

# Pervasive Learning – Using Games to Tear Down the Classroom Walls

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**Abstract:** Pervasive gaming is a new and emerging gaming genre where the physical and social aspects of the real world are integrated into the game and blends into the player's everyday life. Given the nature of pervasive games, it may be possible to use that type of game as a tool to support learning in a university course by providing a gameplay where the students, by playing the game, expands the area of learning beyond the lecture hall and lectures and into the students everyday life. If this is possible, the area for learning will also become pervasive and be everywhere and anywhere at any time. To address this research area, a prototype of a playable pervasive game to support learning in university studies has been designed. This paper presents the experimental pervasive game *Nuclear Mayhem* and how the game was designed to be pervasive and support the curriculum of the course. Analysis of log files showed that 87% of the logins in the game client was done outside of the time period that was allocated to lectures and lab exercises and that logins were registered in all the 24 hours of a day. These numbers indicate that the game became pervasive and a part of the students/players everyday life. Interviews with the players indicate that they found the game exciting and fun to play, but that the academic tasks and riddles that they had to solve during the game were too easy to solve. The paper concludes that games such as *Nuclear Mayhem* are promising tools to support learning and transform the area for learning to become pervasive relative to the players everyday life and suggest improvements in the game for the next versions.

**Keywords:** Pervasive games, Education, Serious gaming, Pervasive learning, Game based learning, Dynamic storytelling

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## 1. Introduction

Pervasive gaming is a gaming genre where the game is not confined to the virtual domain of the computer but extend the gaming experience out into the real world - be it on city streets, in the remote wilderness, or a living room. The players must interact with the environment and with real objects to achieve certain goals (game objectives and missions). In contrast to traditional computer games, which take place in limited and well-defined settings, pervasive games erase the boundaries between spatial, temporal, and social expansion (Lindt et al. 2007). Pervasive games are staged in reality and their main attractiveness is generated by using reality as a resource in the game (Waern et al. 2009).

It can be difficult to motivate students to devote enough time working with the academic material in the curriculum throughout the courses. This leads to students not having the necessary academic maturity and understanding of the course material when the exam is approaching, and in spite of "pressure reading" the last week(s) before the exam it is - for most of the students - not possible to obtain a sufficient understanding of the subject to be able to get a good grade in the course. It is desirable that students work much more smoothly with the subject matter throughout the course instead of just "burst reading" when the exam is approaching. A solution to this problem might be to expand the area for learning outside of the lecture hall to become pervasive and enable learning to happen anytime and anywhere, for the duration of the course.

Given the nature of pervasive games, being games where the players are in the game everywhere all the time for the whole duration of the game, such games may be useful as a tool and a platform to extend the area for learning beyond the lecture room and into the students everyday life in such a way that the area for learning becomes pervasive. The research question is therefore as follows: Can a pervasive game be used to expand the area for learning and awareness beyond the university classroom and into the students' everyday life and enable learning to be anytime and anywhere?.

To address this research question a playable prototype of a pervasive game to support university studies was designed (*Nuclear Mayhem*) and the game went parallel with the course it was designed to support. The

duration of the course, and thereby of *Nuclear Mayhem*, was nine weeks. The students had to complete the game within a given time limit to be allowed to attend the exam, and participation in the game was the only mandatory activity during the course. Apart from participation in the game, everything else was voluntary, including attending the lectures.

## 2. Pervasive gaming – a definition

The terms pervasive game and pervasive gaming are widely used on a lot of different types of games, toys and experiences (Magerkurth et al. 2005). However, the boundaries between pervasive games and other types of games are unclear and to determine if a game is pervasive or not is not always easy. This situation is made more difficult by the fact that the field, due to the many different definitions, is defined very broadly. The term pervasive game is so broadly defined that it becomes almost meaningless.

