encounter any problems, and that the processing time was acceptable. For larger apps, for apps that challenges the technical constraints or for apps that challenges the moral constraints of Apple, longer processing time must be expected.

B. The User Test of the KnowledgeWar Game

To get the users' verdict of what they thought of the KnowledgeWar game we conducted a user test. The purpose of the test was two-fold. First, we wanted to test the usability of the application, as high usability is expected on iPhone/iPod Touch applications. Second, we wanted to see if the students found the game useful for learning and fun to play.

The user test was held on April 30th, 2010 in a reserved auditorium at the university campus. We recruited students from 1st, 2nd and 5th year of the Master of Science (MSc) in Communication Technology to do drop-in sessions during a two-hour time window. In total eight subjects participated. All the subjects had a technical background and were familiar with smart phones. The game was pre-installed on six iPhones and IPod Touches before the test began. The students played against each other with mainly technical questions from a software architecture course in the questions pool. The available wifi network on campus was used as the carrier for the communication, and the game server was hosted on a laptop on the same wifi network.

The users had to go through the following steps:

1. Start the application
2. Input a nickname and select an image for the player profile
3. Challenge another player
4. Play the game
5. Repeat steps 3 and 4 a couple of times
6. Fill inn the questionnaire

The success criteria for the KnowledgeWar game were:

- H1: The game application has high usability
- H2: The game is a fun way of practicing knowledge
- H3: The KnowledgeWar game has a positive effect on learning

C. The Results

To assess the usability of our KnowledgeWar game we used the System Usability Scale (SUS) [24]. SUS measures usability through ten statements, which the subject is to state a degree of agreement by using the Likert scale (from Strongly disagree=1 to Strongly agree=5). Odd statements contribute with their "`average value - 1`", and the even statements with "`5 - average value`". These contributions are multiplied by 2.5 to get a score between 0 and 100 points where higher is better. Table II shows the SUS statements and the scores we got from the student questionnaires.

TABLE II. SUS STATEMENTS AND SCORES

	Statement	Average	SUS Contribution
Q1	I think that I would like to play this game frequently.	3.50	6.25
Q2	I found the game unnecessary complex.	1.88	7.81
Q3	I thought the game was easy to use.	4.13	7.81
Q4	I think that I would need the support of a technical person to be able to use this game application.	1.50	8.75
Q5	I found the various functions in this game were well integrated.	3.63	6.56
Q6	I thought there was too much inconsistency in this game.	1.86	7.86
Q7	I would imagine that most people would learn to use this game application very quickly.	4.38	8.44
Q8	I found the game application very cumbersome to use.	1.88	7.81
Q9	I felt very confident using the game application.	4.25	8.13
Q10	I needed to learn a lot of things before I could get going with this game.	1.38	9.06
		SUS score	78.48

KnowledgeWar received a SUS score of 78 points (see Table II) out of 100. According to Bangor, Kortum and Miller [25], our score is well within the acceptable range on their SUS score, and is about in the middle between the markers for good and excellent. The three biggest contributors to the SUS score was:

- Disagree with the statement: "*I needed to learn a lot of things before I could get going with this game*". This statement contributed 9.06 pts.
- Disagreement with the statement: "*I think that I would need the support of a technical person to be able to use this game application*". This statement contributed 8.75 pts.
- Agreement with the statement: "*I would imagine that most people would learn to use this game application very quickly*". This statement contributed 8.44 pts.

The statement with the lowest contribution was the agreement with the statement: "*I think that I would like to play this game frequently*" (only 6.25 pts). Hopefully it is possible to improve this part by improving the graphical presentation of the game, introducing new game modes, and populating the database with more entertaining and engaging questions. Another possible explanation for the low score could be that

the test was not carried out as a part of a course, and the questions were not taken from their current courses.

Although the number of participants in this study was fairly low (n=8) and there are some sources of errors in how the subjects perceived the game, the SUS score strongly indicates that a quiz game like KnowledgeWar is suitable on the smart phone platform.

The next part of the assessment was to investigate the subjects' perceptions of using a game like KnowledgeWar as a part of a class or for teaching purposes. This assessment was made through ten additional (to SUS) statements in the questionnaire. The results are shown in Table III.

