Knowledge War – A Pervasive Multiplayer Role-Playing Learning Game

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Abstract: This paper describes how a pervasive multiplayer lightweight Role-Playing Game can be used in higher education to motivate and engage students. The primary research goal was to study the educational effect of this type of game, while the secondary research goal was to evaluate the usability of the game. The game named Knowledge War combines gameplay elements from role-playing games where you can build and grow characters with location-awareness that "forces" students to physically move around campus to compete in a knowledge war. The game was tested on students in a software architecture course at the Norwegian University of Science and Technology (NTNU). Data from the experiment was collected through questionnaires as well as group discussions with the subjects. The results show that students found the game both to be fun and educational. However, the results also reveal that the game needs more gameplay elements and game world content to keep the students playing the game regularly. Our main conclusion was that the use of role playing game mechanics in a pervasive game has a good potential for a successful educational tool in higher education.

Keywords: Learning game, Pervasive game, Role-playing game, Student engagement, Student motivation, Knowledge War

1. Introduction

Since the release of the Apple iPhone in 2007, the sales and use of smartphones have become a widespread phenomenon. Today smartphones and tablets are used by almost everybody everywhere at any time. The introduction of smart devices along with the offered infrastructure at schools and universities has opened for the wave of bring your own device (BYOD) applications and platforms (Ballagas, Rohs et al. 2004). At the same time that BYOD has become common in schools and at universities, game-based learning has started to make an impact in the same environment. Well-designed video games are said to be learning machines (Gee 2003), and they have the potential to get the players so motivated and engaged that they are not aware that learning is actually happening. In K-12, games have been found to be beneficial for academic achievement, motivation and classroom dynamics (Rosas, Nussbaum et al. 2003). Games have also been found to have a similar effect in higher education (Sharples 2000). Previous research indicates that games can be made an integrated part of traditional classroom lectures to improve learning, motivation and engagement (Carver Jr, Howard et al. 1999, Carnevale 2005, Wang, Øfsdal et al. 2008, Wang, Elvemo et al. 2014). Most of these games utilize multiple aspects in the classroom, as well as using the large screen in the classroom or lecture hall as a shared screen for the students and the teacher. Games can also be used for learning outside the classroom, and opens for opportunities of combining learning and increased physical activity. Through game concepts that combine the virtual world with the real world, pervasive games makes the player play a game and at the same time being physical active (Guo, Trætteberg et al. 2010). There are also some examples of pervasive learning games with the same features, such as (Shi, Xie et al. 2003, Yau, Gupta et al. 2003, Wang, Wu et al. 2010, Wu and Wang 2011).

There are few contributions in the segment of pervasive or mobile learning games aimed towards higher education. In this paper will presents the pervasive game Knowledge War, which has roleplaying elements to make the gameplay deeper. The game concept is that students choose their own character that should fight knowledge battles against other players answering multiple-choice questions.

The paper is organized as follows: Section 2 presents related work. Section 3 presents the Knowledge War pervasive learning game. Section 4 presents the experiment and results where the KnowledgeWar game was evaluated. Section 5 concludes the article.

2. Related Work

Gamification has recently been a popular trend connecting to a sizeable body of existing concepts and research in human-computer interaction and game studies, such as serious games, pervasive games, alternate reality games, or playful design (Deterding, Dixon et al. 2011). Pervasive gaming is a genre of gaming

systematically blurring and breaking the traditional boundaries of game (Montola 2005). There are many examples of research on pervasive games such as (Cheok, Sreekumar et al. 2006, Jegers and Wiberg 2006, Ballagas, Kuntze et al. 2008, Wu and Wang 2011), and there are also quite a few studies on pervasive learning games (Yau, Gupta et al. 2003, Thomas 2006, Bang, Gufstafsson et al. 2007, Markovic, Petrovic et al. 2007).

