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Trygve Pløhn

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Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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Abstract

"The universe is governed by science.
But science tells us that we can't solve
the equations directly in the abstract."
- Stephen Hawking

Pervasive gaming is a genre of gaming that integrates with the physical and social aspects of the real world and blends into the player's everyday life. The context of this thesis is the use of long-lasting pervasive games to facilitate learning. However, for students to achieve the intended learning outcome from pervasive learning games, they need to participate. Hence, player motivation and engagement are critical success factors and the strategies and mechanisms that can be implemented for this purpose is the focus for this thesis.

Extrinsic and *intrinsic* motivation and *player enjoyment* is the theoretical foundation for the research presented here. Different methods and techniques to increase player engagement have been explored and evaluated, including features to support "in-game" awareness.

The research presented is conducted on three primary artifacts. One artifact was a commercial web-based smokers' cessation program designed as a 50-day real-time pervasive learning game. The two other artifacts were Pervasive Learning Games designed and developed as a part of this research project. Both these games were 100% designed, developed and game mastered by the author of this thesis. The game "Nuclear Mayhem" was in addition programmed by the author while the programming of the second game "HiNTHunt" was outsourced and done by a third party.

A Design Science research method was applied to investigate how storytelling, real-life locations, real-life events, awareness enhancing, social game play, as well as other types of game play and game design, can be implemented in long lasting learning games to motivate and improve player participation.

Results from this research project have been presented to the research community in six scientific papers, all published in renowned international conferences and journals according to the *Norsk Publiseringsindikator* (NPI) listing published by the *Norwegian Centre for Research Data*.

Main contribution presented in these six papers are strategies and solutions demonstrated in the artifacts designed, developed, and instantiated as a part of this research project and expanded knowledge about how to increase player engagement in long-lasting pervasive learning.

We learned that using pervasive learning games could expand the area for learning into the student's everyday life and enable learning to be anytime and anywhere. Furthermore, we discovered that a dynamic game story that incorporates real life events that unfolds in the duration of the game as a part of the game story, created more awareness about the game and proved to be a valuable technique to create increased player engagement. This resulted in the development of the *Dynamic Pervasive Storytelling* model.

Different iterations of the artifact *HiNT Hunt* provided information about the importance of a game story to engage players as early as possible and increase overall player engagement. Iterations of artifact *HiNT Hunt* also provided learning that led to the development of *The-Last-Shall-Be-The-First Dynamic Bonus System*, a method to activate passive players to get them more engaged in the game.

Case study of the commercial web-based *freeFromNicotine* course, which provides a game-based approach to smoking cessation led to the principle of *core assignments* and *individual assignments*, a successful method to ensure that all users could participate in the overall competition on equal terms while still have a unique tailored personal course program to follow.

The work presented in this thesis provides unique insight into strategies and methods for player engagement in pervasive games. This is relevant knowledge when designing and developing pervasive games to increase player engagement and the solutions that have been develop can be reused, as well as provide a good foundation for further research on the topic.

Preface

"If Pac-Man had affected us as kids, we'd all be running around in dark rooms, munching pills and listening to repetitive electronic music."
- Marcus Brigstocke

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) for partial fulfilment of the requirements for the degree of Philosophiae Doctor. This doctoral work was performed at the Department of Computer and Information Science, NTNU, Trondheim, Norway, under the supervision of Professor Trond Aalberg.

The doctoral work is financed by the Games and Entertainment Technology study program at the Faculty of Social Sciences, Nord University.

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"Knowledge is in the end based on acknowledgement."
-Ludwig Wittgenstein

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My research colleagues and co-authors Sandy Louchart, Kjærand Iversen, John Krogstie, and Hong Guo also deserve my gratitude. Without these creative and highly skilled people, I would not have been able to complete this research.

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I owe my deepest gratitude to my wonderful wife, Magdalena, who has supported and motivated me all the way.

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- Shigeru Miyamoto.

Abbreviations and Glossary

"The word abbreviation sure is long for what it means."
- Zach Galifianakis

Abbreviation	Meaning
ADHD	Attention Deficit/Hyperactivity Disorder
ARG	Alternate Reality Game
CSCW	Computer-supported cooperative work
DPS	Dynamic Pervasive Storytelling
ECGBL	European Conference on Games Based Learning
EJEL	The Electronic Journal of e-Learning
FFN	freeFromNicotine.com (a web-based smokers' cessation program)
GBL	Game-Based Learning
HiNT	Høgskolen i Nord-Trøndelag / Nord-Trøndelag University College. Since January 2016, named Nord Universitet / Nord University - www.nord.no
IS	Information Systems
IT	Information Technology
LARP	Live Action Role Playing
NOKOBIT	Norsk Konferanse for Organisasjoners bruk av IT
NPI	Norsk Publiseringsindikator
NSD	Norwegian Centre for Research Data
NTNU	Norwegian University of Science and Technology
PG	Pervasive Game
PGF	The Pervasive GameFlow model
RLE	Real-life events
SGDA	The International Conference on Serious Games Development and Applications
SMS	Short Message Service
TLSBTF	The-Last-Shall-Be-The-First Dynamic Bonus System

1 Introduction

"Life is more fun if you play games."
- Roald Dahl

This chapter is a synopsis of the work conducted. First the research context is specified, then the motivation behind this work and the research questions. Following that, the thesis structure is presented including an overview of the publications presenting the research. Finally, the contributions and the relationship between the published research papers and the research questions are described.

1.1. PhD Context

The research has been done as a part of a four-year Doctoral Research Fellowship financed by the Games and Entertainment Technology study program at the Faculty of Social Sciences, Nord University. The financing of Doctoral Research Fellowship within Game-Based Learning, Pervasive Games, and Game Development was done to strengthen the faculty's academic credentials in this field.

The Ph.D. work is carried out as a part of the Ph.D. program at the Department of Computer and Information Science, Norwegian University of Science and Technology (NTNU), under the main supervision of Professor Trond Aalberg.

1.2. Motivation

Both humans and animals learn by playing, and game play and games has been integral in human culture for thousands of years. Archaeological findings demonstrate that games have been a significant and essential element in human life from ancient times until the present date. Games have historically had many serious applications such as religious purposes[1], to teach spiritual and ethical lessons[2] or to develop mental skills and strategic thinking[3]. This illustrates that game-based learning is not a particularly new invention but has been a part of human culture for at least 5300 years.

For thousands of year's board games has been a main platform for game-based learning, but the emergence of computers inn modern time has given game based learning new opportunities. Electronic games and the computer media has proven to be well suited

[1] The board game *Senet*
[2] The ancient Indian game *Guan Chauper* which earliest version has been found in the Indus Valley civilization dating 3300-1300 B.C
[3] *Shantranj*, and old form of chess

for both learning and teaching [1]. One of the main issues today is how to use electronic games in new and different ways to grab learners' attention and engage them in the learning process.

In the last 20 years, a new type of games has emerged that extend the gaming experience into the real world or/and where the game world blends with the physical world. These games expand the contractual magic circle of play spatially, temporally, or socially [2] and have been labelled as *pervasive games*. Players in a pervasive game participate in a game that surrounds the player all the time, everywhere for as long as the game lasts. Given pervasive games' properties, they may have the ability to make learning pervasive, to something that happens everywhere all the time for the duration of the game.

But even though games have been an essential part of human culture since the Stone Age and that games have been used in serious contexts, such as education and learning, for - if not for thousands - at least for hundreds of years, and that playing games today is more popular than ever before, and that games now are becoming a natural and ubiquitous part of peoples everyday life, there are still a lot of unresolved challenges in how to best use games in learning. One of the challenges of using games as an obligatory part of learning/teaching is that playing the game will no longer necessarily be voluntary for the players but a compulsory requirement. Playing games today is basically something people do because they think it's fun and rewarding, but not everyone likes the same kind of games. When game play becomes mandatory, something you have to do and not something you choose to do yourself, the "magic circle of play" [3] will break for several players. Obligatory participation will necessarily mean that not all players will have the same motivation to participate and play the game. Pervasive games, which take place everywhere, all the time, will to a small extent or not at all, be played in a classroom under the supervision of a teacher; most of the game will take place outside the classroom in the player's own leisure time. Therefore, players will have much greater freedom to decide how much or how little they will participate in the game. In pervasive learning games, the player’s activity in the game will to a lesser extend be controlled by a teacher supervising the activity and, to a much greater extent be controlled by the player’s own motivation to participate in the game, hence this type of games requires other mechanisms to increase the motivation of the players so that they, without being under supervision, in their own free time want to spend time playing and participating in the game.

The context of this research is the use of pervasive games in game-based learning and the overarching aim is to support students to achieve the desired learning outcome by participating in the game. The main focus area in this dissertation is to investigate how to use storytelling, awareness enhancing, social game play, as well as other types of game play and game design, to motivate and enhance player engagement in pervasive learning games.

The idea of Extrinsic and Intrinsic motivation from Behavioural Psychology as defined by John B. Watson and B. F. Skinner [4] and player enjoyment in the context of the Pervasive GameFlow model as described by K. Jegers [5], forms the theoretical foundation used in this research to understand how players are motivated to engage and participate.

As described in chapter 5, the knowledge and understanding of a problem, and its possible solutions, are in design science research achieved in the building and application of the designed artifact. As a part of the journey to learn more and understand how to motivate and engage players in long lasting pervasive learning games several different types of artifacts will be designed, constructed, and tested.

1.3. Research Questions

Given the nature of pervasive games, they can facilitate pervasive learning by providing gameplay where the students expand the area of learning beyond the lecture hall and lectures and into their everyday lives. Pervasive games designed for learning can move learning and teaching out of the classroom to become something that happens all the time, anytime and everywhere, as an integral part of people's daily life; hence the area for learning will also become pervasive and be everywhere and anywhere at any time. However, long lasting pervasive learning games are heavily dependent on the players' motivation to participate in the game. If players don't play (or participate less in a pervasive learning game than intended), the desired learning outcome can be difficult to achieve. If the players do not play the game, there will be no learning outcome, and the game will already have failed as a learning activity; hence the first priority for a game to be successful as a pervasive learning game is to make all players active participants in the game. Thus, the overall topic of this thesis is;

> *to investigate how to motivate and ensure player participation and player activity in pervasive learning games.*

The research looks specifically at the design level, at how game design, storytelling, awareness, game mechanics, and game play can be used to increase player participation in long-lasting pervasive learning games. With the stated topic and specific focus in mind, the following research questions are formulated:

> RQ1: What are the effects and challenges in using pervasive learning games to engage and motivate students outside the classroom?
>
> RQ2: How can storytelling and the use of real-life and real-life events in the narrative design contribute to player engagement in Pervasive Games?
>
> RQ3: How can social game play support and increase player engagement in pervasive learning games?

Design science is a research approach where new artifacts are designed, build, and applied to get knowledge and understanding of a problem and its possible solutions (see chapter 5). To investigate the research questions several new artifacts have been designed, developed and tested. Two different playable prototypes of pervasive learning games have been developed and used as a research platform (see chapters 6.1 and 6.7). In addition to this, a Case Study had been done of an online Pervasive Smoking Cessation course, where game design and the use of real-world artifacts and locations were an essential part of the concept (see chapter 6.9).

1.4. The Structure of the Thesis

The thesis consists of six papers; P1, P2, P3, P4, P5, and P6, as presented in chapter 1.5. All papers are included as appendices from page 121 and onwards.

The remainder of the thesis is organized as follows:

Chapter 2 presents the history and cultural use of games from the 5500-year-old board game Senet to today's computer games. The concept of Serious Games as coined by Clark C. Apt in 1970 is described and Pervasive Games. The uses of games in education with examples are also discussed in this chapter.

The history of Pervasive Games and the many different definitions of the term *pervasive game* are presented in chapter 3. This chapter also discusses the two different main research perspectives used in research on pervasive games and argue that the research presented in this thesis has a cultural perspective. Finally, this chapter discusses the use of pervasive games used in game-based learning and provides some examples of such games.

The psychology behind what motivates people to engage in activities and how this is addressed, used, and facilitated in commercial games and different types of serious games are discussed in chapter 4.

Design Science is a research paradigm in information systems where the approach is to extend the knowledge in the research field by building new artifacts. This research method and how it is applied in this research project is outlined in chapter 5.

In chapter 6, the research platform is described. The research platform is based on three primary artifacts: two artifacts are pervasive games that were developed during this Ph.D. work, and the third and last artifact is a commercial online product that has many similarities with a pervasive game. These three artifacts were the foundation for all the research conducted to answer the research questions described in chapter 1.3.

The significant results of the research that have been conducted and published in this research project are presented in chapter 7 in this thesis. The implication of the results is discussed and presented in chapter 8. Chapter 9 finishes the thesis with the concluding remarks.

1.5. Publications

The research that has been done as a part of this PhD work has resulted in several articles that have been published in scientific international and national conferences and journals. Below is given a list of all the publications that have come out of this PhD work. Those that are the foundation for this thesis and are included in the appendix are listed first, followed by a listing of additional supportive publications that only indirectly are related to the research presented in this thesis.

Publications included in this thesis:

- P1: Pløhn, T and Aalberg, T. *HiNTHunt – a Pervasive Game to Support and Encourage Desired Activities for New Students*. Paper presented at the 4th International Conference, Serious Games Development and Applications, SGDA 2013, Trondheim, Norway, 25-27 September 2013.

- P2: Pløhn, T. *Pervasive Learning – Using Games to Tear Down the Classroom Walls.* Paper published in e-Journal of e-Learning, EJEL 2014, June 2014 Volume 12 Issue 3, pp227 – 311

- P3: Pløhn, T and Aalberg, T. *Increasing Player Participation in Pervasive Educational Games.* Paper presented at the 8th International Conference, European Conference for Game Based Learning, ECGBL 2014, Berlin, Germany, 9-10 October 2014.

- P4: Pløhn, T, Louchart, S and Aalberg, T. *Dynamic Pervasive Storytelling in Long lasting Learning Games.* Paper published in e-Journal of e-Learning, EJEL 2015, March 2015 Volume 13 Issue 3, pp149 – 206

- P5: Pløhn, T and Aalberg, T. *Using Gamification to Motivate Smoking Cessation*. Paper presented at the 9th International Conference, European Conference for Game Based Learning, ECGBL 2015, Steinkjer, Norway, 8-9 October 2015

- P6: Pløhn, T, Iversen, K and Aalberg, T. *A Dynamic Bonus System to Increase Player Participation in Pervasive Learning Games*. Paper presented at the 14th International Conference, European Conference for Game Based Learning, ECGBL 2020, Brighton, UK, 24-25 September 2020

Supportive publications that are indirectly related:

The publications mentioned here are either a foundation for extended versions of articles included in this thesis or have provided broader knowledge helpful for triggering creativity and generating ideas used in the publications included in this thesis.

- Pløhn, T. *Nuclear Mayhem – A pervasive game Designed to Support Learning*. Paper presented at the 7th International Conference, European Conference for Game Based Learning, ECGBL 2013, Porto, Portugal, 3-4 October 2013.

This paper was recognised as “among the best papers at the ECGBL 2013 conference”. As a result, an extended version of this article was published in EJEL 2014. The extended version is one of the articles this thesis is based on (numbered as P2 in the list above).

- Pløhn, T, Louchart, S and Aalberg, T. *Nuclear Mayhem – Learning and Dynamic Pervasive Storytelling.* Paper presented at the 8th International Conference, European Conference for Game Based Learning, ECGBL 2014, Berlin, Germany, 9-10 October 2014.

This paper was recognised as “among the best papers at the ECGBL 2014 conference”. As a result, an extended version of this article was published in EJEL 2015. The extended version is one of the articles this thesis is based on (numbered as P4 in the list above).

- Pløhn, T, Krogstie, J and Guo, H. *Extending the Pervasive Game Ontology Through a Case Study*. Paper presented at the Norwegian National Conference NOKOBIT 2015, Norsk Konferanse om Organisasjoners Bruk av IT, Ålesund, Norway 21-25 November 2015.

When designing Pervasive Games, one would have benefited greatly by modelling main aspects of the game before it is realized. However, within the domain of Pervasive Gaming, a well-defined, suitable, and generally accepted conceptual modelling language does not exist. One approach to overcome this problem is PerGO [6], a proposed ontology to structure and produce domain-specific outputs within the domain of pervasive gaming. This paper aims to evaluate and extend the PerGo ontology within the field of pervasive gaming by mapping an existing pervasive game to the categories defined in PerGO.