Some games are labelled as pervasive games because the players must interact with each other and with the environment around them and physically move to specific places in order to perform tasks within the game (Cheok et al. 2006, Lindt et al. 2007, Segatto et al. 2008, Smith et al. 2005). The game *SupaFly* is labelled a pervasive game because it can be played “anytime, anywhere” using pervasive technology (Jegers and Wiberg 2006). Some argue that pervasive games are played in the real world and not on computer screens (Jonsson and Waern 2008) and others argue that pervasive games enhance computer games by employing emergent pervasive technology (Lindt et al. 2007). One definition of pervasive games uses the metaphorical magic circle of play as its point of view (Montola 2005), another definition focuses on the technology used in the game (Laine and Sutinen 2011) and a third definition states that a pervasive game is a game that is played in physical space, and that the places players visit are given a new meaning by the game (Magnusson et al. 2011).

Different researchers approach pervasive games from different and varying perspectives, defining the term pervasive game based on the technology that enables the game to be played, or the game itself (Nieuwdorp 2007).

In addition to the different definitions of the term *Pervasive game* attempts have been made to clear up ambiguities by – instead of providing a definition of what pervasive games is – defining a conceptual framework *TeMPS* (Hong et al. 2010) to systematically characterize important aspects of this type of games. The main idea behind *TeMPS* is to provide a framework to help game designers understand and communicate about pervasive and social games.

The divergent understanding and definition of the term pervasive game, makes it clear that there is a need for a clear, strict and unambiguous definition of the term, however that is not the aim of this paper. This paper uses the following technologically independent definition of the term *pervasive game*:

*A pervasive game is a game that is pervasive relative to the player’s everyday life.*

For a game to be pervasive relative to the player’s everyday life, it has to be both spatially pervasive and temporally pervasive.

If the game is restricted to only a specific area, such as the university campus, the game is not spatially pervasive relative to the player’s everyday life because when the player leaves the university campus, he will no longer be a part of the game. For a game to be spatially pervasive the player has to be in the game no matter where he is located and game related actions, that needs the players attention, can occur regardless of where the player is located whether he is watching the news on TV at home or he is standing in queue at the mall.

The game also has to be stretched in time in order to be pervasive relative to the players everyday life, therefore it has to last long enough to enable the game to be a part of most events in a person’s everyday life.

If the game only last for 1-2 hours (or less), that timeframe makes it impossible for the game to be pervasive relative to the players everyday life since this timeframe only enables the game to be pervasive during a very small part of the players everyday life.

*Nuclear Mayhem* is a game that is pervasive relative to the player's everyday life. The game last for 9 weeks and the players are a part of the game, no matter their physical location, 24/7 for the whole duration of the game.

### **3. Related work**

There has been a lot of research on the use of games in education. Research has shown that games can be used to support teaching and learning (Jenkins et al. 2003) and that the use of games in education can improve skills in many different types of areas. Research done on how to use community-building mechanics in games to achieve learning in education suggests that social gaming has the potential to revolutionize the way students learn (Hicks 2010). In higher education, games can be used in three areas (Wang and Wu 2009):

- Games can be used instead of the mandatory/traditional assignments
- Games can be used to increase participation and motivation of the students
- Students may, by developing a game, learn about other topics such as for example game development, mathematics, physics, programming, game design and software development

*Nuclear Mayhem* tries to encompass all the three points above. There are no mandatory assignments or requirements in the course the game is designed to support except that the students must participate in the game and complete it within a specified deadline. Participation in the game is also intended to motivate students to spend more time on the subject, and as a part of the game, the player/student must develop a web-based game and as a result of this learn programming and game development.

Pervasive gaming is a research area that is becoming increasingly popular and more and more scientific articles are being published on this topic. Currently, pervasive gaming is mainly taking place within the research community and is not yet being widely used commercially. Research in pervasive gaming has so far been largely technology oriented where the motivation behind the development and design of the games has been to create games that are suitable as a platform for research on the technology one wants to explore. These include games like *Mobio Threat* (Segatto et al. 2008), *The Drop* (Smith et al. 2005), *Epidemic Menace* (Lindt et al. 2007) and *Capture the Flag* (Cheok et al. 2006) where the motivation mainly is to test and explore technologies and how technology can be applied to move games out in the real world.

Research on the use of pervasive games to support learning or education (serious gaming) is a very interesting research area where some research has been done. The pervasive game *The search for the professor* (Spikol et al. 2009) was designed to introduce social web technologies and to support team building for a university course to beginning media technology students. *The search for the professor* shows promise to be a useful tool but needs a clearer integration into the course work.