TABLE III. KNOWLEDGEWAR GAME AND LEARNING ASSESSMENT

	Statement	Average	% (Strongly) Agree
N1	This game can create healthy competition in a class.	4.25	75%
N2	This game can stimulate to involvement in a class.	4.13	88%
N3	I would attend more lectures, if they were supported by such a game.	3.13	38%
N4	This game would help summarize a topic after a lecture.	4.38	100%
N5	The use of mobile smartphones is a good platform for increased motivation in a class.	4.13	88%
N6	I liked the idea of challenging other fellow students.	4.25	75%
N7	I would like to challenge the teacher through this game.	3.75	75%
N8	This game was social.	4.25	88%
N9	Every course at NTNU should have a game like this.	3.75	63%
N10	I would pay more attention in the lecture, if I could play such a game after the lecture.	3.38	50%

Table III shows the results of the additional non-SUS statements in the user test. These statements were added to the questionnaire specifically to address if "*The game would be a fun way of practicing knowledge*" (success criteria H2) and if "*The KnowledgeWar game has a positive effect on learning*" (success criteria H3). We will first look into the former. For the statements 1, 6 and 7, 75% of the participants check the strongly agree box, "This game can create healthy competition in a class", "I like the idea of challenging other fellow students" and "I would like to challenge the teacher through this game", which clearly support H2. 88% strongly agreed to statement 8 that "This game was social". Improved social integration in a class is desirable from both teacher and students support that also support H2.

If we consider success criteria H3, we find that only 38% strongly agreed to statement 3, that "They would attend more lectures if it was supported by a game like KnowledgeWar". It seams that the game in its current version is not likely to improve lecture attendance. However, every subject strongly agreed to that "This game would help summarize a topic after a lecture" (statement 4), which is very encouraging. 88% of the subjects strongly agreed to "This game might stimulate to better involvement" (statement 2) and "The use of mobile smart phones as platform" (statement 5). These are very positive results that encourage us to continue the development of such games in the future.

V. EVALUATION AND DISCUSSION

This section presents evaluation and discussion of using iPhone as a development platform for lecture games and how smart phone affects the usability of lecture games.

A. Developing for the iPhone

Developing for the iPhone proved to be an interesting learning experience. The platform has a number of good characteristics that aid the development of rich and powerful mobile applications. Some of the good features of the platform that deserve to be highlighted are:

- Excellent development tools for both code and GUI.
- Good run-time environment, desirable features at place for the developer.
- Well-documented and mature platform.
- Good process support for certificate generation and provisioning profiles with web portal.
- Provided service for standardized push communication to the mobile device.

What might be left as arguments against choosing the iPhone as platform for a mobile application might include:

- Application guidelines restrict the use of undocumented system libraries, which exclude certain hardware and system information (like visible wifi access points).
- The lack of automatic garbage collector and not so widespread programming language (object C).
- Intel Mac is required to run the development toolkit Xcode & Interface Builder. No support for Windows or Linux operating systems.

The KnowledgeWar game was developed for the iPhone OS version 3.2.3. A major restriction for this version was the lack of support for multitasking. This problem has been solved in the iOS4 (iPhone OS version 4) release where multitasking was introduced. However, the multitasking is still limited as it can only be used to execute some specified services. Here are some new features in OS4 that could have improved our game:

Text messaging - A pre-filled type and send Short Message Service (SMS) screen could have been included in one of the application views. This feature could have been used to improve the social aspects of the KnowledgeWar game.

Background processes – multitasking – is one of the most important contribution of the iOS4. Instead of completely exiting and destroying applications when pressing the Home button, applications can continue to run in a background context. An event is raised informing the application about the state change. Applications that require to prevail can do so by three techniques: (i) *Schedule local notifications* to alert the user of activity, basically a local, scheduled version of the Apple Push Notification Service. Possible usage scenario could be alerting the user about it is time to

play another round of quiz game; (ii) *It can request to run for more time* to complete some important task that will take more time than what is allowed during shutdown, e.g. writing large amounts of data to disk; and (ii) *It can become a background service* that will be awaked at specific intervals or at a specific time. This will allow e.g. background updates to a web service or similar.

The communication and back-end solution was designed and implemented with flexibility and agility as one of the main criteria. Best practices from the respective developer communities have been adopted into this solution's requirements. The flexibility and agility has been provided by using the Spring architecture and the Maven build system. By following Java standards, the solution should also be ready for future changes in the technologies and libraries. Implementing an additional web service or a new server with this solution as a mold, serving a completely different purpose, with its own domain model and another transportation format is trivial and would require only a minimal effort. We have not executed any substantial performance and load tests, but we do not believe that this will be a major problem as it is not likely that hundreds of players will play the game simultaneously. If an alternative component emerge who offers speed, functionality or other improvements, it can be swapped with the original component with no or little source code changes.

Based on experience from this project and others, we find that the iPhone platform is an extensive and mature platform for application and game development. No major technical issues were encountered during the implementation that was impossible to overcome. The solutions provided to the developers for technical issues, like the addressing and delivery of server-initiated notifications, further elaborated the maturity and quality of the frameworks and tools provided for applications and application developers.