1.6. Contributions

The contributions presented in this thesis provide new insights in how to use game design, storytelling, gameplay, social gameplay, real-life locations and real-life events as an integral part of long-lasting pervasive learning games to facilitate increased player participation in those types of games. The contributions and results are mentioned in condensed form in this chapter and described in detail in chapter 7.

This work is presented in six published papers, and the relationship between the research questions:

RQ1: What are the effects and challenges in using pervasive learning games to engage and motivate students outside the classroom?

RQ2: How can storytelling and the use of real-life and real-life events in the narrative design contribute to player engagement in Pervasive Games?

RQ3: How can social game play support and increase player engagement in pervasive learning games?

… and the published papers, P1, P2, P3, P4, P5, P6 (see chapter 1.5), are shown in Table 1 bellow.

Table 1 - Correlation between Published Papers and Research Questions

	RQ1	RQ2	RQ3
P1	X		X
P2	X	X	
P3	X	X	X
P4	X	X	
P5	X	X	X
P6	X		X

The main contribution presented in these six papers are on the one hand, strategies and solutions demonstrated in the artifacts designed, developed and instantiated as a part of this research project and, on the other hand, the knowledge about player engagement in long-lasting learning games that the experiments with the artifacts provided.

The artifacts which have formed the basis for the research are three pervasive games. Two of these games, *Nuclear Mayhem* and *HiNT Hunt* are prototypes that were developed specifically to serve as a platform for the research presented in this thesis, and the third game, *freeFromNicotine.com*, was a commercial web-based smokers' cessation program designed as a 50-day long real-time pervasive learning game. Furthermore, the artifacts *Dynamic Pervasive Storytelling*, *The-Last-Shall-Be-The-First Dynamic Bonus System*, *The principle of core assignments and individual assignments*, and *Intergroup Competition* were designed, developed, and tested as a part of the implementation of and the research conducted on the three main artifacts.

Table 2 - Correlation between Published Papers and the Artifacts

Artifacts (contributions)	Presented in paper
HiNT Hunt	P1, P3, P6
Nuclear Mayhem	P2, P4
freeFromNicotine.com	P5
Dynamic Pervasive Storytelling	P2, P4
The-Last-Shall-Be-The-First Bonus System	P3, P6
Intergroup Competition	P3
The principle of core assignments and individual assignments	P5

The main contributions in the first paper (P1) are the design, development, testing and instantiation of the artifact *HiNTHunt*, which provides a valid starting point for further research on how to increase player participation in long-lasting learning games. This artifact provided a platform to understand some of the reasons for the players' different levels of participation in the game and made it possible to identify two different groups of players that we labelled as, *active players* and *passive players*. One of the lessons learned was that to increase player engagement in long lasting pervasive learning games, both these groups must be taken into account. To increase the overall level of player participation, the game must provide features that target both groups of players. Another significant finding was that the game was successful in terms of satisfying the defined learning goals for those players that were defined as *active players*. Furthermore, several specific reasons why the group defined as *passive players* did not participate as actively in the game as intended were identified, and solutions and improvements were suggested. This paper addresses research question 1 and 3.

The main contributions of the second paper (P2) are the design, development, testing and instantiation of the artifact *Nuclear Mayhem.* This artifact is a pervasive game developed to support university studies in Multimedia and Web-game technology at Nord-Trøndelag University College, Steinkjer, Norway. This experiment provided knowledge on how to use real-life events that were featured in newspapers and in the news broadcast on TV while the game was in progress, as a part of the game, to reinforce the game story, the game plot and create more awareness about the game. This proved to be a valuable technique to create increased player engagement. We also learned that the use of real-life events in the game increased the pervasiveness of the game and helped to raise the awareness of the game among the players in situations where they were generally in a low level of awareness about the game. Another contribution was that we registered that all type of players, including those that had a negative attitude towards the game, were positive to the use of real-life events in the game and thought this made the game more realistic. Regarding whether or not the game facilitated pervasive learning, we found that almost 90% of the logins in the game client was outside the time period devoted to teaching the course at the university, suggesting that the game managed to expand the area for learning beyond the lecture.

The artifact *HiNTHunt* was revisited in the third paper (P3). This second iteration of the game was now, as a part of the Design Science research method, further developed and extended with new features to address the problems identified in the first instantiation of the game. There are two main contributions presented in this paper; the artifact

Intergroup Competition and the artifact *The-Last-Shall-Be-The-First-Bonus-System* (TLSBTF). Both artifacts were designed and implemented in the game to increase the overall player engagement. Both artifacts proved to have a positive effect, and they increased the overall player engagement in this iteration of the game compared to the first version. *Intergroup Competition* and the artifact *The-Last-Shall-Be-The-First-Bonus-System* (TLSBTF) can easily be adapted into similar types of games to increase player participation.

The fourth paper (P4) further clarifies and describes the strategy used in the artifact *Nuclear Mayhem*, with the design and development of the artifact *Dynamic Pervasive Storytelling* (DPS). DPS, as a model, is oriented towards increasing the pervasiveness of the game and supporting a continuous level of player in-game awareness. The main contribution of this paper is the artifact *Dynamic Pervasive Storytelling.* The artifact was a successful tool to increase player engagement and in-game awareness.

Long-lasting pervasive learning games that aim to provide unique tailored learning programs for each player, while still providing competition between the players on equal terms, have some specific challenges. The fifth paper (P5) is a case study of an online smoking citation course that addresses this using the principle of *core assignments and individual assignments*. Furthermore, the case study showed that the gamification approach where everyday activities can be included in a pervasive game as assignments is a promising approach for including everyday types of activities in a pervasive learning game.

The artifact *The-Last-Shall-Be-The-First-Bonus-System* (TLSBTF) was implemented as a static system in the second iteration of the artefact *HiNTHunt*. In the sixth paper (P6), we revisit *HiNTHunt* for the third time and the artifact TLSBTF for the second time, to theoretically develop TLSBTF from a static method to a dynamic method. The major contribution presented in this paper is the development of *The-Last-Shall-Be-The-First Dynamic Bonus System* from a static method to a dynamic model presented as mathematical formulas. The work presented in this paper makes it easier to integrate the artifact into similar types of games and provides a good platform for further testing and development of the dynamic TLSBTF method.

A more elaborate and detailed presentation of the research, the main contribution, the results, and other findings are presented in chapter 7.

2 It's not Just a Game

"Man's most serious activity is play.
- George Santayana

Games have had a serious use for thousands of years. In this chapter we briefly describe the history of games from the oldest board games dating from around 3500 BC up until today's videogame culture. Furthermore, we discuss terms *serious games* and *game-based learning* and give examples of games used in within these concepts.

2.1. The History of Games and Play

Playing is an important part of human lives and the universality of play suggest that it has been passed down from our ancestors. Just like physical features evolve through natural selection, according to Charles Darwin's theory of biological evolution, behaviours that enhance survival or reproduction will also develop through the generations. Studies of animals[4] have shown that they use play to establish their social rank, learn social rules, practice, establish motor coordination, social bonding, manage stress or to develop cognitive and creative skills.

The concept of playing a game dates to the ancient past and is considered and integral part of human societies [7] and cultures. David Émile Durkheim, one of the principal architects of modern social science, states that games were founded in a religious setting and were a cornerstone of social bonding [8]. One of the founders of modern cultural history, the Dutch historian Johan Huizinga, suggests in his book Homo Ludens [10], that games are a necessary condition for the generation of human culture. According to his studies, games were a starting point for complex human activities, such as language, art, law, and philosophy.

2.2. From Board Games to Digital Games

Items for play have been with us longer than the written word [9]. Already during the Stone Age man realized the four-sided hip or ankle bone from hoofed animals could be used for playing [10]. The ancient Egyptian board game Senet, dates to around 3500 BC [11]. Among the treasures found in the tomb of the ancient Egyptian pharaoh

[4] https://www.psychologytoday.com/us/blog/beastly-behavior/201705/why-play-is-important

Tutankhamen, when it was discovered and excavated by Howard Carter in 1922, were four Senet game boards [9]. The Royal Game of Ur is a two-player strategy board game that dates back to at least 2600 BC [8]. Ur was a race game where two players competed to get their pieces across the board by rolling dices made from sheep anklebones [9]. The rules of the game were forgotten through time, but rediscovered in the early 1980s by The British Museum curator Irving Finkel when he was translating cuneiform signs on a Babylonian tablet written in 176 BC [12].

The mancala games are a type of turn-based strategy board games. The name "mancala" is a classification or type of game, rather than a specific game. There are hundreds of different mancala games, some easy and some very difficult, but all of them have in common that two players move game pieces around a board of pit-like holes [9]. The word "mancala" is derived from the Arabic word "naqala" which means "to move". One variant is a game that was designed around 1400 BC and used as an accounting tool for trading animals and food [7]. The history of mancala games is a difficult trail to follow and archaeological records leave much unanswered. It's not known if it originated in Africa or the Middle East or when the first game of mancala was played, but it can be narrowed down to sometime between 3000BC and 1000 BC [9].

Historically, games have been played on either a track or in the restriction of a game board, but the development of new technology has led to new types of games and new ways to play. Especially the introduction of the computer into the game realm and the evolution of digital gaming represents a paradigm shift in what games can do and how games are played.

The invention of the first general-purpose programmable electronic computer, the Electronic Numerical Integrator and Computer (ENIAC) [13], originally invented to compute ballistics during World War II, led to the invention of electronic games. In 1952, the British professor A.S Douglas created OXO (a tic-tac-toe game) as a part of his doctoral dissertation at the University of Cambridge [14]. This was one of the first electronic games.

Ralph H. Baer [15], also known as "The Father of Video Games" [16], invented in 1967 the first working prototype of a video game console. It was named "Brown Box" and could be hooked up with any ordinary TV and offered six simple games with rather primitive graphics compared with today's standards, "Ping-Pong" being one of them. According to the National Museum of American History, Ralph H. Bear has stated in an interview, "The minute we played ping-pong, we knew we had a product. Before that, we weren't too sure." [17]. Today's home entertainment game consoles, such as PlayStation 5, Microsoft Xbox Series X, and Nintendo Switch, through a wide range of development steps are all direct descendants of the "Brown Box". The IBM Personal Computer was launched by IBM in 1981. This is the progenitor of the hardware platform that today is known as a Personal Computer or a PC [18], a very powerful platform for electronic games.

A variant of Tetris that was preinstalled on the Hagenuk MT-2000 mobile phone [19] was the first game for the mobile device platform. The phone was not a commercial success, but in 1997 Nokia launched the very successful game Snake, and this game

was preinstalled on most of Nokia's mobile devices. Snake has since become one of the most played games and is found on more than 350 million devices worldwide [20].

Electronic games are today played on many different technical platforms, and often named or categorized by the type of platform they are played upon. The term “computer game” is used for all types of electronic games, but that is an imprecise use of the term. Usually, electronic games are divided into the terms “video game”, “console game”, “arcade game”, “computer game”, and “mobile games”. Video games and console games usually mean games connected to a TV, whereas arcade games mean games placed in public spaces (and individual cabinets). The term Computer game or PC game usually mean games played on a PC [21]. Mobile games are games played on a mobile phone, smartphone/tablet.

In parallel with the technological platform developments, electronic games themselves have also evolved drastically, from the first simple games such as "Ping-Pong" and "Tic-Tac-Toe" to today's highly advanced single-player games such as "God of War"[5] (awarded "Game of the Year” in 2018 by The Game Awards[6]) and "Red Dead Redemption 2"[7] (awarded "Best Narrative" game in 2018 by The Game Awards) and multiplayer online games like "World of Warcraft"[8].

The advances and adoptions of communication technologies – such as the Internet, position technology and mobile communication – have opened new design spaces for games including pervasive play [9] and mobile games such as "Pokémon Go"[9] which could be labelled as perhaps the most successful commercial pervasive game.

2.3. Serious Games

Discussion of play with a purpose beyond entertainment, are traceable to the work of Plato [22] and it is perhaps not wrong to state that idea of serious games is a contemporary manifestation of centuries old theories and practices [22]. The concept of serious games, however, was first coined in 1970 by the American researcher Clark C. Abt discussing the use of gaming in teaching and learning [23]. He describes serious games as follows [7]:

> *“We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement.”*

[5] https://godofwar.playstation.com/
[6] https://thegameawards.com/
[7] https://www.rockstargames.com/reddeadredemption2/
[8] https://worldofwarcraft.com/
[9] https://pokemongolive.com/

The domain of serious games is interdisciplinarity, which leads to inconsistent definitions, evaluation methods, and multiple conceptualisations [22]. A survey of the literature reveals that there are almost as many definitions of the term "serious games" as there are actors involved [24] but the most used and agreed upon definition is:

> *"Serious games are games used for purposes other than mere entertainment." [7, 22, 24-26]*

Serious games allow learners to experience situations that are impossible in the real world for reasons of time, cost, safety, etc. and are also claimed to have a positive effect on the players' development of a number of different types of skills [24] such as analytical and spatial skills, learning and recollection capabilities, strategic skills and insight, psychomotor skills, etc. Studies conducted over the years has also consistently shown that games promote learning [24].

As mentioned in chapter 2.1, games have had other purposes than pure entertainment since ancient time. One game that have made a significant impact on the serious games movement is the videogame *America's Army* [24] realised in 2002. The game was developed, published and maintained by the US military to improve the recruitment of soldiers to the army, as well as to promote a positive image of the army. The game is a first-person shooter with an emphasis on high realism in weapons and scenarios. The game has been extensively researched for its potential and effectiveness as a training tool [27]. On 7 February 2022, it was announced by the American Army that the game, after a 20-year run, will be shut down on the 5 May 2022, with the following statement[10]:

> *"The free-to-play America's Army PC Game represented the first large-scale use of game technology by the U.S. government as a platform for strategic communication and recruitment, and the first use of game technology in support of U.S. Army recruiting. Three mainline titles and more than 20 million AA players later, the series' original purpose continued. There have been over 30 million objectives completed, 180 million successful missions accomplished, 250 million teammates assisted, and many more in-game achievements attained in AA:PG alone.*
>
> *As time has passed and AA has fulfilled its mission, it is time to shift our focus to other new and innovative ways to assist the Army with comms and recruitment."*

The same year as *America's Army*, was released the Woodrow Wilson Center for International Scholar in Washington, D.C. founded *the Serious Games Initiative*[11] and the term "serious game" became widespread [24]. The Serious Games Initiative communicates science and policy complexities through the world's most dynamic medium: gaming.

[10] https://news.americasarmy.com/americas-army-proving-grounds-mission-success-time-to-withdraw/
[11] https://www.wilsoncenter.org/program/serious-games-initiative

2.4. Categorizing of serious games

Serious games can be applied to a broad variety of different areas and can therefore be categorized in many different ways. An often adopted categorising of serious games into a number of markets was provided by Chen and Michael in 2006 [25]. These markets are:

- political, religious and art games
- military games
- government games
- corporate games
- healthcare games
- educational games

This typology is solely based on the application areas of the games. Various subcategories are possible but the categorizing of serious games into these six applications areas matches to a great extend what is regarded as the core segments [24].

Just as in the past, poems, novels, pop songs and movies have been used as a political statement; a **political game** can also be used for this purpose. Like poems, songs, movies and books, games can also call attention about what is going on in the world. Examples of games that critically address political issues are the online game *Darfur is Dying* [28] addressing the crisis in Darfur in Western Sudan, Africa. Here you play as a Darfuri child searching for water while trying to avoid the heavily armed Janjaweed[12]. Dying is intended "to engage users and provide a window into the refugee experience, offering a faint glimpse of what it's like for the more than 2.5 million who have been internally displaced by the crisis in Sudan" [28]. The game may increase player empathy and raise awareness about the conflict and function as a kind of videogame billboard for more complex information about the crises [28]. *Darfur is Dying* is meant to serve as an entry into the crisis for people that most likely would not use other resources to access this information [29]. Another example of **political use** of games is when US member of Congress Alexandria Ocasio-Cortez in October 2020 livestreamed playing a video game on Twitch[13]. On Monday 19 October Alexandria Ocasio-Cortez tweeted: "Anyone want to play *Among Us* with me on Twitch to get out the vote?" [30]. *Among Us* is an online multiplayer social deduction game, which in itself is not political but it was used by Alexandria Ocasio-Cortez to reach voters. This was highly successful by any reasonable measure [30]. More than 400 000 people watched the livestream, she increased her number of followers on Twitter, and videos of the stream available on YouTube have millions of views [30]. Among Us is not a serious game as such, but

[12] Janjaweed is Arab militia that are active in Sudan, particularly in the Darfur region

[13] Twitch is an interactive livestreaming service for content spanning gaming, entertainment, sports, music, and more (https://www.twitch.tv/).