Although there are some noticeable differences, there are some studies that have some resemblance with the game and experiment presented in this paper. In (Wang, Wu et al. 2010), experiences related to implementing a smart phone quiz game where students can challenge other students in the same location in battle. This game, however, does not utilize the player's location apart from discovering other players in close vicinity. It lacks the discovery elements of the Knowledge War and has very simple gameplay without any role-playing game mechanics.

Using a PDA for Mobile Learning proposes an RPG model for a learning environment, which is considered to provide a good learning space that supports social interactions at a higher level, progression by incremental tasks, and feedback to the player and a reward system (McAlister and Xie 2005). It describes the types of tasks a user can complete (e.g. reading a paragraph, answering a question with the correct answer), and the amount of reward in the form of "experience points" the user can get for completing these tasks. The user can then use these experience points to purchase aids in the form of displaying the correct answer to a question or removing one wrong answer from the alternatives of a question.

Campus Quest allows the users themselves to create the mobile game-based learning experience (CampusQuest 2016). A faculty member can define how and when a game should be played, and since the game is web-based, it is available for most current smartphones. It does not necessarily have to be used to learn the curriculum, but can also be utilised for student orientation, campus tours as well as classroom learning. The game has many other applications. It is a game-based quiz application primarily for use with smartphones, which allows an administrator to set up a game, questions and define alternatives for the questions. Students can then group up in teams or play alone. The players answer the questions the administrator sets up and is then ranked by their performance in terms of speed and correct answers. The administrator can view a pseudo-live scoreboard, updated at a frequency of choice.

3. Knowledge War – A Pervasive Learning Game

Knowledge War is a pervasive role-playing learning game where student walk around the campus discovering virtual treasures and items to pick up, and fight against fellow students in a RPG-fashion quiz-battle if they are in the same physical location. During the initial discussions of how we pictured the game as well as features we wanted to implement, it was easy to draw upon known existing games, which implemented a similar feature. For the battle itself, we pictured the opponents facing each other with some basic information such as name, level and health-bar next to their avatar. Here, the inspiration was mostly based on battle and fighting games like Pokémon, Tekken, and Street Fighter.

As the game was to be set in a virtual game world and incorporate location-dependent gameplay of some sort, the player will need an illustration or map of this world, which display the player in relation to his surroundings. The solution was to implement a fog-of-war type of map, where only a limited area surrounding the player is visible. Undiscovered areas are completely in black, while earlier explored areas that are not in the players immediate surroundings are hidden by fog. This gives some extra excitement to the game, as the player has to explore to find other players, enemies, locations, and items. Figure 1 shows a screenshot from the game's discovery mode where the player's view is circular and in the circle you can see players represented as red and blue pins, as well as two treasure boxes.

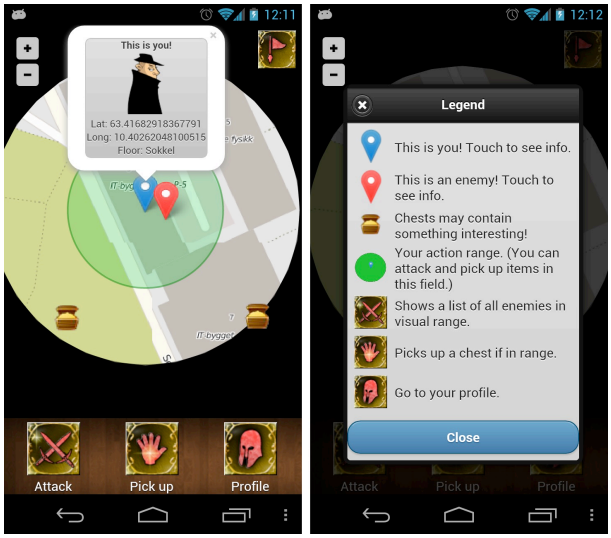

Figure 1 Screenshots from the discovery mode

3.1 Character Creation

In order to provide an immersive and fun setting for the game, we chose a humoristic take on the life and setting of being a university student and (most likely) being a geek of some sort.