Some research has been done on how pervasive games can benefit from being game-mastered rather than be fully automatic (Jonsson and Waern 2008). When a game is to be used in education it is critical that the game is aligned with the curriculum of the courses (Monroy et al. 2011). To ensure the best possible coordination with the topics of the course and the course progress *Nuclear Mayhem* had to be game-mastered.

The boundaries of play in pervasive games are ambiguous, forcing the players to interpret what is a part of the game or not. This interpretation process demands and develops creativity among the players that can facilitate cheating in emergent play situations. However, cheating in games is not necessarily an undesirable thing. If the game master and game facilitators manage to respond to this type of emergent game play in a correct and creative manner, this type of activity can be used as a driver to promote creative learning processes (Ejsing-Duun et al. 2013). This strategy was not formalized as a part of the game play in *Nuclear Mayhem*, but the

game story and the game plot in *Nuclear Mayhem* is flexible and dynamic enough to facilitate this type of creative learning processes provided that the activity is discovered and handled properly by the game master.

#### 4. Nuclear Mayhem

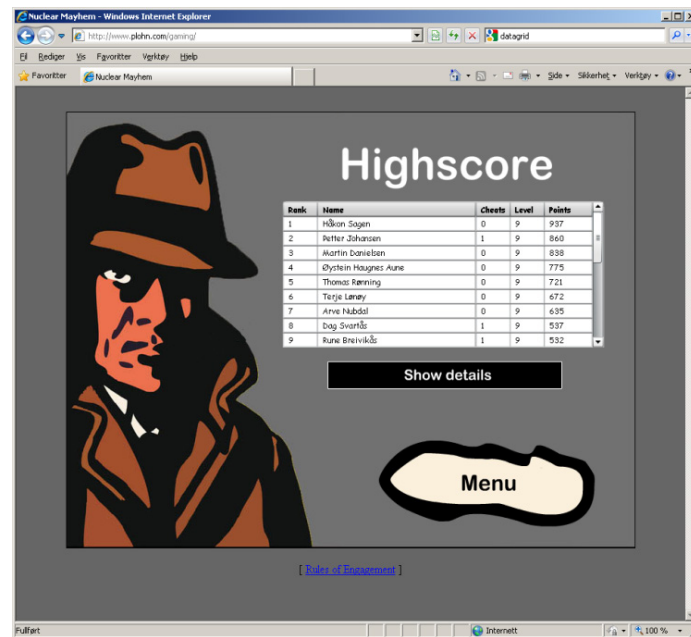
*Nuclear Mayhem* is a prototype of a pervasive game developed to support university studies in Multimedia and Web-game technology at Nord-Trøndelag University College, Norway. The pervasive game, *Nuclear Mayhem*, supports the course by providing a gameplay that is strongly related to the course syllabus. To be successful in the game, the players have to understand and master the topics in the syllabus.

The game starts on the first day of the course and ends when the examination is conducted. During this period the players (students) are in the game 24/7 everywhere and anywhere, both when they are at the university taking classes, when they are at home in bed, out partying with friends or doing whatever students are doing in their leisure time.

The game engages in the player's everyday life in many ways. Clues and tasks are found on Facebook, are sent by SMS to the player's phone in the middle of the night, is a part of the cityscape in Steinkjer (for example, tags that are placed in shop windows - Figure 1), is a part of student life (some of the lecturers appear to have secret messages that players must obtain) and on the Internet (clues and tasks are spread across different websites that players need to find).