Cortez use of the game is an example of Serious Gaming. She is using a commercial game to gain political attention.

Religious use of games is perhaps the first and oldest type of serious games. There is evidence that the ancient *Senet* board games had a religious significance [31]. A more recent example of a religious game is *Catechumen*, a video game released in October 2000 [32]. The game tells the story of early first-century AD Christians in Rome. The story is set in the year AD 171 during the days of the early Christian church and the protagonist must delve into the Roman catacombs to save converts who have converted to Christianity.

Art games are described as video games designed to emphasize art or intended to produce some kind of reaction in the audience [33]. *The Night Journey* (2007-2018) is a game project conceived by Bill Viola, an internationally acclaimed artist, which uses both video and game technologies to explore the universal story of an individual's journey towards enlightenment [34]. According to its developers, *The Night Journey* is one of the first experimental art games ever made[14]. The game explores the question: what are the gaming mechanics of enlightenment? After being exhibited in venues around the world as a game in progress, the game was made available on PlayStation 4, PC and Mac. *The Night Journey* "raises an inquiry on being a video game with its mechanics and at the same time being an artwork with its aesthetic, conceptual and artistic qualities" [35].

The military has a long history of using games and simulations for training and **military games** dates back to ancient times. The Indian board game *Chaturanga* (a predecessor to chess [36]) and the Chinese board game *Wei Qi* (a skill-based game representing the Chinese way of war [37]) are four thousand year old games used to train officers to become better planners for battles [24, 25]. In 1981 the American army developed a simulation tool known as *The Bradley Trainer* to train new recruits to operate a Bradley tank [7] and in 1996 the *Marine Doom Game* (an modification of the commercial Doom released in 1983 by id Software) was applied in training of members of the US Marine Corps. As mentioned earlier in this chapter, in 2002 the US military released a first person shooter game *America's Army* to improve the recruitment of soldiers to the army [24]. These are examples of a more modern use of military games. *The Bradley Trainer* and *America's Army* are examples of military games developed by the military itself. The *Marine Doom Game* is an modification of a commercial game, but there are also examples of commercial civilian wargames that are being used by the military such as *Harpoon 3 and TacOps* [24].

The board game *The Game of Politics* created by Oswald Lord in 1935 is one of the earliest games based on geopolitics and elections. **Government games** can be applied for various tasks and situations such as to simulate and train on disease outbreaks, crises management, city planning, ethics training and terrorist attacks [24]. These types of games attempt to simulate the government and politics of the whole or a part of a nation. They may be similar to classical wargames but also different due to their

[14] https://www.thenightjourney.com/

abstraction of action and military elements. A major advantage is that these games and simulations can be run repeatedly with varying degrees of severity and in different scenarios with low cost in material and personnel resources [24] and to train first responders in situations that are dangerous or impossible to train on otherwise.

Corporate games are games that are used to train employees in a number of topics such as teamwork, people skills, job-specific skills, strategy skills, communications skills, organisations skills [24] and to innovate and recruit [38]. Some games can be used in different corporations while other games are specific for a corporation's own requirements. In 2015 it was estimated that 40% of the world's 1000 largest organizations used games/gamification as an applied strategy to their enterprise activities [39]. Corporate games may be especially useful when learning material can be perceived as boring, when the objectives are difficult or complex to learn or when developing corporate strategies [24]. Corporations of all sizes are utilizing games as a training tool. European Central Bank uses *€conomia*[15], a game based on the monetary policies of the European Central Bank, to teach employees about the impact of interest rate changes on unemployment, production growth, inflation, and other vital economic indicators [40]. LiveOps[16], a virtual call-centre outsourcing company, implemented a gamified productivity enhancement system and found it led to a significant reduction in training time from 4 weeks to only fourteen hours as well as reduced call times, an increase in sales by 8-12%, and an average of 9% higher customer satisfaction [38]. Another example of a corporate game is the game *Reveal* used by L'Oréal[17], the world largest cosmetics company, in their recruitment process [24]. The main objective of Reveal is that the numerous candidates competing to get a job at L'Oréal are to better understand the specificities of the company and that the company get to know the candidate (player). The L'Oréal recruiters can more easily identify potential worker talents thanks to the game [41].

Healthcare games exist in large numbers [24]. Serious games applications related to health and healthcare are becoming common and have a variety of different applications. These games are applied in areas such as physical fitness, education, distraction therapy, recovery and rehabilitation, training and simulation, diagnosis and treatment of mental illness [24] so there is a great diversity in the application of serious games in healthcare. *BLAPP* is a game developed to improve toddlers' nebuliser treatment and was designed for use before, during, and after nebuliser treatment [42]. The potential of the game is that it might facilitate a shared focus which brings the treatment into the background for the children. Research suggest that children playing the game while receiving treatment, may experience at least parts of the treatment as meaningful [43]. An example of a commercial game that have shown to have a significant impact on the players' physical activity from playing the game is Pokémon Go. A study shows that engaged players increased their physical activity more than 25% while playing Pokémon Go compared to their prior activity level [44]. Pokémon Go was released in the summer of 2016 and may be considered to be one of the most successful

[15] https://www.ecb.europa.eu/press/pr/date/2010/html/pr101208.en.html
[16] https://www.liveops.com/
[17] https://www.loreal.com/en/

exergames[18] ever released [45]. EndeavorRx[19] is the first game-based therapeutic videogame to be approved by the US Food and Drug Administration (FDA) as treatment for children with Attention-Deficit / Hyperactivity Disorder (ADHD) [46]. This means that doctors can give prescription on the game EndeavorRx as treatment for a disease just like on any other prescription-based medicine. EndeavorRx delivers treatment not as information or counselling, but as an engaging video game. *freeFromNicotine.com* (FFN), one of the three games used as a research platform for the research presented in this thesis and described in detail in chapter 6.9. is another example of a healthcare game. FFN was a commercial gamified web-based smokers' cessation program that used gamification both as a motivational factor but also as a tool to monitor the players' progress throughout the 50-day long course.

One cannot regard the adopted categorising of serious games into a number of markets [25] as inviolable. The categories bleed into each other. Some of the earlier mentioned military games, government games, corporate games or healthcare games could very well also be categorised as educational games. **Educational games** are games used within game-based-learning (GBL). This can be games that are designed and developed specifically as a learning tool or commercial games that are used in a learning environment. Given that game-based-learning is an important concept in this thesis it requires a more elaborate explanation and will therefore be described in a more detailed manner in the following chapter.

2.5. Game-based Learning

There are several definitions of game-based-learning but the definitions mostly emphasize that it is a type of game play with defined learning outcomes [47]. Most often its assumed that the game is a digital game, but also board games or other types can be used in learning [47]. Studies have shown that educational games can effectively engage students in a learning activity and that added player engagement has a positive effect on learning [48].

Play, the essential activity in games, is considered an important and critical element in human development and have long been acknowledged by psychologists as an important factor in cognitive development and learning [47]. In game-based learning (GBL), game content and game play are used to enhance knowledge and skills acquisition using activities and challenges that give the players a sense of achievement [49].

A lot of research is conducted on the use of games in education. Research has shown that games can be used to support teaching and learning, as demonstrated by the Microsoft-MIT iCampus project[20], Games to Teach, where they developed more than

[18] Exergame or fitness game is a term used for video games where the gameplay also involves some form of physical activity or exercise.
[19] https://www.endeavorrx.com/
[20] http://icampus.mit.edu/

fifteen conceptual educational games to support teaching across math, science, the humanities, the arts, and the social sciences at an advanced high school or early college level [50].

Research done on how to use community-building mechanics in games to achieve learning in education suggests that social gaming has the potential to revolutionise the way students learn. BOTS, an online, multiplayer game that allows players to engage in simple programming and problem-solving puzzles, is used as a research platform to investigate the effect of social gaming in learning games. The main goal of this project is to refine the methodology for designing and evaluating player-to-player interaction in Serious Games and methods for evaluating performance across a span of gameplay [51].

One of the main challenges in educational games is how to facilitate learning without making the game boring. Many attempts in developing engaging learning games has failed due to what is described as "trying to combine a bad lecture with the educational value of a bad game" [24]. How to make good and engaging learning games have been researched extensively for many years and we have learned more on how to combine games and learning in a more successful way. There is still much more to learn – hence the topic for this thesis - but there exist now many examples of good and engaging learning games. One example of such a game is *Kahoot!*[21], a game-based learning platform used to review students' knowledge, for formative assessment or as a break from traditional classroom activities. It is a game-based student response system where the classroom is temporarily transformed into a "game show" with the teacher as host and the students as the contenders [52]. *Kahoot!* is among the most popular game-based learning platforms with more than a million players a year in more than 200 countries [53]. A literature review including 48 studies that investigated the learning outcome of using *Kahoot*! states "All these studies show improved academic results for the non-traditional teaching approaches where Kahoot! was used as one of the tools." [54]. The review also identified another 20 studies with experiments that showed a statistically significant increase in learning from using Kahoot! in classroom teaching.

Some researchers argue that "commercial off the shelf game design is replete with effective constructivist teaching structures and that such games should play a more prominent role within mainstream education" [55]. An example of a commercial game that was not initially developed for learning but later has been used as a learning tool is the 3D sandbox game *Minecraft*. It was created by the Swedish video programmer Markus "Notch" Persson and was first made public in May 2009 as a development release with the full version of the game released in November 2011. The game world is composed of rough 3D objects representing various materials, such as dirt, stone, ores, tree trunks, water, and lava and the gameplay revolves around picking up and placing objects. The game world is virtually infinite and procedurally generated as players explore it [56]. At its simplest, *Minecraft* can be described as a game about breaking and placing blocks. The game quickly became popular as a tool for teaching as a large proportion of children were familiar with the basic gameplay and the gameplay was attractive to both males and females [57].

[21] https://kahoot.com/

Minecraft allowed modification ("mods") to the game and this has been explored within game-based-learning. One example is a Math Learning Game that was created as a collaborative game for teaching maths to UK primary school children (age 7-9) [57]. Researchers concluded that Minecraft is a useful tool for building learning environments and the game was "demonstrably appealing to the players" and that "the value of using Minecraft as the basis for the game was high" [57]. Another example of a modification is a multiplayer game designed to be a team building tool intended to improve both the motivation and the ability to collaborate and work in teams [58]. Research showed that this Minecraft modification had the potential to provide a better game and group experience than a non-digital game with cooperative aspects [58].

In 2014 Microsoft bought Minecraft, or more specifically Mojang Studios, the company behind Minecraft, for US$ 2.5 billion. Microsoft early noted the growing interest in using Minecraft for education and reached out to educators to learn more about how they used the game in the classroom [59]. This led to a special edition of the game named *Minecraft: Education Edition* was developed and released on November 1, 2016. Minecraft: Education Edition is an educational version of Minecraft specifically designed for classroom use and has features built specifically for learning environments to support collaboration, assessment, coding, and more [60].

The Digital Education Lab, a school of education technology based in Rome (Italy), has developed a method of using Minecraft Education Edition to teach the fundamental concepts of mathematics, geometry and computer science for students in the age group 8-10 years [61]. While traditional teaching methods in general provide abstract definitions and ideas before practical use, education through game-learning with Minecraft Education Edition is based on the experientiality of concepts. The results obtained were very positive and showed that game learning promotes rapid and strong learning of even complex concepts and that students are able to go from the practical to abstract degree on their own [61]. An examination of 627 online lessons plans designed for Minecraft Education Edition show that the uploaded lessons is mainly for students in the 8-10 and 11-13 year old age groups within a broad range of subjects such as science, technology, engineering, mathematics, social science and humanities [62]. Minecraft Education Edition has also been used to teach cultural heritage for primary age school children (age group 5–11 years) by creating an archaeological reconstruction of the prehistoric landscape surrounding the Neolithic passage tomb of Bryn Celli Ddu[22] in Minecraft [63]. Minecraft Education Edition has even been used within bioinformatics to present, visualize and interpret results within the complex research field of metabolomics [64]. When it comes to using Minecraft in this capacity the researchers' state; "Basing the program on a widely recognized 3D modelling platform significantly lowers the barrier to entry for new users with little previous experience of metabolomics" [64].

Another adaption of a commercial game into a learning environment is Ubisoft's *Assassin's Creed*. This game series has immersed players in environments and historical settings such as the Italian Renaissance, the Holy Land, Imperial China, Constantinople,

[22] https://en.wikipedia.org/wiki/Bryn_Celli_Ddu

the American Colonies, the Seven Years' War between Great Britain and France, and more. The games narrative includes real historical figures and events from those settings and time periods. Ubisoft has adapted and released a special version of three of these games, for ancient Greece, ancient Egypt and the Viking Age, into a series called *Discovery Tour*[23] [65, 66]. In practice they have made these games into a living museum, giving players the ability to achieve real learning outcomes through participation in audio-guided tours curated by real-life historians. Professor Marc-André Éthier from the University of Montreal used the ancient Egypt version of the Discovery Tour game on nearly 300 high school students across eight schools and 40 classes and found that students who used the video game improved their grades from 22 percent to 41 percent [67].

Other examples of commercial games, not developed as learning games, but used within game based learning are *Roblox* [68] an online game platform and game creation system that allows users to program games and play games created by other users, *Fortnite* [69, 70] an online Battle Royale game and *Call of duty* [55] a first-person shooter video game franchise published by Activision.

Research done on using gamification in a learning environment has shown that students participated more with a gamified learning experience. The students found the gamified courses to be more motivating and interesting than regular courses [71].

Nuclear Mayhem and *HiNT Hunt*, two of the games used as a research platform for the research presented in this thesis and described in detail in chapter 6.1 and 6.7, are pervasive learning games that are used within game based learning at University level.

In higher education, games can be used in different ways [72]:

- Games can be used instead of 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 was designed to support University Studies in Multimedia and Web-game technology and makes use of all three of these methods:

- Instead of seven mandatory assignments there are seven levels of security in the game that the players had to breach, and there is one password to discover for each week of lecturing needed to break each level of security and progress in the game. The code/password is hidden in the academic assignment for each week of lecturing. There are seven passwords in the game that correspond to the seven academic assignments in the course. This is described further in chapter 6.5.
- The game was designed to increase participation and motivation of the students by providing an engaging and thrilling game story that made use of the real

[23] https://www.ubisoft.com/en-gb/game/assassins-creed/discovery-tour

world and real-world events that unfolded in the duration of the game (se chapter 6.2). The game was also designed as an individual competition where the top three winners (those with the highest game scores) received prizes.

- The final project in the *Nuclear Mayhem* was to design and program a game that would be used to distract the guards and make it possible to pass unseen and access the game's objective.

HiNTHunt is designed to increase participation and motivate new students to perform activities needed to get the best possible start to their new student life and get started with their studies (see chapter 6.7).

freeFromNicotine.com, a commercial gamified web-based smokers' cessation program, used as a case study in this thesis, was designed to increase the participants motivation to follow the program as intended to increase the chance of successfully quitting smoking (se chapter 6.9).

It is important to point out that the intention of the research presented in this thesis is not to focus on the learning aspect, but on how to increase the players' motivation and willingness to participate in learning games.

3 Background and State-of-the-art

"Pervasive games, like vampires, can only enter if you let them in."
- Sean Stewart

In this chapter, the history and concept of pervasive games is presented. The many different definitions of pervasive games are discussed and the two main perspectives of research that has been conducted on Pervasive Games are described. The chapter ends with a brief overview of how games and Pervasive Games have been used in education.