Most of the limitations we encountered such as no support for background process have been addressed in iOS4. Other issues like undocumented system libraries and time-consuming application approval process still put extra burden on the developer, but these restrictions can be beneficial for the end-user with a more homogeneous and reliable end product. In some applications these properties can be worked around, but in others they are deal breakers that will force the use of another platform.

Research projects that do not demand, or will pass an application approval process have alternative means of distribution which will lift some of the restrictions as presented in this paper, but imply other restrictions like maximum one hundred pre-registered ad hoc users.

The push functionality in our game was implemented by using Apples Push Notification Service (APNS). The APNS was selected for addressing and routing simplicity as a server-initiated channel and it proved to be easy to use, reliable and fast. The second communication channel was a lightweight REST/JSON web service, which was designed and implemented with flexibility and extensibility in mind. This worked also very well in our architecture.

B. Usability and Learning

The KnowledgeWar game was tested by a small number of subjects during a usability experiment before they answered a questionnaire about usability and the use of games in an educational context. Overall, the feedback from the experiment was very positive, especially on the general usability. We found the smart phone platform in general and iPhone/iPod Touch platform specifically to be well suited for lecture games. The main benefits of using this platform is that the platform is popular with the students, it provides high usability if the applications are designed correctly, it has a large screen that is well suited for quiz games with texts of varying lengths, and it is a cheap platform for doing large scale tests with own equipment. A major headache when doing large-scale user tests with mobile equipment is to provide enough sim cards for several mobile phones or smart phones. It might be possible to get a limited set of non-functional sim cards to opens the phones so they can be used in tests where only the wifi network is used. However, if applications are developed for the iPhone/iPod Touch platform, iPod Touch devices can be used for testing. These devices cost about the half or less than smart phones, they have all the functionality of smart phones apart from being able to make calls, and they can be used for testing right out of the box. The major limitation of using iPod Touch as a deployment platform is that the device does not come with a built-in GPS. This means that the iPod Touch works well for testing location-aware applications that do not require very accurate positioning (accuracy of 15-20 meters and better) or positioning without wifi coverage.

The location-awareness functionality in the KnowledgeWar game is designed not to be intrusive by showing the physical distance to other players connected to the game server. This makes it possible for players to choose to play the game face-to-face or remote. With iOS4, we could have improved the location-awareness functionality of the game. One improvement could be to let the game run in background and notify the user when other players are nearby. Similarly, we could have extended the game lobby to allow users to create friend lists. This could stimulate players to build a community of players that enjoy playing against each other.

The KnowledgeWar game it self is not a very complex game. What we would like to add in the future is a role-playing aspect where the players level up and get new features and game modes as they progress. The goal of the game will then be to level up and be the king of the hill (the best overall player). Another feature to make it a more interesting experience is to add AI-controlled knowledge monsters that players have to beat to level up. Some of these monsters might be very powerful and skillful and could involve knowledge fights where several players have to collaborate to beat the monster (similar to quests in MMORPGs). There are limitless opportunities of expanding the game. In this design process, the main drivers is to make the game more social and hook the players into the game by providing new and interesting features as they level up (rewards). Further, we could provide every player with an avatar that levels up as the game progress, which will also improve players vs. player encounters. In this way, we hope that this will be a game motivating students to spend more time studying, just to beat the game.

VI. CONCLUSION

The KnowledgeWar game was designed with three success criteria in mind: H1: “The game application should have high usability”, H2: “The game should be a fun way of practicing knowledge”, and H3: “The KnowledgeWar game should have a positive effect on learning”.

The results from our user test shows that the game has high usability (close to 80% SUS score). However, we identified some areas that must be improved. The statements with lowest scores were “I would like to play this game frequently” (6.25 point) and “I found the various functions in the game well integrated” (6.56 points). These statements indicate that the coherence of the game application must be improved along with providing more engaging and variable gameplay. We believe adding role-play elements to the game including leveling up, new game modes, and challenges against AI knowledge monsters can solve this problem. Further, we believe that improving the social aspects of the game will also make students to play the game more frequently. This can be done by adding friend lists and opening for collaborative gameplay.

The scores from the non-usability statements were overall positive in relation to the game being a fun way of practicing knowledge and to have a positive effect on learning. The students liked that the game was social and that this was an engaging way of rehearsing theory. The statements that scored the lowest were “I would attend more lectures, if they were supported with such a game” (38%) and “I would pay more attention in the lecture, if I could play such a game after a lecture” (50%). We believe that these statements scored low as the user test was not carried out in the context of a course, and this issue can be improved if we make the game more competitive and introduce a clearer overall goal of the game (e.g. to be the king of the hill). Especially, if we introduce a prize for the best player of the semester, and if the questions are directly linked to the lecture, we believe that lecture attendance and paying attention during lectures will improve.

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