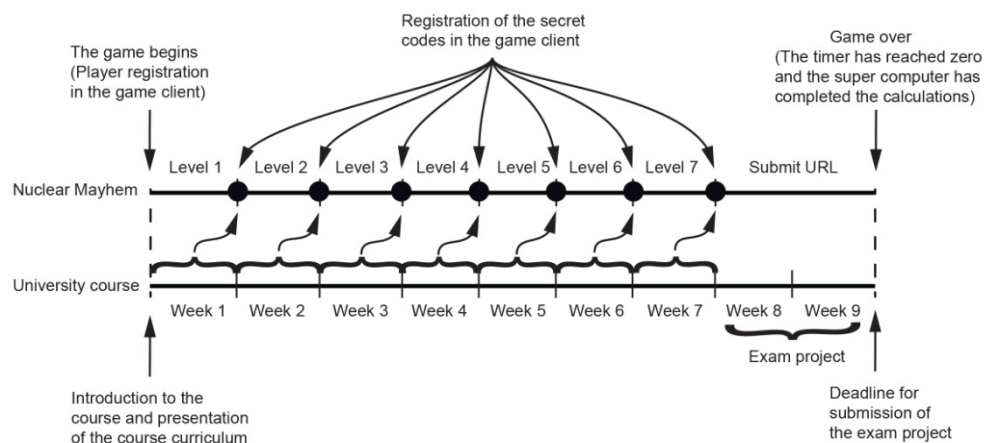


**Figure 1:** A paper note with a game clue is placed in the window at a hair salon in the main street of Steinkjer. Several of the tasks that are carried out by the players during the game give points. For those players who are keen to win the game, it is an important strategy to be the first to perform the various tasks. The players can at any time see how many points they have in the game high score list (Figure 2). When the game is finished, the three players with the most points will be awarded.



**Figure 2:** The high score list of the game *Nuclear Mayhem* and the academic connection

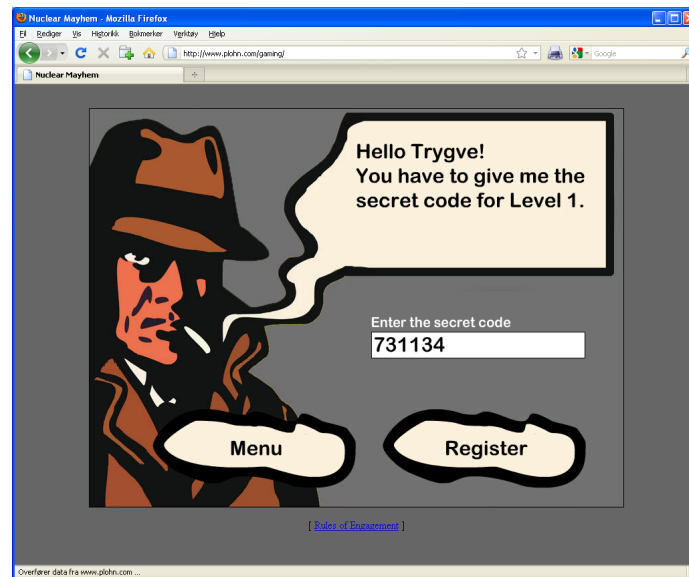
The relationship between *Nuclear Mayhem* and the teaching of the curriculum of the course is illustrated in Figure 3.



**Figure 3:** The alignment between the curriculum of the course and the pervasive game *Nuclear Mayhem*. The top line represents the game *Nuclear Mayhem* and the bottom line represents the university course. The game and the course both start and end exactly at the same dates.

The course starts with a presentation of the curriculum of the course and information on how to register as a player in the game *Nuclear Mayhem*. The students are told that participation in the game and completing the game within a given time limit is mandatory to be allowed to take the exam. After this information, the teaching of the course begins with the curriculum of week 1.

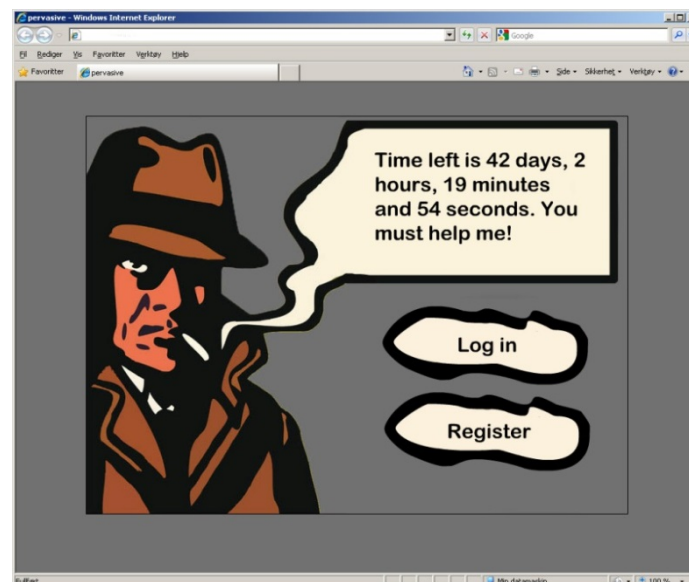
To be able to complete level 1 in the game and register the secret code in the game client at the end of level (Figure 4), the student/player has to learn the topics that are taught in week 1 since the academic challenge in level 1 is directly related to this. Furthermore, the academic challenge at level 2 is directly related to what is discussed in lectures in week 2, the same for level 3/week 3, level 4/week 4 and so on.