3.1. Pervasive Games

Pervasive games is a genre of games that integrates with the physical and social aspects of the real world and blends into the player's everyday life. The game *Pervasive Clue* from 2001 is likely to be the first game labelled as a "pervasive" [73, 74] and according to the book, *Pervasive Games – Theory and Design* [2], the term *Pervasive Game* was probably introduced in the same year. This was the year Microsoft launched the game *The Beast* to promote the movie *A.I.: Artificial Intelligence* directed by Steven Spielberg. In the credits of trailers for the movie, observant viewers would notice something odd. A person named *Jeanine Salla* [75] was credited for being *The sentient machine therapist* in the production team (Figure 1).

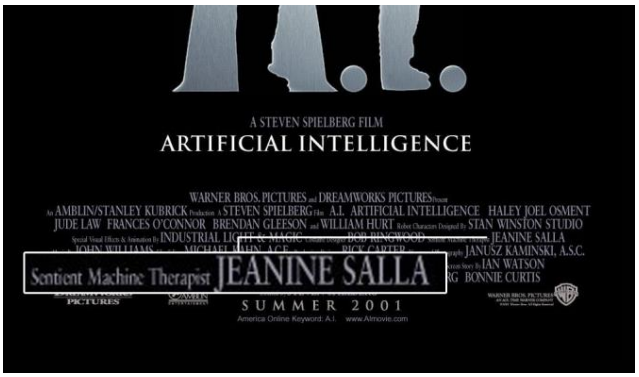

Figure 1 - Screen Capture from the A.I.: Artificial Intelligence Movie Trailer

Even in a movie about humanoid robots with artificial intelligence seemingly capable of complex thoughts, the need for a *Machine Therapist* as a part of the production team would be unnecessary as no such machines exist in the real world. None of whatever

types of machines that exist in 2001, when the movie was produced, would ever need any kind of therapy.

Jeanine Salla was what is later known as a *rabbit hole*: a metaphor originating from the book *Alice in Wonderland (1865)*, because players that stumbled into a rabbit hole would plunge into an unreal world like Alice did. Viewers reacting to this strange credit and searching for the name Jeanine Sallas on the web, would also plunge into an unreal world. They would find that Jeanine had a homepage with a blog, and it turns out that something weird recently happened; a man called Evan Chan had died in a boating accident even though the boat sank close to land and Evan was an excellent swimmer. Following the subtle hints and solving the puzzles written into the text and source code of this Website, people would be led to dozens of other Websites relating to this fully-fledged mystery. The initially observant viewer had plunged into a *rabbit hole* and discovered a strange and parallel world, changing from a passive movie viewer into an active alternative reality game player.

The premise of *The Beast* was that the whole of the Internet should be regarded as one single player where all participants worked together to find the solution; hence the game could evolve all over the world, and information from a newspaper in Osaka, Japan, in the morning could be used by someone in Iowa, USA by supper time [2]. Participants in the game, from all over the world, cooperated to solve the puzzles and proceed further in the game and finally solve the murder mystery. To entertain large crowds for more than a few moments, the game's puzzles were designed to be extremely hard. Many of them could only be solved by the corporation of large communities of participants. Decoding the complete game took 43000 messages for the largest community.

The game was designed and run under the principle; *This is not a game*. Microsoft created the game, but the game designers never confessed during the run of *The Beast* that they were behind it or that the game even existed.

The American Magazine *The Atlantic* state that *The Beast* was the first genuinely successful alternate reality game (ARG) [76]; however, the primary motivation behind creating *The Beast* was not to create an ARG but to promote Spielberg's movie *A.I.: Artificial Intelligence*. The game launched on March 8, 2001, and ended on June 29, the movie's release date. Today *The Beast* is regarded as one of the most elaborate movie promotions ever conceived [77] and a ground-breaking marketing campaign [78]. According to the game creators, more than three million people actively participated in the game, and the campaign generated over 300 million impressions for the film through the press [2].

A similar strategy was used in 2009 to promote a new crime novel featuring Inspector Harry Hole by the Norwegian writer Jo Nesbø.

> *"June 2009, stylist Borgny Stem-Myhre creates a profile on Facebook, connects with friends, and starts to write a blog on her life during the summer, until it is brought to a brutal end in August where she is found murdered, drowned in her own blood. Shortly after, police officer Harry Hole is kidnaped outside the Oslo Opera house. Two young girls film the kidnapping and publish it on YouTube. Harry loses his notebook, and it is found by a man who puts it out on Flickr with*

all its cryptic notes, sketches, names, and telephone numbers. Harry's closest friends, Rakel and Øystein, put up missing person posters asking the public to help them find Harry. They set up a Website where people can discuss and work together on any clues found. Information is announced on the radio and in the media, on blogs and Internet Groups and the general public start getting involved. The hunt is on." [79]

This is the beginning of the ARG "Savnet Harry Hole" (English title: Missing Harry Hole). The game was promoting the launch of the book; "Panserhjerte" (English title: The Leopard), a Jo Nesbø novel about the Policeman Harry Hole. Using characters from the story, an interactive universe complete with both fictional and real persons was created. Slowly the players were able to gather the story's threads and understand more of what is going on. By sharing tasks, chatting, and cooperating (Figure 2), the players were – similarly as in The Beast – able to solve the puzzles and proceed further in the game and finally solve the murder mystery.

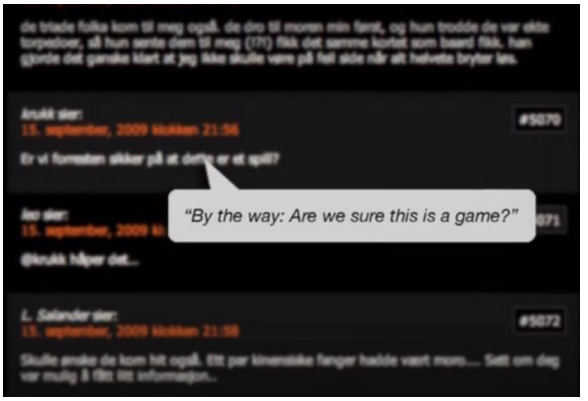

Figure 2 - Screen Capture from the "Savnet Harry Hole" Discussion Board.

A screenshot from the discussion board where the players discussed events and cooperated to solve the puzzles in "Savnet Harry Hole" (see Figure 2) illustrates that the game expands the magic circle of play and extends into the players everyday life by the remark of one of the players; "By the way: Are we sure this is a game?". The event discussed, is a real-life-event that had just occurred in the game. Actors (not virtual actors but real people in the real world) – in the role as Chinese Triad – had just been at the front door at the home of one of the players asking for information.

Savnet Harry Hole has, as *The Beast* did before, won several advertising prizes, and the campaign generated a lot of attention in the Norwegian media and received media coverage far beyond what a typical book launch would have entailed [80, 81].

Savnet Harry Hole and *The Beast* are excellent examples of games that blur the "magic circle of play", where game and life bleed together, trying to blur the distinction between reality and the game. Some type of pervasive playfulness can most likely be found in all civilisations, but the launch of *The Beast*, and other location-based ARGs, such as *Majestic* [82] and *BotFighters* [83] in 2001, was probably, even if not all of these games were successful, the origin of the term *Pervasive Game*.

Today ARGs are considered to be a subgenre of Pervasive Games. Since *The Beast* was launched, experimental and commercial Pervasive Games have spawned everywhere. This new family of games has been called by many names: *alternate reality games, augmented reality games, geo games, mixed reality games, context-aware games, cross-media games, hybrid games, immersive games, location-based games invasive games, ubiquitous games, mobile games, reality games pervasive games,* and so on. This plethora of name-giving on similar but not identical games demonstrates that Pervasive Games are part of the zeitgeist and illustrates the challenges of understanding this playing field [2].

3.2. Definitions of Pervasive Games

For some years, Pervasive Gaming has been described as a new and emerging gaming genre. Many different types of games, activities, and experiences have been labelled and defined as Pervasive Games or Pervasive Gaming, like the list of name-giving of Pervasive Games in the previous section illustrates. But even though the terms Pervasive Game and Pervasive Gaming are widely used, the definition of the terms is not unambiguous.

Pervasive gaming is a broad category of gaming that includes location-based games, cross-media or mixed-media games, immersive games, urban mobile games, urban superhero games, and alternate reality games [84]. To provide a clear and unambiguous definition of the term *Pervasive Game* is not easy. The definitions that are used within the research community today vary greatly and are, naturally, influenced by the researchers' point of view and the type of research being conducted, as the following definitions of *Pervasive Games* illustrate:

> *Pervasive Games are staged in reality and their main attractiveness is generated by using reality as a resource in the game. [85]*

> *Pervasive Games enhance computer games by employing emergent pervasive technology. [86]*

> *A Pervasive Game is a game that is played in physical space and where the places are given a new meaning by the game. [87]*

> *Pervasive Games are games that use mobile and context-aware technologies to combine the real world with the virtual world in a game play. [88]*

> *Pervasive Games are games that are played in the real world and not on computer screens. [89]*

> *A Pervasive Game is a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally. [2, 90]*

> *Pervasive Gaming is not limited to the contractual play space of the traditional magic circle of gameplay hence follows that participating in a Pervasive Game influences the ordinary life of the player quite directly. [90]*

Pervasive Games extend the gaming experience out into the real world—be it on city streets, in the remote wilderness, or a living room. [91]

Pervasive Games are, by definition, located on the border between game and the ordinary. [2]

When computers become pervasive, they change from being a localized tool to a constant companion, enabling continuous interaction and promoting informal, unstructured activities without clear starting or ending points. Pervasive Games implement and exploit this new role of computational technology to enhance computer game design and the computer-gaming experience. [92]

A pervasive game delivers to the player an enriched experience of game through an evolvement of the dynamics of the game, expanding the space of the game according to the context where it is played. This allows breaking the boundaries of the game world, making reality part of it and that the elements in that reality have an influence during the game. [93]

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 [73]. As illustrated above, the definitions of a *Pervasive Game* are based on "the magic circle of play", "the physical space" where the game is conducted, the use of "reality as a resource in the game", or the "technology" that is used to run the game. The definitions vary, and it is not easy to say clearly what defines a Pervasive Game. This situation is made more difficult by the fact that the field, due to the many different definitions, is defined very broadly.

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 [94] to systematically characterize essential 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. Further work has been done in this area by PerGo (Pervasive Game Ontology), which attempts to construct an ontology towards Model-Driven Pervasive Game Development by analysing the domain of Pervasive Games. Domain analysis produces important outputs like a domain-specific vocabulary (DSM), which formally represents domain solutions using high-level concepts close to the problem domain [6]. Extending the ontology and populating the domain of pervasive gaming may also help to define what makes a pervasive game. One of the publications that has come out of this Ph.D. work examines this field further [95] by attempting to evaluate and extend the ontology within the area of Pervasive Gaming by mapping an existing pervasive game to the categories defined in PerGO. However, that work is only indirectly related to the research presented in this thesis (see chapter 1.5) and is not a part of this thesis.

The broad definition of *Pervasive Games* is a challenge when conducting research within the field of Pervasive Games and Pervasive Gaming. If the boundaries and definitions of what we are researching are not clear and unambiguous, there are opportunities for errors and misunderstandings.

The work presented in this thesis uses a technology-independent view on pervasive gaming and removes the technological aspect. This means that pervasive gaming is not limited to the contractual space of the traditional magic circle of gameplay, the technology used, or the physical location where the game is conducted, but deduces that participating in a pervasive game influences the player's ordinary life directly [90].

For a game to be pervasive relative to the player´s everyday life it has to be both spatially pervasive and temporally pervasive related to the player's real life. Suppose the game is restricted to only a specific area, such as the university campus. In that case, 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 need 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 a queue at the mall.

The game also has to be stretched in time to be pervasive relative to the players' everyday lives. It is probably impossible to give a clear and unambiguous definition of how long a game must last to be temporally pervasive, but the game has to last long enough to enable the game to be a part of most events in a person's everyday life. Suppose the game only lasts for 1-2 hours (or less). In that case, that timeframe makes it impossible for the game to be temporally pervasive relative to the players' everyday life since this timeframe only enables the game to be pervasive during a tiny part of the players' daily life. The game has to continue without breaks for as long as the game lasts so that game related activities can happen at any time anywhere for the whole duration of the game.

The three games / artifacts (see chapter 6) used as a research platform for the PhD work presented in this thesis are both spatially pervasive and temporally pervasive related to the players' real and everyday life. Nuclear Mayhem, HiNTHunt, and freeFromNicotine.com are all designed to be played everywhere at any time. Even though some events are based on specific locations in all three games, game-related events can occur regardless of where the player is physically located. All the games run 24/7, HiNTHunt lasted for a week, freeFromNicotine.com lasted for 50 days, and Nuclear Mayhem lasted for nine weeks, so even if one cannot expressly state how long a game has to last to be temporally pervasive, all of these three games did last long enough to become a pervasive part of the players' everyday life during the period the game was taking place.

3.3. The Technical or Cultural Research Perspective

Research on pervasive games is mainly done within two different perspectives [73]. One is the technological perspective that looks at technical solutions and how pervasive technology can facilitate games. The second is the cultural perspective, where the focus is on the game itself and how it relates to the ordinary world.

Examples of research in the field of pervasive games with a main focus on the technological aspects are many. Games that focus on the topics localisation,

communication, cross media augmentation, devices, authoring and game engine, and orchestration and surveillance to meet the technology challenges of pervasive augmented reality games [96] include *NetAttack*, a combined indoor and outdoor "scavenger hunt"-like game; *Epidemic Menace*, a cross media game that test game play across a large number of different devices and different media channels; and *TimeWarp*, an outdoor augmented reality game. *Can you see me now* uses wireless- and GPS-technology to facilitate a game of catch were the physical and virtual world are mixed together [91]. *MobiMissions* is a location-based pervasive social game developed to learn more about how to use camera phones with location-based capabilities, and specifically the Cell-IDs used in the mobile phone network as the location system, to explore how location-based services could support new experiences that engage players with the physical world and each other [97]. *moBIO Threat : Disease Control* was developed to try to overcome the problems of localization tracking and signal coverage in pervasive games by integrating multiple wireless technologies, mixing their capabilities and neutralizing their limitations [98]. *Order Elimination* is a prototype of an outdoor augmented reality game that is used as a case-study to test *geolocative raycasting*, a technique for real-time buildings detection in pervasive games to assist developers of outdoors pervasive games to generate a realistic field of view for the players in augmented reality applications [99], merging outdoor and indoor technologies for the creation of pervasive games by integrating hardware devices originally aimed at the creation of outdoor games for children in an indoor Interactive Space [100]. *Shoot them All* was a pervasive game implemented as a web application to test whether JavaScript APIs are a mature enough technology to open the door to web based pervasive games [101] are some examples of research conducted in the field of pervasive games where researchers are interested in the technological perspective.

Examples of research on pervasive games with a cultural perspective, where the focus is the game itself and not the technical solutions are also numerous. *FreshUp* is a pervasive game that, similar as *HiNTHunt* (see chapter 6.7), aims at helping new students to overcome the initial difficulties of freshmen such as orientation in a new environment and organizing their courses [102]. The game was developed and used at the University of Potsdam, Germany. "The empirical evaluation showed that *FreshUP* significantly helps freshmen at universities to orientate, acquire study competencies and socialize with their fellow students" [102]. A qualitative study done on the pervasive game *Pokémon GO* investigates the types of behaviour changes within the context of the popular game [103]. The study discovered 8 types of behaviour changes and 13 game features relevant to those behaviour changes. Another research study on the effect of incorporating narrative elements in pervasive games concluded that narrative element incorporation to active virtual reality games helped to increase physical activity among college students [104]. Research on the pervasive game *IdleWars*, a game designed to raise awareness and promote behaviour change in relation to energy waste in the workplace, showed that the game was successful in catalysing existing social dynamics in the workplace where it was deployed [105] and that the game triggered discussion around energy waste in the office. The game *Arcane Gallery of Gadgetry* [106], more detailed described in chapter 3.4, is another example of game research with a cultural perspective.

The research that has been conducted as a part of this Ph.D. work has a cultural perspective. It is not the technology that is the essential and interesting factor but how to design games, gameplay, and game stories that motivate and increase player participation in pervasive learning games. Player participation is one of the crucial success factors in learning games. The learning outcome from pervasive learning games is, of course, also dependent on other factors to become a successful teaching tool, but if the players don't play the game, there for sure will be no learning outcome from the game, hence the topic of the research presented in this thesis.