To be able to create characters that fit well into the university setting of NTNU, Scott Johnson was contacted regarding use of his illustrations in the 56 Geeks project. We received permission, which gave us a suitable set of avatars to choose from. The game allows the players to choose one of four character classes, each with slightly different character attributes. The final avatars and classes chosen were an attempt to make the player identify himself or herself with the character in the game. The four different classes available for players to choose from are shown in Figure 1, and include Computer Geek (a), Robot Geek (b), Lab Geek (c) and Math Geek (d). Each class has their own set of attribute points and different start weapons and armor.

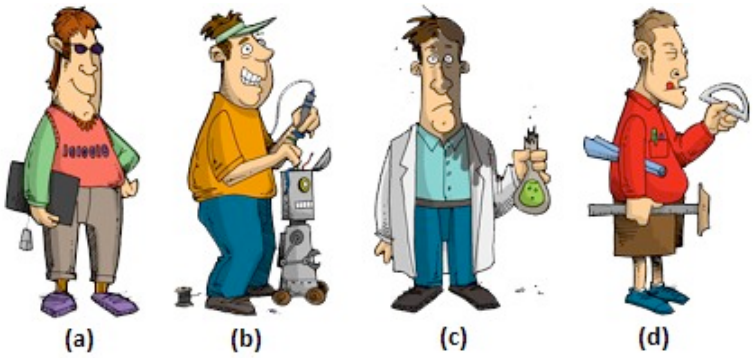

Figure 2 Four character classes

Inspired by high-profile computer RPGs like World of Warcraft and the Fallout series, character attributes for each class was worked out. Primary attribute points are multiplied by two and added to the base attack damage, while secondary attribute points are multiplied by 0.5 and added to the base attack damage. The Stamina attribute dictates the amount of Health Points (HP) a player has. The amount of attribute points in Stamina is multiplied by a constant and added to the base HP of the class. Strength is a primary attribute for attack strength for the Robot Geek class and a secondary attribute for attack strength for the Computer Geek and Math Geek classes. Intelligence is a primary attribute for attack strength for the Lab Geek and Math geek classes. Agility is a primary attribute for attack strength for the Computer Geek class and a secondary attribute for attack strength for the Robot Geek and Lab Geek classes. Table 1 shows an overview over the attributes for the four character classes. Players are given an extra set of attribute points upon character creation to distribute as they see fit. This to encourage strengthening the character's primary and secondary attributes, as well as giving the player a chance to customize the character to their liking. Whenever an avatar increase level, the players are provided with more additional attribute points to distribute.

Table 1 Initial attributes of the four character classes

Attribute	Computer Geek	Robot Geek	Lab Geek	Math Geek
Health	150	150	150	150
Stamina	5	5	5	5
Strength	10	20	5	10
Intelligence	5	5	20	20
Agility	20	10	10	5
Weapon	Dirty sticky keyboard	Flathead screwdriver	Test tube	Pencil
Armor	All-weather jacket	All-weather jacket	Lab-coat	All-weather jacket

3.2 Gameplay

The game consists of three gameplay elements: Discovery, Battle, and Battle Report. In *discovery* mode the player will walk around the NTNU campus while seeing their character on the screen. While walking around, the player can discover items and other players playing the game. It is also possible to find treasure chests located around the campus. These contain weapons and armor, which can be equipped by a character, making it stronger.