**Figure 4:** Each plot ends with a secret code that has to be registered in the web-client

The last two weeks of the course, the students will conduct the exam project, which is to develop a functioning web game. At the same time period the players in *Nuclear Mayhem* have been assigned a mission where they shall create a web game that will be used to distract a guard, and that they – when the game is ready – will inform the saboteur group about this by registering the game URL in the *Nuclear Mayhem* game client.

Registering the URL address in the game client completes the game. To succeed with *Nuclear Mayhem's* main mission, the URL address must be registered within a given deadline, a deadline that coincides exactly with the deadline for submission of the exam project in the course ([Figure 5 below](#)).



**Figure 5:** The game client shows the countdown towards the deadline for both the game and the course

This is the only time limit that exists in the game and the game client is reminding the players about this by displaying a timer that is counting down towards the deadline second by second.

## 5. Game Story

The game story was constructed from the ability to support the story by referring to real life events that had already occurred (reality hack), and the likelihood that something would happen related to the story that



would be referred to by the news media (newspapers, television) and would be possible to implement as a part of the game story or game plot while the game was in progress. The strategy behind this design choice was that the use of real life events would help to create awareness about the game and make the game more pervasive and the game story more "real".

At the time, Iran's alleged nuclear weapons program was often mentioned in the news. There had already been a number of different events that could be used to substantiate the game story (Dagbladet 2010, Nettavisen 2004, Today 2009), and the issue seemed to be so relevant that it was highly probable that one or more events could happen during the game, that would be featured in the news media and thereafter could be implemented in the game. On the basis of these considerations the background theme chosen for the game story was Iran's nuclear program.

This means that all tasks in the game in one way or another are motivated by the game story. For example, in one of the plots the player has to find a code that is located in a shop window in Steinkjer (Figure 1). To find the code, the player must first find a number of other physical locations in Steinkjer. In the game story this action is explained/justified by the need to lead the player around at different locations in Steinkjer so that "someone" can observe the player to ensure that the player is not followed.

## **6. Participants**

17 students were attending the University Course that *Nuclear Mayhem* is designed to support, and all of the students were male. The age distribution of the students was from 20 years to 45 years.

17 students started *Nuclear Mayhem* and of those students, 15 live in the city where the game takes place and two students had to commute. A total of 16 students completed the game and of those, 14 students took the exam (included the two students that had to commute).

None of the students had any previous experience with pervasive gaming.

## **7. Methods and procedure**

The nature of a pervasive game such as *Nuclear Mayhem* that is designed to be played anywhere at any time in the players everyday setting, is such that it is practically impossible to use an ethnographic approach where we study and observe the players while they are playing the game. An ethnographic approach to register and capture the players' interactions with the game and all the potential situations of game play, would require that the players were observed 24 hours a day, both in their private and professional life, for the whole duration of the game. Furthermore it is not possible to study the players' interactions with the environment and the environments ubiquitous artefacts since those are not directly accessible (Jegers and Wiberg 2006).

Since an ethnographic method for evaluation is unsuitable, four other methods were used to overcome the methodological challenges:

- a questionnaire
- interview of selected individual players
- system logs of user activities
- observations made by game master during the game

The game was played during a 9 week period. In this period, all the activities that were done by the players via email, Web or SMS to interact with the game were logged. A questionnaire, with both open-ended questions with free-text answering and multiple-choice questions, was used to capture the player's subjective opinions of the game. The data collection was done via a Web-based questionnaire that the players had to complete immediately after the game was completed.