3.4. Pervasive Learning Games

Research on pervasive games and how these can be used in a learning context extends across many different research areas. Technology, pedagogy, game development, motivation, social networks, storytelling, group dynamic, how to blend the physical and virtual world, gameplay, and content design, are just some examples of areas in which pervasive learning games have been developed and explored in context.

The *Arcane Gallery of Gadgetry* is an alternate reality game (ARG) designed to expose middle school students to the information research process behind the history of early telecommunications in the 19th century. The objective of this research was to learn about the challenges and opportunities of designing an education-based ARG specifically for teenagers and how the core elements of ARGs, such as distributed multimedia, collaborative tools, physical objects, and a blurring of fiction with reality, can be tailored for teenagers in a learning environment [106]. One of the conclusions from the experiments was that many of the players found that the game made learning history more interesting and interactive.

Pervasive games have educational potential by encouraging learning through physical role-play, as demonstrated in the collaborative location-based game *Savannah*, where groups of children hunt as lions on a school playing field [107]. This experiment also identified problems on how to design collaborative location-based experiences as the approach of using discrete, bounded locales as trigger zones for content – was fraught with difficulties that arise from interactions between player behaviour, content design and the operation of the underlying technologies [107].

Research on the pervasive augmented reality game for smartphones *Pokémon GO* found that the game reshaped the formation of player communities to no longer take place at a specific time and place, but all the time and everywhere [108]. These communities were coined as pervasive learning communities. A literature review conducted on health effects of playing *Pokémon GO* concluded that the game has a positive effect on both psychical activity and mental health but the physical effects only lasts as long as people are playing the game [109]. Another finding was that playing *Pokémon GO* increased social motivation, reduced social anxiety, increased social interactions, improved and strengthen social relationships, players were more outdoors, lost weight and got better sleep. Furthermore, the literature review showed many different motivations for playing the game such as getting physical exercise, having a fun and immersive experience and social reasons. Some of the reasons that caused people to lose motivation and stop playing the game, were lack of variation and content in the game, slow progress in the

game and technical challenges. The final conclusion of this literature review were that *Pokémon GO* show benefits beyond entertainment and can be regarded as the most successful exergame of all time [109]. One of the most significant results of a survey done on the health and social impacts of playing *Pokémon GO* on various player groups, was how the game managed to motivate groups that are hard to motivate to become more socially and physically active [45]. Players who initially were less physically active experienced a more substantial positive physical effect than casual or non-players. This demonstrates that pervasive games has a considerable potential as a positive force to promote health and learning, and to motivate groups that normally are hard to reach [45]. *Pokémon GOs* novelty is a combination of a well-known franchise, location-awareness, and the inspiration found in augmented reality based apps [45]. Augmented reality experiences are associated with greater immersion, usefulness, enjoyment and novelty than more traditional applications [110]. The physical effect of playing *Pokémon GO* is a direct consequence of the game design. In playing *Pokémon GO* the players became more physically active because of the story and the gameplay and not because physical movement was implemented in the game as an exercise or activity.

Another example of a game that was developed for pervasive learning is the EduPARK app [93]. EduPARK[24] is a research and development project aiming to generate and implement "original, attractive and effective strategies for interdisciplinary learning in Natural Sciences, Physics-Chemistry, Mathematics, History, among others, through the creation of a mobile interactive Augmented Reality application, using mobile devices, to support geocaching activities to be explored by teachers and students from basic to higher education in outdoor environments, but also with potential use in the tourism sector/ general public." [111]. The EduPARK app was developed to promote contextual, active and authentic learning for students and teachers from primary to higher education. One innovative aspect of this app is that the learning methodology combines technology with physical locations that are familiar and well known to the students', and thereby moves learning out of the classrooms and into the spaces of the students' community, such as their local park or neighbourhood [112]. Work done on evaluating students' opinions on mobile learning and the educational value and usability of the EduPARK app concludes that the app has a high educational value. However, students also reported problems such as needing an internet connection, not being allowed to use mobile devices in schools, and the fact that mobile phones give access to distractions [111].

Pervasive games have good potential as learning tools [84] and advances in ubiquitous and pervasive computing may offer significant innovation in the field of game-based learning. Research findings suggests that ubiquitous and pervasive learning offers improved capabilities for communications, coordination, collaboration, and knowledge exchange and removal of time and space constraints for accessing information [113]. The fundamental "always on" concept of pervasive games enables pervasive learning as an "always on" education that is available 24 hours a day, 7 days a week, anywhere, at any time"[114]. Blending the fictive game world with the physical world provides a

[24] http://edupark.web.ua.pt/

drive for player engagement and foster situated learning approaches. Time and space, along with social contexts, bring a meaningful influence in the gameplay [93].

Nuclear Mayhem, *HiNT Hunt* and *freeFromNicotine*, the three games used as platform for the research presented in this thesis and described in detail in chapter 6.1, 6.7 and 6.9, are examples of pervasive learning games. Within this research project these games have been used to learn more about game design, storytelling, awareness, game mechanics, and game play can be used to increase player participation in long-lasting pervasive learning games.

4 How Games Motivate Players

"Motivation is the art of getting people to do what you want them to do because they want to do it."
- Dwight D. Eisenhower

In this chapter, an overview is provided of how different game types motivate players to engage and participate in the game as much as possible. The psychological factors that can affect player motivation and specifically the idea of extrinsic and intrinsic motivation from Behavioural Psychology and how game developers facilitate game mechanics and game play to increase both the extrinsic and intrinsic motivation of the players without triggering the "overjustification effect" are discussed.

We also look to other types of games as a starting point to try to understand what elements may have a positive effect on player participation. Beyond looking at the research on player activity in pervasive games, it will also be natural to investigate which elements and methods commercial games and other types of serious games employ to increase player engagement in these types of games.

In what degree a player chooses to participate in a game and how much time and energy the player decides to use on playing a game is ultimately determined by the player's motivation.

Motivation is the sum of extrinsic and intrinsic motivation [115]. Despite this, the psychological factors are not part of the research in this dissertation beyond the fact that we, of course, understand that the elements we use and introduce into the game design, such as storytelling, awareness enhancement, social gameplay, use of the real world as part of the game and game history, somehow affect the player's motivation in such a way that the player hopefully chooses to participate to a greater extent in the activity than if these elements had not been present. Whether the features we have introduced lead to increased player engagement or not is one of the overriding research objectives in this Ph.D. thesis.

4.1. Understanding Motivation and Player-engagement in Games

There are many concepts, theories and models that say something about what creates motivation to participate in games and that try to explain which elements and features that are important for designing games that people would want to play and facilitate as high player participation as possible. These theories and models are not isolated entities but are connected and interact and affect each other. To simplify the picture, I have nevertheless chosen to divide the theoretical foundation for how games motivate players

into three themes, which I then describe in more detail separately. This is illustrated in Figure 3.

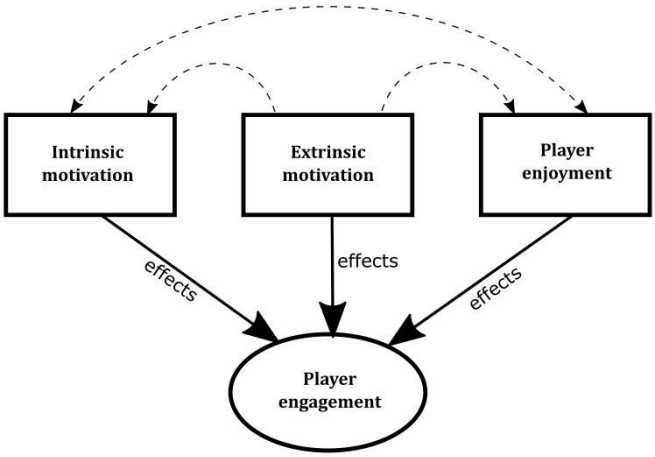

Figure 3 - Models and Theories to Understand Player Engagement

Figure 3 above illustrates the three theoretical building blocks which form the foundation for understanding player engagement for all of the research presented in this thesis. The theories/models used in this dissertation as a basis for understanding player engagement are *Intrinsic motivation*, *Extrinsic motivation* and *Player enjoyment* which all have an effect on player engagement as illustrated by the arrows. The arrows illustrate only that there is an effect on player engagement, but not the type of effect meaning that the effect can be both positive (lead to more player engagement) or negative (lead to less player engagement). The dotted lines illustrates that the theories affect each other. Extrinsic motivation can have an effect (positive or negative) on player enjoyment and intrinsic motivation, and player enjoyment and intrinsic motivation can be affected (positive or negative) by each other. The model and each of the three theories are described further in the following subchapters.

4.2. Intrinsic and Extrinsic Motivation

To understand player behaviour and player engagement, we need to look at what motivates the players and why they choose to participate or not in a game. Of course, it is ultimately psychological factors that determine and influence the extent to which the individual player chooses to participate in an activity or not. To understand "motivation", one of the most popular models is the idea of Extrinsic and Intrinsic motivation from Behavioural Psychology as defined by John B. Watson and B. F. Skinner [4]. A simple explanation of this theoretical model is that Extrinsic Motivation is when a task is done for reasons beyond the task itself, usually to receive a reward (like going to work to get a salary). Intrinsic motivation is when a task is done for its own sake because the task itself is perceived to be meaningful or enjoyable (like having a hobby). Intrinsic Motivation is usually far more robust and lasts longer than extrinsic

motivation. A hobby can last for a lifetime, but how long will one continue to work if one is no longer paid?

In trying to understand what made computer-based learning environments engaging and fun, Dr Thomas W. Malone reviewed a number of theories of intrinsic motivation and studied several highly motivating computer games. This work resulted in a theory of intrinsically motivating instructions [116] as illustrated in Figure 4.

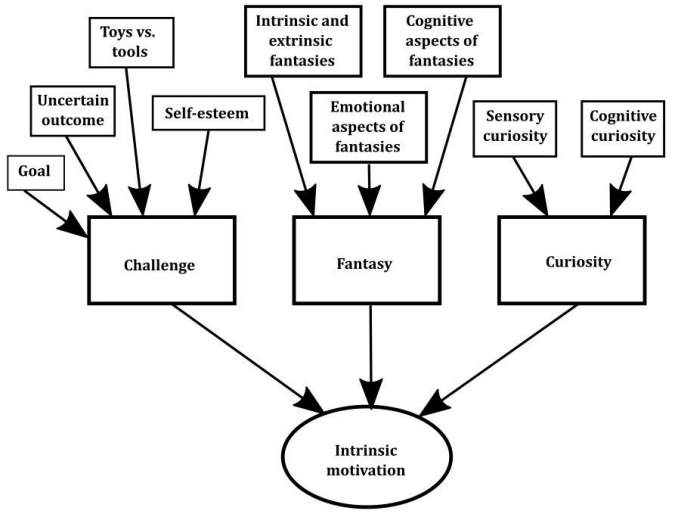

Figure 4 - Framework for a Theory of Intrinsically Motivating Instructions

According to Malone's theory [116], intrinsically motivational instructions take place in computer games when players are offered choices around three key categories: *challenge*, *fantasy* and *curiosity*.

Challenge is emphasized as an important element in effecting intrinsic motivation. One feature of making an activity challenging is *goals* (see Figure 4). For a goal to be motivating it should be personally meaningful, obvious, or easily generated and provide feedback to inform the player whether they are achieving their goal or not. The game must be designed so that there is an *uncertain outcome* (see Figure 4). A game does not have an uncertain outcome if it is designed such that player is certain to reach the goal or certain to not reach the goal. There are at least four ways a goal can be made uncertain for the same player at different times or for a variety of players: variable difficulty levels (balancing the game), multiple level goals (several different levels of goals), hidden information (provoke curiosity and contributing to the challenge), and randomness (surprise, heighten interest). In this framework there is also an important distinction between *Toys vs. tools* (see Figure 4). Tools are used as a means to achieve an external goal, but toys can be used for their own sake with no external goals. The requirements for good toys vs good tools with respect to challenge are mostly opposite [116]. Challenge engages the player's *self-esteem* (see Figure 4). Success in any challenging activity can make people feel better about themselves. The downside is that failure in a challenging activity can lead to lower self-esteem and even decrease the

player's interest in the game. One implication of this is to "balance the game" as discussed in chapter 4.11 and to present performance feedback in a way that minimizes the possibility of self-esteem damage.

Fantasy is emphasized as another important element in effecting intrinsic motivation. Fantasies can make instructional environments more fun and interesting. Malone define a fantasy-inducing environment as one that evokes "mental images of things not present to the senses or within the actual experience of the person involved" [116]. *Extrinsic fantasies* are fantasies where the fantasy depends on the use of the skill but not vice versa. Examples of this is when one overlays an existing curriculum with a game in which the player progresses toward some fantasy goal such as Hangman, where progress in the game depends only if the answers are right or wrong. The exercise of the skill does not depend in any way on the fantasy of "hanging a person". *Intrinsic fantasies* are fantasies where the fantasy and the skill are mutually dependent. This usually means that problems are presented in terms of the fantasy [116]. In a game of Darts (the fantasy of playing darts) the skill of estimating distance is applied to the fantasy. The skill and the fantasy are mutually dependent as one key feature of playing darts is to be able to estimate distance. Malone claims that intrinsic fantasies are more interesting and instructional than extrinsic fantasies and one advantage of intrinsic fantasies is that they often indicate how the skill could be used in the real world to solve a problem or accomplish a goal. *Cognitive aspects of fantasy* only apply to intrinsic fantasies. Metaphors or analogies in games that are facilitated by intrinsic fantasies often provide the player with the opportunity to use old knowledge to understand new things. Another cognitive advantage of intrinsic fantasies is that they can improve memory of the material by provoking vivid images related to the material being learned. *Emotional Aspects of Fantasy* in games are impacted by the emotional needs they help to satisfy in the people who play the games, and almost certainly derive some of their appeal from that. Different people find different fantasies appealing so if the game designers can create many kinds of fantasies for different kinds of people, the game is much more likely to appeal to a more diverse group of people. Creating fantasies also raises moral issues that one should be aware of. This is an issue we have to take into account in designing the artifact *Dynamic Pervasive Storytelling* that uses real life events to create the game-story.

Curiosity may have killed the cat, but curiosity is also an important element in effecting intrinsic motivation. To evoke the player's curiosity the game should not be too complicated or too simple regarding the player's skills and knowledge. They should be novel and surprising, but not completely incomprehensible [116]. There are parallels between challenge and curiosity. Challenge could be described as curiosity about one's own skills and knowledge and curiosity could be described as a challenge to one's understanding. One major difference between challenge and curiosity is that the notion of self-esteem is central to the concept of challenge but is usually not involved in the curiosity concept. It is useful to distinguish between two kinds of curiosity; *sensory curiosity* and *cognitive curiosity* (see Figure 4). Cognitive curiosity is the desire for new information, while sensory curiosity is the desire for new sensations and thrills [117]. Sensory curiosity involves the attention-attracting values of changes in light, sound, or other sensory stimuli of an environment. Cognitive curiosity is evoked by the prospect of modifying higher level cognitive structures. According to theories, the way to engage

the player's cognitive curiosity is to present just enough information to make their existing knowledge seem incomplete or inconsistent [116]. If a person is reading a murder mystery, and has read all chapters but the last one where the murderer and the plot is revealed, he or she would have a strong cognitive curiosity and motivation to complete the missing knowledge by reading the last chapter to learn and find out who the murderer was.

Curiosity is a powerful tool to motivate behaviour and has been considered a basic instinct that enables intelligent species to learn and master new things in their environment, promote survival, use tools, and develop technological advances [118].

4.3. Player Enjoyment – Flow

Player enjoyment is a term that correlates directly to the level of player participation in games. If a game is perceived as a fun game to play, players are more likely to spend time on the game. Studies have suggested that the phenomenology of enjoyment has eight major components [119]:

1. The task must have a chance of completion.
2. One must be able to concentrate on the task.
3. The task has clear goals.
4. The task provides immediate feedback.
5. One acts with deep, but effortless involvement that removes awareness of the worries and frustrations of everyday life.
6. One exercises a sense of control over one's actions.
7. Concern for the self disappears, yet, paradoxically the sense of self emerges more strongly after the flow experience is over.
8. The sense of duration of time is altered.

When all of the components above are present, one will experience a state of consciousness called *Flow* - a state of concentration so focused that it amounts to absolute absorption in an activity [119]. *Flow* has an order of consciousness and creates fun for users [120].