A *battle* consists of multiple consecutive battle rounds. A battle round consists of two stages, where in stage one the players choose an action, and in stage two players answer a quiz question. This continues until a player's Health Points (HP) has been depleted or a player forfeits the battle. In the first stage, a player can choose one of three actions: Attack, Defend, and Special Attack (where the Special Attack is only available once the player has accumulated enough special resources). The Attack action produces damage to the opposing player. The Defend action makes sure that you receive no damage at all and will build up your Special meter more quickly. Finally, the Special Attack action will unleash a powerful and devastating attack causing more damage than a normal attack. When both players have chosen an action, the battle round is taken in to stage two. In this stage, both clients receive the same question and the same four possible answers. The answers are randomized to prevent the player from knowing which alternative to answer the moment the player sees the question. Along with the questions and answers, the players are presented with a time limit for answering the question. When both players have chosen their answer, or the time has run out for one or both players, the round is finished. The outcome of the round is calculated at the end of each round, as well as a check to see if the battle is won by either of the players. A player wins if the opponent's health points are depleted or the opponent decides to forfeit. If a player chooses to forfeit, his or her opponent is notified and declared as the winner. Figure 3 shows screenshots from the Battle mode.

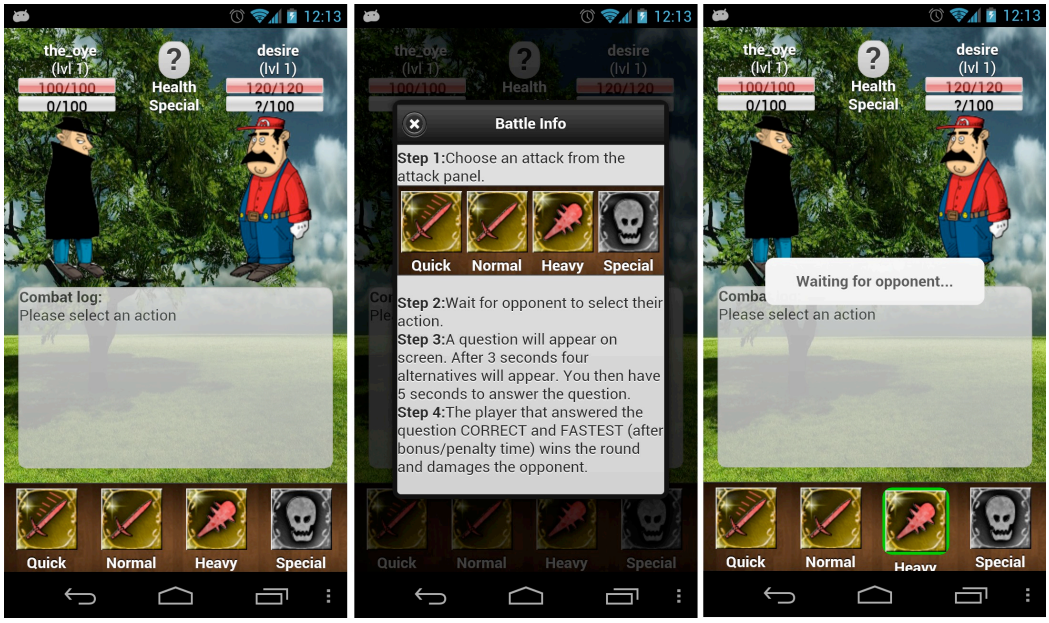

Figure 3 Screenshots from the Battle mode

After the battle is finished, players are taken to the *battle report*. Here, players have the opportunity to review all the questions presented during the battle rounds. The questions are displayed as a clickable list, enabling the player to review the questions from current battle, see how much time was used to answer the question, and whether or not the given answer was the correct one. This type of after battle report is included to allow reflection to be a part of a learner experience. Allowing players to reflect on their answer is a possible way to learn the correct answer and the course's curriculum. Figure 4 shows screenshots from the battle report.