The questionnaire dealt with topics such as participation in the teaching program, previous programming experience, the use of mobile devices, previous gaming experience, the types of games you usually play, how you played *Nuclear Mayhem*, what you liked or disliked, what motivated or demotivated you to participate in the game and how the game managed to support the course.

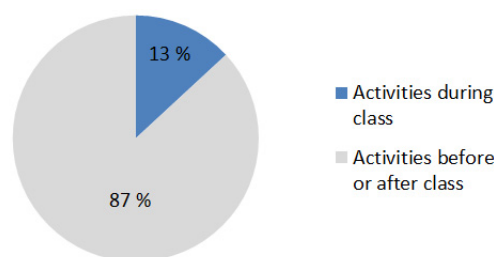
There are too few participants in the survey to have statistically significant results, but the answers still provide an indication of the players' attitudes and opinions. Based on the responses in the questionnaire five people were chosen for in-depth interviews. The subjects were chosen based on their attitude towards the game. Of those who were selected for interview, there were two persons with a *positive* attitude, one person who was *neutral* and two persons who were *negative* to the game.

The in depth interviews were conducted after the exam grade was set, and the interviewees were informed about this fact and that nothing they would say in the interview, whether it was positive or negative, would make any difference to their final grade.

The interviews dealt with the respondents' general attitude towards games and the game *Nuclear Mayhem* in particular, how they felt about the game, the experience of the individual game plots, suggestions for improvements, the use of reality and the real world as part of the game and specific and detailed questions about what they perceived as good or bad during the game.

## 8. Results and discussion

In the duration of *Nuclear Mayhem* the 16 players logged in at the game client a total of 610 times. Of those logins 80 of them were in the same time period as the lectures in the course (in the classroom or at the computer lab) and 530 logins were in the period where there were no lectures in the course (before or after lectures or at dates there were no lectures at all).

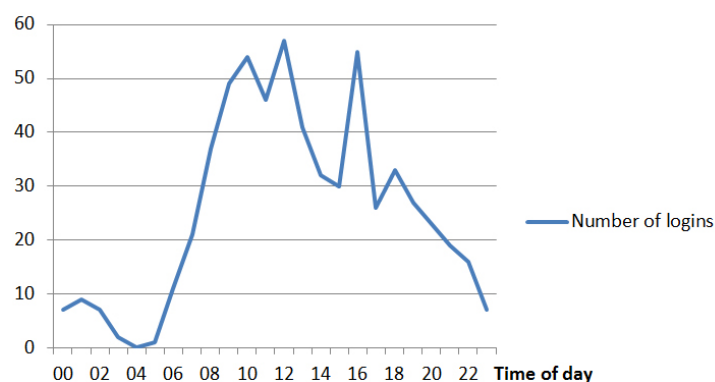


**Figure 6:** The percentage distribution of logins in the game client within and outside of the time period allocated to lectures in the course

87% of the logins that were made in the game client was outside the time period devoted to teaching the course. The fact that so much of the game client activity occurred outside the time allocated for lectures in the course, suggests that the game managed to expand the area for learning beyond the boundary of the lecture hall.

Analysis of log files also show that although the majority of logins occurred in the period from 0800-1600, players logged into the game client most of the 24 hours a day.

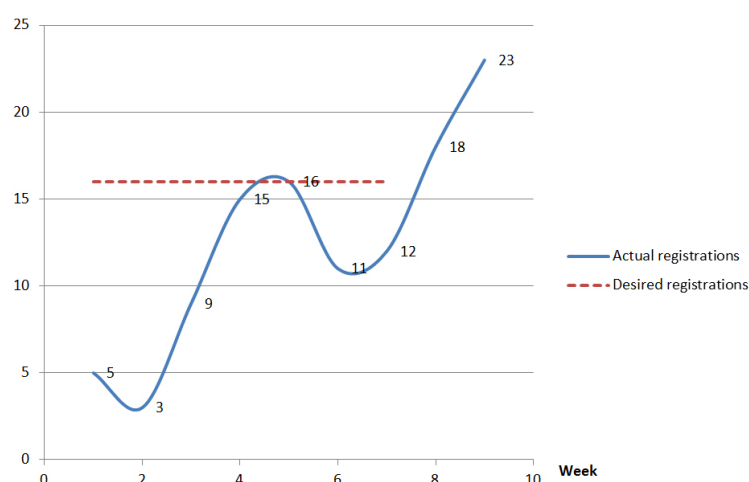




**Figure 7:** Number of logins in the game client during day and night time

The fact that there was activity in the game client around the clock suggests that the game succeeded in becoming pervasive in relation to the player's everyday life in the period the game lasted.