4.4. Player Enjoyment - The GameFlow Model

Enjoyment in games is often discussed in the context of *The GameFlow model* [121], which is a model that maps elements of gaming to elements of *Flow*. For each element, the GameFlow model includes an overall goal and a set of central criteria that can be used to design and evaluate games with respect to player enjoyment [121] (see Table 3).

Table 3 - GameFlow Criteria for Player Enjoyment in Games

Element	Criteria
Concentration Games should require concentration and the player should be able to concentrate on the game	• games should provide a lot of stimuli from different sources • games must provide stimuli that are worth attending to • games should quickly grab the players' attention and maintain their focus throughout the game • players shouldn't be burdened with tasks that don't feel important • games should have a high workload, while still being appropriate for the players' perceptual, cognitive, and memory limits • players should not be distracted from tasks that they want or need to concentrate on
Challenge Games should be sufficiently challenging and match the player's skill level	• challenges in games must match the players' skill levels • games should provide different levels of challenge for different players • the level of challenge should increase as the player progresses through the game and increases their skill level • games should provide new challenges at an appropriate pace
Player Skills Games must support player skill development and mastery	• players should be able to start playing the game without reading the manual • learning the game should not be boring, but be part of the fun • games should include online help so players don't need to exit the game • players should be taught to play the game through tutorials or initial levels that feel like playing the game • games should increase the players' skills at an appropriate pace as they progress through the game • players should be rewarded appropriately for their effort and skill development • game interfaces and mechanics should be easy to learn and use
Clear Goals Games should provide the player with clear goals at appropriate times	• overriding goals should be clear and presented early • intermediate goals should be clear and presented at appropriate times
Feedback Players must receive appropriate feedback at appropriate times	• players should receive feedback on progress toward their goals • players should receive immediate feedback on their actions • players should always know their status or score

Control Players should feel a sense of control over their actions in the game	• players should feel a sense of control over their characters or units and their movements and interactions in the game world • players should feel a sense of control over the game interface and input devices • players should feel a sense of control over the game shell (starting, stopping, saving, etc.) • players should not be able to make errors that are detrimental to the game and should be supported in recovering from errors • players should feel a sense of control and impact onto the game world (such as, their actions matter and they are shaping the game world) • players should feel a sense of control over the actions that they take and the strategies that they use and that they are free to play the game the way that they want (not simply discovering actions and strategies planned by the game developers)
Immersion Players should experience deep but effortless involvement in the game	• players should become less aware of their surroundings • players should become less self-aware and less worried about everyday life or self • players should experience an altered sense of time • players should feel emotionally involved in the game • players should feel viscerally involved in the game
Social Interaction Games should support and create opportunities for social interaction	• games should support competition and cooperation between players • games should support social interaction between players (chat, etc.) • games should support social communities inside and outside the game

There is one element of *Flow* missing from the Table above, i.e., the task must have a chance of completion. This is because the task is the game itself [121].

The more *concentration* a game requires in terms of workload and attention, the more absorbing and enjoyable it will be to the player [121] as long as the workload is at an appropriate level for the player's perceptual, cognitive, and memory limits [122].

If the games *challenges* are greater than the player's skills, this can result in negative feelings such as stress or anxiety but if the player is not adequately challenged the result is boredom or apathy, therefore the challenges of the games has to be balanced according to skill level of the player [123]. However, it is also important to be aware that some games are popular precisely because they are notoriously difficult. In these games, the player does not get any help or dynamic adjustment of the difficulty level to make the game easier. It is the difficulty itself that is motivating. Good examples of

such games are Dark Souls[25], Demon's Souls[26] , and Bloodborne[27] , all developed by FromSoftware. These games have been so influential that they almost have become a new type of gaming genre called "souls-like" games. Nonetheless, even if some players perceive the high difficulty in "souls-like" games in itself to be an attractive and motivational element, educational games that want to target a wider audience where players may have varied and different skill levels and reason to play games, such as would be the case in a school class, a balanced approach would be a sensible choice when designing the games challenges.

For a game to be enjoyable it not only has to provide balanced challenges but must also support *player skill* development. The player's perceived skills must match the games challenge and both challenge and skills must exceed a certain threshold but should be possible to overcome as the player "gets better", therefore players must develop their skills while playing the game to truly enjoy the game [121].

Players must be allowed to exercise a sense of *control* over their actions and able to adequately translate their intentions into in-game behaviour. Game controls should be basic enough to be easy to learn and the player should be able to customise the controls or the game should be designed to allow different styles of learning and playing [121]. Players should not be able to make mistakes that stop the game from working and the game should provide help to so that players can recognize, diagnose and recover from errors. It is important that players perceive a sense of impact onto the game world [124].

Games should provide players with *clear goals* at appropriate times with a clear overriding goal early in the game which should be conveyed to the player in a clear and straightforward way, and also provide multiple goals within each level or part of the game [121]. Goals in games, strategies and their effect will be further discussed in chapter 4.9.

Games need to provide appropriate in-game *feedback* for players to determine distance and progress towards objectives and the feedback should be provided at appropriate times. The players should be able to identify their status and score in the game and the game should also provide immediate feedback for player actions and reward players with feedback on progress and success [121].

Immersion, engagement, and absorption are important concepts in game design and research. Immersion as an element of flow are described as a deep but effortless involvement which can often result in loss of concern for self, everyday life and an altered sense of time [119]. Players become less aware of their surroundings and less self-aware, the game becomes the most important part of the player's attention, and their emotions are directly affected by the game [125]. The narrative adds little to player immersion and engagement in game play [126], can still be important for immersion, as it gives the players a storyline and background, telling them who their characters are

[25] https://www.fromsoftware.jp/ww/detail.html?csm=086
[26] https://www.fromsoftware.jp/ww/detail.html?csm=070
[27] https://www.fromsoftware.jp/ww/detail.html?csm=094

and what is happening, which makes the players feel they are part of the story [121]. In terms of engagement and immersion, games have been far more successful than most if not all other computer software applications [126].

Social Interaction is not an element of flow, and social interaction in games may even infringe immersion. However social interaction is clearly a strong element of joy in games so even if it is not an element of flow, the game should – according to the GameFlow model – provide a means to allow social interaction [121] and create opportunities for player competition, cooperation, and connection. The importance of social interactions in games can be illustrated by the evolvement of Discord[28] which is a social instant messaging and digital distribution platform that grew out of gamers need for social activity and social interactions within games. Even if many games provide in-game communication, players often prefer to use Discord and it can also be used for other game related actives, such as finding people to play with, discussing games, or just chatting with people also when you are not playing a game. The fact that Discord exists at all, clearly illustrates that social interaction is an important aspect of games.

4.5. Player enjoyment – The Pervasive Game Flow Model

The GameFlow model is a widely used model of player enjoyment with hundreds of applications in the design and evaluating of games and game-like experiences [127]. Work done on evaluating the GameFlow model in relation to pervasive games as a means to understand player enjoyment in pervasive gaming [5] concludes that the GameFlow model is appropriate for gaining an understanding of player enjoyment in pervasive games. This led to the outline of a model – the *Pervasive GameFlow model* – that can be used as both heuristic guidelines for designers and as evaluation criteria in the user-centred evaluation of pervasive games [128].

There are however a number of criteria regarding all of the eight elements of the GameFlow model (PGF) that may be problematic and that need to be addressed when it comes to pervasive games [128]:

The element of **concentration**:

> The nature of pervasive games, with place- and time independent gameplay is problematic regarding the criteria that players should not be distracted from tasks and should be able to concentrate and keep focus throughout the game. Hence these requirements are in PGF replaced by:

- Pervasive games should support the player in the process of switching concentration between in-game tasks and surrounding factors of importance

The element of **challenge**:

[28] https://discord.com/

The view in PGF is that the most important driving force in gameplay in pervasive games and a premise in pervasive gaming is the social interaction among players. With that in mind the criteria that the level of challenge should increase as the player progresses through the game and increases their skill level and that games should provide new challenges at an appropriate pace are problematic. According to PGF pervasive games should stimulate and support the players in their own creation of game scenarios and pacing instead of controlling the pace and levels of challenge. Hence these two requirements are in PGF replaced by:

- Pervasive games should stimulate and support the players in their own creation of game scenarios and pacing
- Pervasive games should help the players in keeping a balance in the creation of paths and developments in the game world, but not put too much control or constraints on the pacing and challenge evolving

The element of **player skills**:

According to PGF the player skills element seems unproblematic and relevant from a pervasive gaming perspective except for the criteria regarding developing player skills i.e., that games should increase the player's skills at an appropriate pace as the player progresses through the game need to be elaborated:

- Pervasive games should be very flexible and enable the players' skills to be developed at a pace set by the players

The element of **control:**

The criterion that players should feel a sense of control over the game regarding starting, stopping, saving the game etc. becomes problematic for pervasive gaming's place and time-independent requirement. Hence this criterion is in PGF replaced by:

- Pervasive games should enable the players to easily pick-up game play in a constantly ongoing game and quickly get a picture of the current status in the game world (in order to assess how the state of the game has evolved since the player last visited the game world)

The element of **clear goals:**

With the PGF view on pervasive games as being games without a pre-set and controlled structure, and where social interaction is the driving force, the role of the game changes from providing clear and intermediate goals at appropriate times to supporting the players in creation of their own personal and intermediate goals. Hence this criterion on clear and intermediate goals is in PGF adjusted to:

- Pervasive games should support the players in forming and communicating their own intermediate goals

The element of **feedback:**

This element is unproblematic and is not in need of further elaboration.

The element of immersion:

Immersion as referred to in the GameFlow model becomes difficult to support when the game world changes from being a completely virtual world to becoming an integrated part of the physical real-world. When game-play may occur at any time and place, everyday social norms and the game world become difficult to separate. In PGF the element of immersion should adjust to the following criteria:

- Pervasive games should support a seamless transition between different everyday contexts, and not imply or require player actions that might result in a violation of social norms in everyday contexts
- Pervasive games should enable the player to shift focus between the virtual and physical parts of the game world without losing too much of the feeling of immersion

The element of **social interaction**:

The criteria for social interaction in the GameFlow model are either to focus on aspects outside the game or to general to say something substantive about social interaction as the driving force in gameplay. To better suit pervasive games, this criterion should be more focused on the quality and purpose of social interaction as described by the following criteria in PGF:

- Pervasive games should support and enable possibilities for game oriented, meaningful, and purposeful social interaction within the gaming system
- Pervasive games should incorporate triggers and structures (e.g. quests and events, factions, guilds or gangs) that motivate the players to communicate and interact socially

4.6. Problems with the Pervasive GameFlow Model

One of the main issues with the Pervasive GameFlow model (PGF) is that it is constructed on Jegers conception of what pervasive games are [129], but as described in chapter 3.2 the terms pervasive game are widely used on many different types of games and experiences and the definition of what makes a pervasive game is not unambiguous. As shown in Nieuwdorp's discourse analysis [73], and discussed in chapter 3.3 there are two main perspectives on the term; the technological perspective that looks at technical solutions and how pervasive technology can facilitate games and the cultural perspective, where the focus is on the game itself and how it relates to the ordinary world. When it comes to PGF one should be aware of that pervasive gaming' is by no means a clear-cut term [129].

The perspective of PGF is technology-centred [129] and it can therefore be discussed to which extent the model is applicable to games that are pervasive according to the cultural definition of pervasive games and not to the technological definition. As

described in chapter 3.3 the research on pervasive games presented in this thesis has a cultural perspective.

One tool to keep players interested and engaged in the games is *pacing.* Relevant to games, pacing can be explained as "the rhythm" of the gameplay the player is experiencing. Pacing describes the relationship between an activity, the intensity of that activity, and the duration of the activity [130]. To keep the game from becoming boring or repetitive, it is important that the same gameplay is not used for too long, that the game uses different types of gameplay within the same game and changes between them constantly, that the game uses different "intensities" such as shootouts, that are high intensity, and puzzles, that are low intensity, and change between them fluently so that they don't become boring. Pacing is also about how often the game introduces entirely new ideas, whether that's areas, mechanics, and enemy types, and so on. Pacing is, of course, more straightforward in a linear game than in an open-world game or a pervasive game.

Jegers idea of pervasive games as games where the most important driving force in gameplay is the social interaction among players [128] and because of that concludes that pervasive games should let players provide their own creation of game scenarios and pacing instead of the game controlling the pace and levels of challenge, which is problematic regarding using pacing as a tool to keep players interested. Two of the pervasive games that provide the research platform for the findings presented in this thesis, Nuclear Mayhem (see chapter 6.1) and freeFromNicotine (see chapter 6.9) are games where the game controls both pacing and the level of challenge.

Furthermore, the requirement that the players should create their own game scenarios directly contradicts the idea of the artifact *Dynamic Pervasive Storytelling* (DPS) which is one of the important research contributions presented in this thesis (see chapter 7.4). Research on storytelling in games has shown that the game story is an important design factor to create player enjoyment and motivation to play the game. Storytelling or narrative is commonly used in both digital entertainment and serious games to motivate players to engage and then keep them engaged. Work by Lazzaro [131], Fullerton [132], and Yee [133] all identified storytelling elements as key motivations for players in entertainment games. Storytelling, for similar reasons, is also regarded as a key element for the design of serious games.

All three pervasive games used as a research platform in this thesis, provides a pre-set and controlled structure with clear goals. According to Jegers idea of what defines a pervasive game, this is problematic, but whether user-driven game play is more enjoyable than scenario-driven game play is still subject to debate [129].

Work done on evaluating the Pervasive GameFlow model (PGF) points out that one reoccurring issue with the PGF model is the fact that some of the added criteria seem to reflect a particular conception of what pervasive games are, rather than specifying determinants of player enjoyment [129]. They concluded that using the PGF model as a basis for observing and surveying participants allowed a systematic and elaborate review of both the technology-based and the nontechnology based pervasive games but a number of issues arose while applying it, both general in nature, as well as in the context of non-technology based games [129] and suggest that the criteria for social

interaction in PGF should be extended even more. While PGF focus on game-oriented interaction it was observed that social interaction that is not oriented towards the game may also contribute to creating a pleasurable player experience. Enjoying the environment and having the company of others may provide intrinsic reward in itself, and this is not taken into account by PGF that focuses on the extrinsic reward

of skill development [129]. The final issue this evaluation identified is that PGF completely ignores the role of non-players even though non-players can play various important roles and have an important effect on the players in-game-experience [129].

4.7. The "Overjustification Effect"

When it comes to Thomas W. Malones theory of intrinsically motivating instructions [116] in trying to motivate players to increase their activity in games, we also need to consider the "overjustification effect".

The overjustification effect was proven in a field experiment in 1974 [134]. It was shown that using extrinsic goals to motivate an activity that a person already has an intrinsic motivation to conduct actually may lead to a decreased interest in that activity.

A meta-analysis using 50 experimental studies of the overjustification effect showed consistent results that demonstrated the overjustification effect across age, dependent measure, and design type, in situations when it would be expected to occur [135]

The knowledge on how extrinsic and intrinsic motivation affects the players can be applied to game design. Games that focus on exploration (such as The Legend of Zelda: Breath of the Wild[29]), creativity (such as Lumines Remastered[30]), and growth may focus more on intrinsic motivation. When more extrinsically motivating systems, such as explicit goals, progression meters, and achievements, are added to those games, it can negatively affect players' motivation. Studies have shown that extrinsic rewards can make people worse at problem-solving [136], less creative [137], more prone to cheating [138], and may lead to the players losing their motivation entirely once the rewards stop, even though they previously were happy to participate for the activities/games own sake.

This is not to say that game developers never should implement goal-rewards motivational systems in games that are more intrinsically motivating games, as some players are not very good at or interested in motivating themselves. One benefit of the goal-reward system is that it can provide structure and progression to play, but it must be applied carefully.