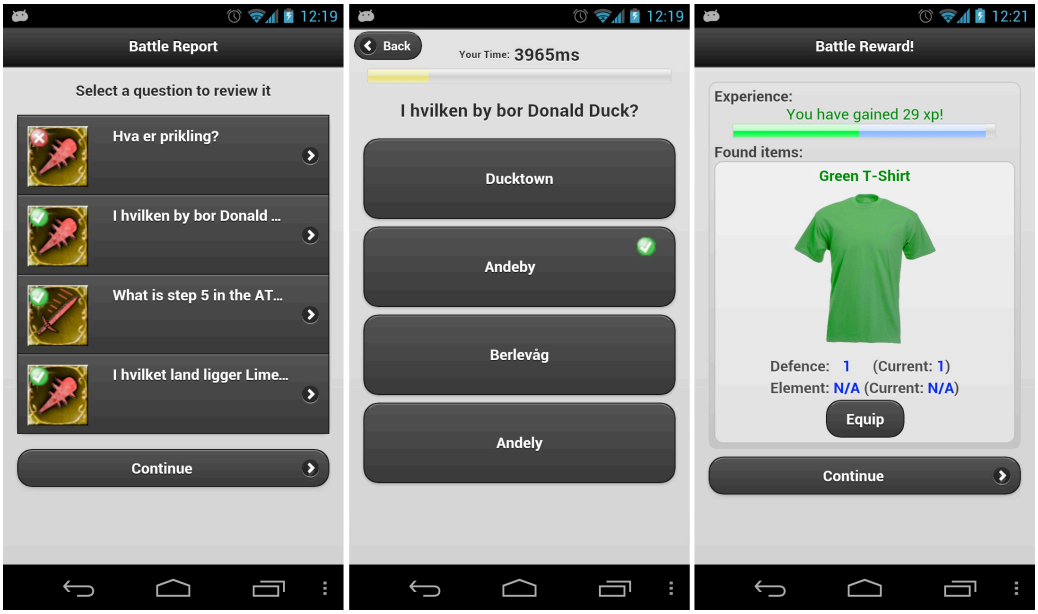

Figure 4 Screenshots from the Battle Report mode

4. Experiment and Results

The subjects for the experiment were recruited from a software architecture course at NTNU. The experiment was carried out in two phases where first six students participated in one, improvements were implemented to the prototype based on feedback, and another six students then played the improved prototype. The method used was a mixture of observation, questionnaire and interview.

4.1 Test Phase 1

The tests were carried out at the campus at NTNU, and the day of the first test is was nice weather but the temperature was below 0 Celsius degrees. The experiment was initiated with a short presentation where the concept of the game was presented together with some screenshots of the game in order to take the participants through the basics. To further motivate the participants, a scoring system was presented where they would get points for each chest they pick up, one point for every player the battled against, and three points for every level they advance to. The player who had the most points at the end of the test session would be declared the winner and receive the prize.

4.1.1 Feedback from Test Phase 1

After the test phase was done and everyone had finished filled out the questionnaires, we had a discussion with the participants on how they had experienced the game. One response was that their fingers were frozen and that their battery had been drained during the test. This was to be expected as both the 3G and GPS services have high power consumption on the smart phones. The participants further expressed frustration over the answer buttons in the quiz. Most of the players complained that the buttons were unresponsive when pressed, and that the countdown timer continued after they had given their answer. This made them feel that they did not get the correct answer time and was experienced as quite frustrating. Participants also found battles to be long and tedious. This was also evident from the server logs, which show that battles lasted from 15 to 23 rounds. This is about twice as long as was first intended. As the game also had a rather small database of questions, players also complained that they got the same questions multiple times, not only in one battle

but sometimes several times in a row. As battles were so long and tedious, none of the participants managed to reach a level where they would find any new and interesting weapons or armor.

Some of the participants found the map to be a bit confusing, and wanted either the map to turn as they walked around campus or a compass to help them navigate. Some also wanted the map to automatically center itself on their location as they moved. Others wanted a bigger visual range or an arrow indicating a direction where they might find an enemy or a treasure chest. As there were few participants walking around and only three treasure chests available for pick up at all time spread out on the campus, players experienced a lack of things to do in the game.