There was only one deadline in the game (Figure 5) that players had to comply with and to get the best possible match between the teaching of the course and the game, the players had to play and complete the game as shown in Figure 3. Analysis of the log files indicate that not all players played the game as intended and this is illustrated in Figure 8.



**Figure 8:** Registration of the seven secret codes (level codes) in the game client

The figure above shows when the seven level-codes were registered by each player in the game client. To achieve the best possible match between the game and the lectures in the course the line with the actual registrations and the desired registrations should match exactly. The reason that the lines do not match is that some of the players have completed the tasks in the game later than it was intended.

The fact that some players did not play the game according to the planned schedule is unfortunate because those students are not getting the desired relationship between the game and the course and they will not get the same learning outcome of playing the game as those who complete the game as planned.

The use of a game story that is designed based on real events has certainly helped to reinforce the game story and make it more exciting and real. The use of real events, that was featured in newspapers and in news broadcast on TV while the game was in progress, as a part of the game, reinforced the game story, the game plot and created more awareness about the game.

Furthermore, the use of real life events in the game also increased the pervasiveness of the game. The fact that the players were “exposed” to the game story in situations where they were normally in a low level of awareness about the game, such as while they were watching the news broadcast in the evening in the comfort of their own home - and then the newscaster presents a segment strongly related to the game story, or while they were buying groceries at the market - and then discovers that the front page of the newspapers in the newspaper stand are featuring a story that is directly connected to the game story. Such events happened several times in the duration of the game and this helped to raise the awareness and the pervasiveness of the game among the players. “I saw it on the news and then I knew that something was going to happen”, is a quote from one of the players that clearly illustrates this effect.

**Table 1:** Quotes from the interviewed players/students on the topic of the use of the real world and real world events as part of the game and the game plot

<i>It makes it all the more realistic ... or more real ...</i> <i>For my part, I think it made it more real ... when you connect it to more realistic stuff so ... it increases the tension as well.</i> - Subject A
<i>It was a good plot, there was a lot of work put in it.</i> <i>It was good. It made it the more exciting ...</i> - Subject B
<i>The story itself was well supported, it was well made, and the details were good.</i> <i>It was exciting, it was. It increased the atmosphere of the game.</i> - Subject C
<i>I think that was good because it made the story more believable. Being able to read it in the newspapers made it a bit more credible. Real.</i> - Subject D
<i>... story was perhaps a little too serious ... and then it might be a bit difficult to take it seriously</i> <i>... I think it might be good ... then it becomes a little more realistic ...</i> - Subject E

All the interviewed students were positive to the use of real events in the game, even those who did not like this type of game or were negative to the game. The only objection that was mentioned was a player who thought the game might be a bit too serious, but the same player also emphasized that this made the game more realistic.

The use of stories from real life, where real people have been killed or injured, as part of a game raises some ethical questions that one should reflect on. In *Nuclear Mayhem* it was referred to the real terror attacks and the liquidation of real people to create a game story and a game plot. Nevertheless, no one has reacted to this. None of the players have reacted or noted this as a problem and none of the academicians I have discussed this issue with had any objections. This may be because the story takes place in Iran, a country that is far from our everyday world. The mental distance among the players and other participants in the game, between their everyday life and the real events that are used in the game, is considerable which certainly helps to create a distance to the events that have been used in the game. If there had been participants with greater proximity to the events depicted in the game, for example students from Iran, then maybe the use of these events in the game would be perceived differently as more abusive and offending. This is an issue one should be aware of when using real life events to design a game story.