[29] https://www.zelda.com/breath-of-the-wild/
[30] https://luminesremastered.com/

4.8. Everybody Likes a Good Surprise

There is one type of reward that has been shown not to trigger the overjustification effect when it comes to rewards. In that above-mentioned field experiment, there were three groups; one group was told they would receive a reward (this group experienced the overjustification effect) and one group was told that they would not receive a reward. The third group was given a reward at the end as a surprise, and this group increased their activity. This study [134] shows that rewards can have a motivational effect in intrinsic situations provided that the reward is not expected, is reasonably low value, and feels connected to the game and the actions performed. This is important when considering rewards in activities and tasks where the player may already be intrinsically motivated; however, rewards can also increase intrinsic motivation for tasks where the player has no or little intrinsic motivation in the first place. The use of unexpected rewards is implemented in the game design in almost all Blockbuster and Trippel-A games. In Super Mario Odyssey 2017, there are rewards for doing unforeseen things like wandering about not taking the shortest path. In Breath of the Wild, exploration and curiosity may reveal resources that the player may need.

4.9. Explicit Goals Versus Experimentation and Exploration

In-game design, an often-used solution to encourage players to use a specific feature or get them motivated to learn a new mechanic or to get people to play the game for longer (increase in-game-activity) is the goal-reward system; if you do this, you get that. This is a design approach that uses extrinsic motivation to facilitate intrinsic motivation.

This can be implemented in the games as challenges that unlock cosmetics or quests that lead to experience points or awards if you kill a certain number of enemies in a certain way, just to mention a few examples. But this type of engagements systems has shown not always to work as the game designers want them to; in specific situations, the goal-reward system can have the complete opposite effect of what was intended. This negative effect is most likely caused by the overjustification effect as discussed in chapter 4.3 .

Another problem with the goal-reward system was demonstrated in the development of "Don't starve", a survival sandbox game developed by Klei Entertainment and released in 2013[31]. During testing, while developing the game, the developers realized that the players who were testing the game did not know how to play the game and became stuck in the game. The players had no idea about what to do or how to progress in the game. To help the players, the developers provided a few hints, and when the players used the clues, they were able to experiment, explore, and have fun playing the game [139]. As a result of this experience, Klei Entertainment designed a series of small tutorial-like quests to help players get started. These quests were of the type "survive this many nights" and "find this many items". However, the game designers discovered

[31] https://www.kleientertainment.com/games/dont-starve

that, beyond getting players to learn how to play the game and get started in the game, these quests' effects harmed the game play.

The problem was that the players focused only on the quests and considered everything else in the game as a distraction. The developers registered that the players optimized their play to finish the quests, ignoring anything that is not part of the quest, thereby playing the game in uninteresting ways. As a result of this the quest design was never incorporated into the finished game. Klei Entertainment chose another solution than quests to get the players started, leaving players to learn, explore and create meaning for themselves [139].

The lessons learned about the goal-reward system, was that in games that are about player-guided discovery and exploration, an explicit goal could limit a player's creativity and imagination, causing players to do less of what the game designers want the players to do, even after the players have completed all the goal-reward activities in the game. This experience suggests that it is better to use large overarching goals that players can complete however they want rather than restrictive "step by step" instructions. Goals can also be made optional, like the challenges in the game Hitman[32] released in 2016, or hidden, like the achievements in Outer Wilds [140].

When it comes to goals in games it seems to be that a goal that that is set by the player itself (an intrinsic goal) is way more powerful than a goal someone else (the game developer) is setting for the player (an extrinsic goal) [116]. That is not to say that games should not use extrinsic goals as those can lead the player to create his or her own intrinsic goals. Hence most games use extrinsic goals and rewards to facilitate increased player activity.

4.10. Meta-game Reward Systems

Another example of extrinsic goals is the implementation meta-game reward systems such as "trophies" on the Sony PlayStation[33] console platform and "achievements" on the Microsoft Xbox console platform. Trophies and achievements are basically the same thing so I will just describe PlayStations concept of trophies here. Trophies are extrinsic rewards the player can earn by accomplishing objectives such as clearing levels, finding collectables, or completing certain tasks. Different games have different tasks and objectives that the player has to complete to be awarded a trophy. If the player gets all the trophies possible in one game, he or she will be awarded the Platinum trophy. The trophies a player has earned is visible "outside" of the game and the combined sum of all trophies earned from all games makes the player increase their "trophy level". This is a ranking determined both by the number of trophies the player has earned and the type of trophy (platinum trophies are worth more than gold, silver or bronze trophies). Trophies are extrinsic goals but can facilitate and effect the player's intrinsic motivation.

[32] https://hitman.com/global/
[33] https://www.playstation.com/en-us/support/games/how-to-earn-trophies-on-playstation--consoles/

Research has shown that meta-game rewards systems like PlayStation's trophies can enhance motivation for interested players, and increase player-enjoyment, engagement and time spent playing the game [141]. Completionists, which in game context means a player who attempts to complete every challenge and earn every achievement or trophy possible in a game, may derive great satisfaction from earning all of the trophies available [141].

One well-known example of this in the game community here in Norway is the Norwegian game journalist Rune Fjeld Olsen, who several times has stated on the game related podcast "Level BackUp"[34] where he is one of the hosts, that it is very important for him to get the platinum trophy in games. Because of this he will use more time to play the game, doing more game related activities than he would have done had if he not been intrinsically motivated by being awarded the platinum trophy. Another example is the author of this thesis, who has spent countless hours engaging in game related activities in PlayStation games such as "Horizon Zero Dawn", "God of War" and "Ghost of Tsushima" just to be awarded the platinum trophy in those games.

Research also suggest that there are some intrinsic aspects of meta-reward systems such as their competence supporting and gameplay experimentation properties, as well as, extrinsic aspects such as ego-maintenance or social comparison properties [142].

4.11. Balancing the Game

Balancing the game is closely connected to *challenge*, one of the three key categories that, in Dr Thomas W. Malone's theory of intrinsically motivating instructions [116], is emphasised as an important element in effecting the players intrinsic motivation (see chapter 4.2). *Challenge* affects the players' self-esteem and can increase or decrease the players' motivation to play the game. According to Malone, one important element of *challenge* is that games should be designed so that there is an *uncertain outcome*, meaning that it is not certain that the player is able to reach a goal. This can be done in at least four different ways as described in chapter 4.2, one of them being implementing *variable difficulty levels* in the game. This game design is often referred to as *balancing the game*.

In the same way as pervasive learning games, commercial games are games that take place in the player's leisure time and depend on players wanting to spend time playing the game. A commercial game that does not have players is a failure, and gaming companies that make games that no one wants to play quickly go bankrupt and out of business. To prevent the games from being too complicated, leading to player's quitting due to frustration, many commercial games adjust the challenges for different skill levels. If a player fails more at a given point in the game or at a given level than what was intended by the game designers, the challenge will be dynamically reduced so that the player can overcome it and progress further in the game. This author experienced

[34] https://www.modernemedia.no/levelup

this first hand recently while playing the action-adventure game "Ghost of Tsushima"[35] developed by Sucker Punch Productions and released for PlayStation 4 in July 2020. After failing several times fighting one of the more challenging game characters – more times than what the game developers had intended – the game suggested that the difficulty level should be changed to a more manageable level. This is one way of adjusting the game challenges according to the player's skill level. Other strategies may be to grant players additional moves or hints on what to do to progress.

When a game is balanced, meaning the game is not so easy that it's boring and not so difficult that it becomes frustrating or stressful [143], the player may experience a state of consciousness called *flow*. This is a state of concentration so focused that it amounts to absolute absorption in an activity [119]. During flow, people typically experience deep enjoyment, creativity, and a total involvement with life. The concept of flow is a well-established construct for examining experience in any setting [144]. Game researchers have used this construct as a foundation for understanding player enjoyment in games and The Pervasive GameFlow model, described in chapter 4.3, is a model that maps elements of gaming to elements of *Flow*. The element of *challenge* [121] in the Pervasive GameFlow model is a requirement directly related to *balancing the game*.

One approach to facilitate game balancing is to design predefined difficulty levels such as beginner, intermediate and advanced and let the player choose the most appropriate difficulty level for him or her. Most videogames will at the beginning of the game, require the player to choose the level of difficulty in the game (most games will allow the player to change this at a later stage if the game becomes too easy or too difficult). However this "static" approach to balancing the game is by itself not suited to deal with the great diversity in players in term of their skill level and capacity to learn and adapt new skills and/or domain knowledge [145]. To allow the classification of the players' skill levels to be finely tuned and for the game to adapt to the players personal evolution as they progress through the game most videogames also use *dynamic game balancing*. This is a process where the game as quickly as possible must identify and adapt itself to player's initial skill level, it must as closely and as quickly as possible track changes in the player's performance and when the game adapts to the players skill level the behaviour of the game must remain believable [145]. Dynamic game balancing concerns changing parameters in a game to avoid undesired player emotions, such as boredom and frustration [146]. An evaluation showed that games that implement a dynamic game balancing approach performed close to players' level, and also provided the highest player satisfaction [145].

4.12. In-game Awareness

A major challenge in long-lasting pervasive games that last for days, weeks or months, is to support in-game awareness, meaning that the player needs to develop a kind of information awareness to preserve the "feeling" of being in a game while not actively

[35] https://www.suckerpunch.com/category/games/ghostoftsushima/

participating in any specifically related game activities. In this area, we have drawn from the research field of Computer-Supported Cooperative Work (CSCW).

CSCW research tries to understand the nature and requirements of cooperative work to make it possible to design better computer-based technologies to support that type of cooperative work [147]. The CSCW research community is multi-disciplinary involving both computer scientists and social scientists (such as sociologists, anthropologists, psychologists and cognitive scientists) and as a follow of this, various methodologies and theoretical frameworks have been used in the conduct of workplace studies to understand work. Various concepts have emerged from these workplace studies and some of these concepts have become a part of a shared language and common point of reference within the CSCW community [147]. These concepts include:

- Differentiating dimensions
- Situated actions and work-practice
- Double level nature of work, including articulation work
- Seamless transitions
- Role of artefacts, including coordination mechanisms, common artefacts and boundary objects
- Workaday world
- Awareness

The concept that perhaps have had most influence on both social and technical research in CSCW is the concept of *awareness* [147]. It is generally acknowledged that awareness as an achieved outcome is a critical element of any cooperative work situation [147]. Within the CSCW community, surveys have ended by listing and describing up to nineteen different types of awareness information [148], some of which are:

Peripheral awareness denotes how people implicitly monitor each other and the local work environment while they are conducting their own job [147]. Current systems designed to support peripheral awareness has been developed with business environments in mind. When collaborative technologies move out of the office and into the home or local community, new requirements for information and media emerge [149].

Social translucence is an approach to designing digital systems that emphasise making social information visible within the system. It is suggested that socially translucent systems have three characteristics: visibility, awareness and accountability. These three characteristics are building blocks of social interactions and they enable people to draw upon their social experience and expertise to structure their interactions with each other. The concept of social translucence is often explained by using the example of the “door with the glass window”. A door with a glass window supports socially translucent systems because [150]:

- The glass window makes socially significant information visible. If you are going to open the door, then you can see if there is somebody on the other side of the door before you open it.

- The glass window support awareness. Since you can see through the glass window that there is a person just at the other side of the door, then you don't open the door quickly because you don't want to slam the door into that person.
- Since the person on the other side of the glass window also can see you, and know that you can also see him/her, then that person will also know that if you slam the door into him, then it is very likely that you did it on purpose and therefore hold you accountable for your actions.

Social translucence is implemented in the pervasive game *SupaFly* [92], a game that tries to explore pervasive game play in the context of people`s everyday life, in the form of an online magazine. Not only a few, but every action in the game generates news that the game displays in the magazine and the sensational value of the news is determined by the action and the status of the players involved. The online magazine acts as a virtual "glass window", it supports visibility since each player can see what the other players do in the game and what their status are, it supports awareness and accountability since the players know that all actions will be published in the magazine for everyone else to see. The players will know that every action may result in some consequences and will because of this most likely adjust their behaviour to the social rules within the society or social group of which the player is a member. However, since SupaFly is just a game there are maybe other rules for what is socially acceptable within the game than in the real world.

The game SupaFly also supports the above-mentioned *peripheral awareness*. The game sends SMS messages to the players and when a player hears the notification sound the phone makes when a new SMS message is received (if the sound is turned on), the player will know that something has happened in the game, even if the player does not look at the phone or read the message. The player can then choose if he or she will use this awareness information to interact and read the message, and maybe act upon the content of the message, or continue with the current activity and read the message later. Even if this is not visible information but "a sound" it facilitates peripheral awareness and allows lightweight transitions from awareness to interaction.

Both peripheral awareness and social translucence will enhance in-game-awareness among the players but the developers and game designers of Supafly also try to increase in-game awareness by using location data as a part of the gameplay to enhance the player's awareness and understanding of other people in the game [92]. The game developers theory and motivation for this function is that making players aware of other players in the surrounding geographical area should enhance the feeling of a constantly ongoing game anytime, anywhere [92].

In the game *Mobio Threat*, a pervasive game where two teams are competing to accomplish a mission while trying to prevent the other team from achieving its goals, location information and location awareness about players, both the players in the players own team but also about the players in the opponent team, is maybe the most important type of awareness to support the gameplay. When players move around the game area, they can be noticed by other players that can see them and observe what they do. This is emphasized by the researchers as one of the most notable aspects of the game: "The fact that the players can actually see what other players are doing and where

the enemies are, makes a game experience that is completely different from what people have been used to" [98].

In the CSCW world the tasks are most often work related and the systems are designed to support those types of activities. How these systems are designed is based on studies of the workplace. In the world of pervasive gaming the tasks are about reaching the game objectives and the game missions. The goals that the players in pervasive gaming are trying to achieve are most likely very different from the goals in a "normal" workplace, and as such the goals for cooperation in pervasive gaming are somewhat different from the goals of standard CSCW. Since awareness technologies often have been specialised to give information for particular work activities pervasive games may need other types of awareness technologies than what is needed in a working environment.

Pervasive games have many of the same awareness needs as CSCW, but also has some challenges from the fact that they may need other kind of awareness information than what is normal in the CSCW area, such as "awareness of being a participant in a game". There is still a lot of research needed to find out how in-game-awareness can be supported in pervasive games. It is nevertheless clear that *in-game-awareness* as an achieved outcome is a critical element of any pervasive game and pervasive games should be designed with this in mind.

4.13. Other Motivational Factors

Work done on analysing how game reward systems provide positive experience for players suggest that reward systems can be viewed as player motivators and that they have different effects on players according to the players preferences [151]. Game rewards may even enhance the players feeling of fun long before the reward is actually received by creating a sense of anticipation among players who know what is required to earn them. Player interest in rewards may also be increase by concealing details about the reward since players may exert considerable effort in investigating and revealing this information and many players consider this learning process fun and enjoyable [151].

The use of virtual characters in serious games has a significant positive effect on player engagement [73]; however, this is not a design strategy for pervasive learning games where much of the gameplay occurs in the real world and the players play as themselves.

Group-based competitions are frequently used in pervasive games to motivate individuals to participate or behave in a certain manner. However, what motivates groups, may not always translate to successful behaviour change at the individual level. Work has been done to understand the tension between group and personal success, based on an empirical study on a long-term real-world deployment of a pervasive health game for youth [152]. It was found that deploying a group-based competition did not automatically lead to cooperative behaviour. Instead, it created a myriad of behaviours based on the players' motivation, existing athletic skills, interest, social relationships, and different social statuses. From this, five distinctive player types were identified, and

design suggestions to help game designers integrate group mechanisms to maximize player enjoyment were one of the contributions of this research.

Leaderboards may be a better motivator than set goals and achievements in a game because goals and achievements may function very much like a checklist of activities that can be completed, but on the other hand, leaderboards have no finish, one can improve on one's personal best forever, which partly explains why Tetris is still a popular game after three decades. All three games used as a research platform in this thesis implement leaderboards, two of the games on individual level and one game on both individual- and group level.

One factor that can decrease player participation and player enjoyment is if the game suffers from technical problems. In a game that was developed to teach visually impaired children how to navigate their neighbourhood by using a location-based pervasive game as motivation for mobility training [87], research showed that, even if the game was well suited for integration in the mobility training, technical problems with GPS positioning, and the fact that GPS positioning was not accurate enough resulting in that locations could only be relied on within 10-20 meter, was stated as the main reason that the game received a low rating by the test participants in the evaluation.

Pervasive games can benefit greatly from being game-mastered rather than fully automatic [89]. For game mastering to be successful it must strike a balance where the game can respond to player improvisations and real world events without becoming just a playground without rules where anything goes [89]. The artifact *Dynamic Pervasive Storytelling*, one of the major contributions presented in this thesis depends heavily on a creative and active game-master to be successful.