As the discussion turned towards the concept and gameplay, the participants showed great interest and enthusiasm for the potential of the game. Several of the participants presented ideas of gameplay elements as shops and a form of in game currency that could be used to buy upgrades for their character. The shops would also serve as a physical place where one might find other players to battle. Others wanted to be able to fight bigger bosses or maybe team up and battle two vs. two players. One participant proposed an interception feature, where if two players had the same chest within their action range and one of the players attempt to pick it up, the other player would be warned and given the opportunity to initiate a battle with the player, in order to stop him and take the chest for himself. One of the ideas presented stood out from the rest as it had nothing to do with the gameplay itself but rather addressed the educational aspect of the game. A participant suggested having a reference to more information about a specific question or a topic from the either the battle report or question review screen. This reference could simply be a Wikipedia article, a PDF, a web page made by course staff or just a reference to pages in the course curriculum where one might read up on the topic.

4.1.2 Improvements

Based on the feedback of the first software prototype test, some simple steps and tweaks were identified in order to mitigate some of the issues the test subjects experienced. These tweaks would hopefully to be able to minimize issues that broke the gameflow and give the participants a better gameplay experience. An increased gameplay experience could then help to further increase the educational effect and motivation of the game. The following improvements were implemented:

- **User interface response time**: Several of the participants complained about the lack of or severely reduced response when they tapped on one of the alternatives of a question. This problem was solved by using a more efficient way of communicating with the server, giving a more responsive GUI.
- **Answer time**: Participants expressed some frustration, as they did not have enough time to read some of the longer questions before the answers arrived. Furthermore when the answers themselves were more than a single word, they did not have time to read them all while trying to remember the theory. This lead them to just guessing wildly before the time ran out. This is not very pedagogical, as one of the main goals of the game is to help the students to memorize existing knowledge by giving them some mental “pegs” for this knowledge. To resolve this issue the question-only read time was increased from 3 to 5 seconds, giving the students better time to read the question and start a thought process. Furthermore the answer time after the answers arrive was increased from 5 to 10 seconds to allow the students time enough to read all the answers, think and eliminate answers before answering. This increased answer time further lead to increased bonus/penalty time of the “Quick” and “Heavy” attack types from 0.5 to 1 second.
- **Character progression**: From the feedback session it became clear that participants thought battles were too long, taking up to 15-23 questions before victory. Together with a limited set of questions in the database this meant questions was repeated often and battles became long and tedious. As the test phase was limited to approximately one hour, long battles also meant that players did not have time to fully experience the game. The players did not have enough time to get to a high enough level to experience anything but the lower tier of weapons and armor available. This was partially a result of the initial intention to have a longer running test phase and the gameplay had been designed thereafter. Some simple steps were taken to solve this. *First*, the attack attribute was increased for all character classes. This attribute is used as a base to calculate the amount of damage that is done on the opponent when a player win a round, which in turn will help decrease the number of rounds/questions in a battle. *Second*, the number of wins/experience needed to level up was reduced to exactly two wins per level. This greatly increased the rate at which players advance in the game.

Third, the coupling of weapons and armor tiers was decreased to follow single character levels instead of doubles, which together with quicker character progression will enable the participants to have a greater gameplay experience.

4.2 Test Phase 2

In order to test whether the tweaks had any real effect, a second user experiment was set up. After the short presentation, the instruction sets were handed out and the participants started to download and install the client. As some participants were using 3G for communication and others Wi-Fi, there were some significant latency differences between players. This caused differences in when the players received the quiz question and outcome of a battle round. This caused participants to believe the latency had an effect on their answer time, as they would hear the sound effects from their opponent's smartphone before they got it themselves. Wi-Fi players were limited in their ability to move about and discover treasure chests, and caused players to cluster around the same area and alternate on challenging each other. With the extended answer and bonus/penalty time it soon became obvious to the players that using the quick attack was the safest and most effective attack strategy, and using special when available.