Whether the students/players experienced the game as fun to play or not, seems to depend on what kind of game they preferred initially. Those who are positive to this type of games experienced the game as very

funny, while those who do not like RPGs were negative to the game even if they thought the game was well made. However, most of the players had some experiences in the game which they thought were interesting or fun regardless of whether they were positive or negative to the game.

**Table 2:** Quotes from the interviewed players/students on the topic whether they experienced the game as fun game to play

<i>I think it was awesome</i> <i>I liked it a lot</i> <i>... I thought it was fun.</i> - Subject A
<i>I don't like this type of games.</i> <i>... I have never had a taste for RPG games, and maybe this game it's more like an RPG.</i> <i>... It was very well made, but it was not for me.</i> - Subject B
<i>... when you entered the code in the game client ...that was very exciting. It really was the highlight. That was fun.</i> - Subject C
<i>... it was exciting to enter the code ... I knew it was correct but it was still ... hehe</i> <i>... I would recommend next year students to participate in the game.</i> - Subject D
<i>... my biggest motivation was to win the game.</i> - Subject E

Another factor that may have affect on the gaming experience is the fact that the prototype only had one way through the game that all the players had to follow, and that this could have lead to an experience of railroading (Jonsson and Waern 2008), but none of those interviewed mentioned this as a problem.

All interviewees mentioned that they got a learning benefit of participating in the game, but several of them pointed out that they felt they would have had a greater benefit with an ordinary arrangement of compulsory exercises. At the same time, several of the interviewees mentioned that their participation in the game resultet in them using more time trying to understand and review the programming code using the textbook than if they had not participated in the game.

**Table 3:** Quotes from the interviewed players/students on the topic of the learning benefits of participating in the game

<i>... the academic assignments were too easy</i> <i>... I knew that the assignments were taken directly from the textbook</i> - Subject A
<i>... to solve the problems in the game I used the textbook to compare the programming code and I learned something by doing this</i> <i>... I did not understand until later that the game levels were following the lectures.</i> <i>... I think I would have learned more if there was a deadline on each level since it would then almost have been like a compulsory assignment that must be completed within a given time.</i> - Subject B

*... participation in the game was a motivating factor for me to sit down and study the programming code.*

*... by participating in the game, I've learned a lot about Flash. I did not know that there was something called pervasive gaming before I was involved in this, but now, I know what it is and what it entails.*

*- Subject C*

*... to solve the academic assignments in the game I opened the programming files and went through them step by step. Read the code bit by bit and used the examples in the textbook to compare and see what was altered.*

*.. This debugging made it easier for me to understand the examples in the textbook.*

*... I have learned about ActionScript 3.0 by participating in the game. I did not know how to program before.*

*- Subject D*

*... I would say that I have learned some ActionScript 3.0 and also something about pervasive gaming by participating in the game.*

*- Subject E*

The learning benefit each player got from participating in the game also appears to be dependent on their level of expertise. Hence it can be that each player would have a larger learning benefit with a more dynamic model that adapts the professional challenges to the player's skills.

All players who finished the game managed to pass the exam.

## 9. Conclusion

This paper has presented the concept and the prototype of the pervasive experimental game *Nuclear Mayhem* and showed how the game is designed to support learning in university studies.

Participants in the game reported that they believe they gained a learning benefit from participating in the game. Since all of the students that completed the game also passed the exam, the learning outcome of the game is also indicated by the fact that the students were able to recall and use the learned material to solve a given problem (the exam project and the academic challenges on each level). However, there is still a need for a stronger connection between the game and the course in addition to better adapted academic challenges in the game relative to the individual players' academic level.

An instrument in ensuring a better match between the progress of the game and the lectures in the course would be to attach a deadline to each of the seven codes and a requirement for when each code has to be registered in the game client. A deadline on each of the seven secret codes will be easy to implement in the game.

All of the players, including those who were negative to the game, mentioned that they experienced all or parts of the game as fun or motivational.

*Nuclear Mayhem* has shown that this type of game has the potential to expand the learning space towards being pervasive and facilitate pervasive learning, but to better evaluate the academic benefits of participation in the game there is a need to develop a model to measure the academic benefits of participation in this type of game in terms of the learning objectives in the course to identify the "how, when and where" learning is facilitated in the duration of the game.

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