4.2.1 Feedback from Test Phase 2

Our observations of the players in phase 2 revealed that the participants had fun playing the game and battling each other. However, the main area of discussion both during and after the test phase was the unstable performance of playing the game over a Wi-Fi connection. Wi-Fi players complained that they experienced a lot of delay, as they had to wait for the client to re-establish the connection to the server quite often, and that they had to move over large distances before they got a new and updated position on the map. One participant complained that he had lost a newly picked up weapon. The client had frozen during battle because it had lost the Wi-Fi signal, which forced both players to have to close and re-open the client.

Figure 5 Picture from testing the Knowledge War game

One participant commented on the randomness of questions as he had gotten the same question three times in a row. Others had issues with the map and wanted a compass to show which way they ware heading. One participant explained that he had to zoom out and in again in order for the map to display properly, which the developers have discovered is a bug specific for Android. Some ideas to more gameplay elements also arise, as some wanted three-way battles, more items or single question creeps/monsters they could encounter which would attack the player. Even though the test phase had been agreed upon to last 45 minutes, the participants continued playing for an additional 15 minutes before walking back to the meeting room. This might be an indication that the game has become more engaging and fun to play.

From the battle logs from the second software prototype test, the number of questions/rounds per battle ended up ranging from 8-15. Which is a more suitable length and which is supported by the fact that none of

the test subjects complained that they found the battles boring, with the exception of getting the same question multiple times in a row. Although, there were more technical issues in the second phase due to the use of Wi-Fi vs. 3G, there seemed to be a higher level of enthusiasm and enjoyment of playing the game than when testing the first software prototype.

4.3 Results from the Questionnaire

The participants in the experiment were asked to fill in two questionnaires. The first one was a System Usability Scale (SUS) questionnaire (Brooke 1996). SUS consist of ten statements about usability, and the result is a score between 0 and 100 where 100 is the best. A system with a usability score of 70 or more is said to have good usability. The prototype for phase 1 got a SUS score of 78 while the prototype for phase two got a SUS score of 84.

The second questionnaire was on the students' perception of the game itself. The Likerts scale (Likert 1932) from 1 to 5 was used where 1 represented totally disagree, 2 disagree, 3 neutral, 4 agree, 5 totally agree. The results are shown in Table 2.

Table 2 Results from questionnaire on students' perception of the Knowledge War Game

ID	Statement	Average Score
1	My knowledge from NTNU courses came to use	3.75
2	The game stimulated me to learn more	4.25
3	The game makes course theory more fun	5.00
4	I would like to take courses that use a game like Knowledge War	4.75
5	I was motivated to learn more in order to do better in the game	4.50
6	I reviewed my answers after a battle	2.00
7	The game was fun	4.50
8	I would like to play this game even if I am not required to	4.25
9	I got relevant feedback on how to play the game	4.50
10	I was motivated to move around and discover	4.00
11	I liked the look-and-feel of the game	4.24
12	It was fun to battle against fellow students	4.75
13	I liked the fact that I have to move around to play the game	3.75
14	Playing against fellow students made me concentrate more	4.50
15	I do not like to loose against fellow students	4.75

The table shows that the participants perceived the game to be educational, fun and motivating, and that they were positive to a pervasive game they had to physically move around. The results also revealed that the students did not review they answers after a battle, and that it might be a good idea to motivate the students to use this feature through boosting the player stats.

5. Conclusion

In this paper we have described an experiment where the pervasive learning game Knowledge War was tested. Our results show that there might be several technical and practical issues to be solved for such applications including limited battery time, weather and temperature, use of various wireless networks (Wi-Fi and 3G), as well as various approaches for responsive user interfaces.

Our results did also reveal that there is a potential for pervasive learning applications, if the technical issues are resolved. Pervasive learning applications can be made fun, educational, motivating, as well as giving the students an opportunity to physically be active. The use of role-play game mechanics worked well to make a simple quiz-game deeper and opening for a more strategic approach for playing the game. Discovery based on finding virtual items by moving around in a physical space was also a motivating game mechanics that worked well.

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