There is a change in all games that one or more of the players will try to cheat, bend the rules, or take shortcuts to get ahead in the game. The chance of someone trying to cheat in a learning game is something one should consider when designing the game, and one should probably consider it inevitable. Cheating in learning games can be a problem, but it can also be a resource and help to promote learning processes. Research has been done on how pervasive learning games designers and facilitators may benefit from the ambiguity in play and potential cheating by using the ambiguity as a driver for creative learning processes [153].

Chapter 4 and its subchapters are not exhaustive in relation to a presentation on what motivates increased player engagement in games. What motivates people to perform given activities is an extensive and comprehensive topic. The methods, theories, and models presented in this chapter are only those on which the Ph.D. work presented in this dissertation is based and must not be viewed as an exhaustive overview of the topic. However, in the end, it all boils down to whether the game is fun or not. All the topics that are presented in this chapter are just different ways and methods to try to increase the player's experience of enjoyment when playing the game. If the players experience a game as a fun game to play, they will play it.

5 Research Method

"Research is an organized method of trying to find out what you are going to do after you cannot do what you are doing now."
- Charles F. Kettering

This chapter describe the Design Science research paradigm. In the first subchapter the definition and the seven guidelines for understanding, executing, and evaluating the research is presented. The following seven subchapters are detailed presentations of each of the seven guidelines (design as an artifact, problem relevance, design evaluation, research contributions, research rigor, design as a search process, communication of research).

5.1. Design Science

There are two research paradigms in information systems; *design science* and *behavioural science*. Behavioural science develops and verifies theories that predict or explain human behaviour. The design science research approach is to extend the knowledge in the research field by building new artifacts. This chapter describes design science and how this research method has been applied in this research project.

In design science research, the knowledge and understanding of a problem, and its possible solutions, are achieved in the building and application of the designed artifact. Design science research can be defined as follows [154]:

> *Design science is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem.*

From this follows that a fundamental principle of design science is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artifact [154]. Design science is fundamentally a problem-solving paradigm whose end goal is to produce an artifact that must be built and then evaluated [154]. Understanding the salient issues of an artifact by going through the process of designing, constructing, and testing the artifact is central to this paradigm. The knowledge generated by this research produces information on how the artifact can be improved and if it can solve the problems it is designed to solve.

The performance of design science research in Information Systems (IS) can be described via a concise conceptual framework and seven clear guidelines for

understanding, executing and evaluating the research [155]. The seven guidelines are presented in Table 4.

Table 4 - Design-Science Research Guidelines

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

5.2. Design as an Artifact

Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.

The term *artifact* is used to describe something artificial, or constructed by humans, as opposed to something that occurs naturally [156]. The artifacts must improve the existing system or be a first prototype/solution to an important problem [154]. Artifacts in Information Technology (IT) are broadly defined as follows:

- Constructs (vocabulary and symbols)
- Models (abstractions and representations)
- Methods (algorithms and practices)
- Instantiations (implemented and prototype systems)
- Better design theories

The artifacts which have formed the basis for the research are the *instantiations* of three pervasive games. Two of these games are prototypes that were developed specifically as a research platform for the research presented in this thesis, and the third game was a commercial web-based smokers' cessation program designed as a 50-day long real-time pervasive learning game. These three pervasive games are presented in detail in chapter 6:

- Nuclear Mayhem
- HiNTHunt
- freeFromNicotine.com

Furthermore, several *methods* were designed, developed, and tested as a part of the implementation and research conducted on these games:

- Dynamic Pervasive Storytelling
- The-Last-Shall-Be-The-First Dynamic Bonus System
- The principle of core assignments and individual assignments
- Group competition

5.3. Problem Relevance

> *The objective of design-science research is to develop technology-based solutions to important and relevant business problems.*

The problem must be explicated to formulate the initial problem precisely, justify its importance, and investigate its underlying causes. The problem should address the question [157]:

> *What is the problem experienced by some stakeholders of a practice and why is it important?*

People are diverse, we like different things, and we get engaged and involved in activities for various reasons. We tend to think that playing games is an enjoyable activity (which it is) but people that play games like different types of games. What engages and motivates one player another player may perceive as boring or not interesting. Game play that one player perceives as fun may be perceived as tedious and frustrating by another player. A game story that one player finds engaging and interesting another player may find unengaging and boring.

This diversity is a challenge when using games as an obligatory part of learning/teaching, and the whole group/class has to play the same game. We cannot expect people to participate in a game for the only reason that it is a game, and we, therefore, need to find out what type of techniques and methods we can use when designing learning games to engage as many people in a positive way to increase player participation and player activity in the game.

In pervasive games, which take place everywhere, all the time, and mostly in the player's own leisure time where the players have much greater freedom to decide for themselves how much they will participate in the game (compared to when a game is conducted in a classroom under the supervision of a teacher) the need for in-game features that motivates and engage players are even more necessary and critical to be able to design good pervasive learning games.

If the players do not play the game, there will be no learning outcome, and the game will already have failed as a learning game; hence the priority is to get the players to participate in the game.

As a mean to identify relevant problems and designing artifacts to improve or solve these problems, a literature study has been carried out to learn how other types of games motivate players and support increased player participation. This study is presented in chapter 4.

Table 5 - Correlation Artifacts, Research Questions and Published Papers

Artefact	**Description**	**Artefact Type**	**Research Question**	**Published Paper**
Nuclear Mayhem	Prototype of a pervasive game	Instantiation	1, 2	2, 4
HiNT Hunt	Prototype of a pervasive game	Instantiation	1, 2, 3	1, 3, 6
freeFromNicotine.com	A pervasive game	Instantiation	1, 2, 3	5
Dynamic Pervasive Storytelling (DPS)	DPS is oriented towards increasing the pervasiveness of the game and supporting a continuous level of player in-game awareness through the use of real-life events	Method	1, 2	2, 4
The-Last-Shall-Be-The-First Dynamic Bonus System (TLSBTF)	TLSBTF is a strategy to increase player participation in pervasive games by rewarding players which activates passive players.	Method/ Instantiation	1, 3	3, 6
The principle of core assignments and individual assignments	A strategy for generating individually tailored game sequences while at the same time ensuring fair competition between the individual participants	Method/ Instantiation	1, 2, 3	5
Intergroup-Competition	A strategy to increase player participation in pervasive learning games by facilitating intergroup competition	Method/ Instantiation	1, 3	3, 6

All the artifacts that have been used in this research, and that are listed in Table 5, investigate different strategies on how to increase player participation in long-lasting pervasive learning games.

5.4. Design Evaluation

> *The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.*

To evaluate the artifacts listed in Table 5, several different research strategies were applied.

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 be observed 24 hours a day, both in their private and professional life, for the game's whole duration. Furthermore, it is not possible to study the players' interactions with the environment and the environment's ubiquitous artifacts since those are not directly accessible [92].

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

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

The game was played during a nine-week period. In this period, all the activities that the players did via email, Web, or SMS to interact with the game were logged. A quantitative 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 completing the game. This questionnaire dealt with topics such as participation in the teaching programme, previous programming experience, the use of mobile devices, previous gaming experience, the types of games you usually play, how they played Nuclear Mayhem, what they liked or disliked, what motivated or demotivated them to participate in the game and how the game managed to support the course.

There were too few participants in the survey to have statistically significant results, but the answers may still indicate 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 selected for an interview, two persons had a *positive* attitude, one person was *neutral*, and two persons

were *negative* to the game. The in-depth interviews were conducted after the exam grade was set. 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.

HiNT Hunt was developed to test more specific design ideas than Nuclear Mayhem. Two methods were used to gather data:

- a questionnaire
- analysis of system logs of user activities

HiNT Hunt was played during a nine-day period, and all interactions with the game client were logged. To finish the game, each player had to complete a questionnaire with both open-ended and multiple-choice questions. Lessons learned from the evaluation led to the development of new artifacts and adjusting of existing artifacts. These adjustments and artifacts were then tested the following year in a new and updated version of the game to identify their effect on player participation.

In the case study of freeFromNicotine.com, the data was collected from the activity of the 181 registered users. This includes all types of activity logs from various usage patterns ranging from those that only logged in once and performed none or few tasks to users that logged in every day and completed all tasks and assignments they were given. The collected data is gender and age-neutral, and depersonalised, but all data can be connected to the specific user that generated the data. The following types of data have been analysed:

- The user's personal journal (each day, each user was given an assignment to write about their thoughts about quitting smoking, difficulties experienced, how they stay motivated, personal issues, and whatever is on their mind)
- The discussion forum (the users were throughout the course given assignments to write and discuss different topics in the FFN forum, the postings were anonymous).
- General user activity (game points, how many times they have logged in, progress, etc.)

Users finishing the course were asked to complete a questionnaire about their experience and suggestions for improvements. Fourteen users answered this voluntary questionnaire. Even though such a small sample does not allow for statistically significant results, the analyses of responses of the open-ended questions may still indicate the users' opinion about the competition aspect and the course in general. Furthermore, in-depth interviews were conducted with the person who was in charge of the development and maintenance of the system. The discussion mainly dealt with the system's design, the effect of using gamification, and lessons learned while the system was online and running.

Nuclear Mayhem, HiNT Hunt, and freeFromNicotine.com are the primary artifacts on which the research presented in this thesis is based upon. However, these three games contain several other artifacts and methods developed and tested as a part of this research. The research platform is presented in detail in chapter 6.

Furthermore, research articles that present the results are published at the European Conference on Games Based Learning (ECGBL), The Electronic Journal of e-Learning (EJEL), and Norsk Konferanse for Organisasjoners bruk av IT (NOKOBIT). At ECGBL and EJEL, all papers are double-blind peer-reviewed to ensure an adequate standard before the paper is accepted for publication. The publication of scientific articles that presents the research and results is therefore also an essential part of the evaluation process.

5.5. Research Contributions

> *Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.*

Two functional and playable prototypes of Pervasive Learning games, HiNTHunt and Nuclear Mayhem, have been developed as a research platform (see chapters 6.1 and 6.7). Both prototypes are useful research platforms and tools to extend the research beyond what is presented in this thesis and can be used by other researchers who wish to bring forward the research in this field.

The playable prototype HiNTHunt has already been adopted by others. Since the research presented in this thesis was completed, students at Nord University, on their initiative, have used HiNTHunt to help new students at the start of the academic year to familiarize themselves with the study program, the schedule, the campus, and to socialize and get to know their fellow students. The students have run HiNTHunt for the first week of the academic year at the Campus in Steinkjer, Norway, several years in a row. Furthermore, HiNTHunt was also used as a tool to get researchers that were attending the European Conference for Game Based Learning (ECGBL) in Steinkjer, Norway, the 8th and 9th of October 2015, to socialise and to familiarise themselves with the Campus hosting the conference and the city of Steinkjer.

Although these runs of HiNTHunt have only been executing the gaming part of this research platform and that no further research has been conducted during these runs, this still demonstrates that HiNTHunt has become a popular game and such is well suited as a platform for further research on pervasive learning games.

For this reason, HiNTHunt, now under a new name NORDHunt (the University has changed the name from HiNT University College to Nord University), has been continued as a part of Centre for Excellent IT Education (ExcIted), which in 2018 published the paper, *NordHunt – gamification for a smooth start of university life,* at the EdMedia + Innovate Learning international conference in Amsterdam, Netherlands [158], presenting further research work on the HiNTHunt/NORDHunt project.

The research carried out in this Ph.D. work has also led to the development of the model *Dynamic Pervasive Storytelling*, a model and method for implementing real-life events into the game history in "real-time" as they take place and unfold in the real world.

The case study of the commercial product *freeFromNicotine* has given insight on how to use real-life events and tasks that are not automatically detectable by the game client as an integral part of a Pervasive Game.

And last but not least, the work done with the research platform HiNTHunt has led to insight on how to use social gameplay to increase player participation by the use of social groups and competition between these groups, and how to use motivated and eager players to get less motivated players to boost their activity in the game. This insight has resulted in "The-Last-Shall-Be-The-First-Bonus-System" approach.

5.6. Research Rigor

> *Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.*

Rigor addresses how research is conducted. Design-science research requires the application of rigorous methods in both the construction and evaluation of the designed artifact [155]. Given the nature of IT artifacts and the environment in which they must perform, it may be difficult to describe them using excessive formalism. Trying to be mathematically rigorous may cause essential parts of the problem to be too abstracted or "assumed away" [155]; hence rigor must be assessed with respect to the generalisability and applicability of the artifact. To support the development, construction, justification, and evaluation activities of the artifacts, the existing knowledge base needs to be consulted and employed [159].

Both before and during the design and construction of the artifacts used in this research project, literature studies were conducted to identify relevant sources that could contribute to the artifacts' development. A synthesis of the literature study is presented in chapter 4.

Other relevant sources were other researchers within the research field of Game-Based Learning, and many artifacts were designed, constructed, or improved as a result of these discussions.

5.7. Design as a Search Process

> *The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.*

Design-science research often simplifies a problem by representing only a subset of the relevant means. Even if such simplifications and decompositions may not be realistic enough to have a significant impact on existing practice, it may still represent an

appropriate and valid starting point where further progress is made through iterative processes to expand the scope of the design problem [155].

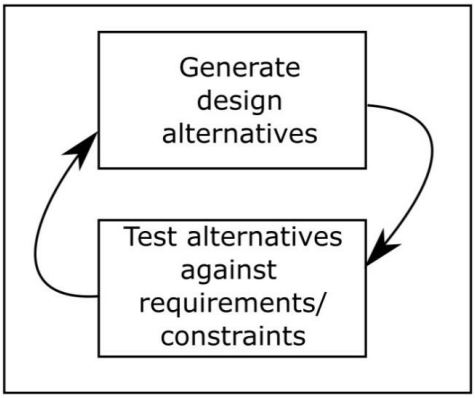

Figure 5 - The Generate / Test Cycle

Design science is inherently iterative. First alternative designs are generated to solve or improve the identified problems. The designed artifacts are then tested against the requirements and constraints they are designed to solve or improve. Then the design alternatives are adjusted, improved, or redesigned due to the findings made during the testing. Then the improved design is tested and so on in an iterative circle, as illustrated in Figure 5 above.

During the design of the artifacts used in this research project, all of them were first theoretically designed and tested and then adjusted through several iterations before they were physically implemented in an executable prototype. All artifacts were implemented and tested in a prototype at least once. Some artifacts, such as "The-Last-Shall-Be-The-First-Bonus-System" approach, were iteratively developed and evaluated through several executable prototypes.

The scope of this research project is such that it was not possible to conduct many design/test iterations on all artifacts through executable prototypes; however, all artifacts have been further developed theoretically with regard to lessons learned from the testing and evaluating of the prototypes. These artifacts are still a progression from the previous state within this research field. They provide a good starting point for further research and development, which is, as mentioned at the beginning of this section, also a goal of design science.

5.8. Communication of Research

> *Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.*

The results of the research carried out in this project are published in renowned international conferences and journals that are approved by *Norsk Publiseringsindikator* (NPI) and *Norwegian Centre for Research Data* (NSD). NSD is a Norwegian state-

owned limited company under the Ministry of Education and Research. The purpose of NSD is to have a public actor responsible for archiving data and facilitating its reuse for research purposes [160].

Research articles that present the results from the research, lessons learned, and suggestions for further work are published at The International Conference on Serious Games Development and Applications (SGDA), The European Conference on Games Based Learning (ECGBL), The Electronic Journal of e-Learning (EJEL) and Norsk Konferanse for Organisasjoners bruk av IT (NOKOBIT).

The prototypes that were developed as a part of this research project are the property of Nord University. The source code and description of the prototypes can be obtained by contacting Nord University for those that want to run their own instances of the prototypes that have been developed.

This has actually already been done with the prototype HiNTHunt which was run as a part of the 15th European Conference on Game Based Learning to help the participants to socialize and familiarize themselves with the Campus. Since all the participants were researchers within the field of Game-Based Learning, the intention of running a version of the prototype of HiNTHunt was also to demonstrate and thereby transfer knowledge of the game and its use.

Before, during, and after developing the artifacts, knowledge and experiences gained have been shared to stakeholders, students, fellow researchers, and other interested parties. This was done through discussions, presentations, scientific papers and lectures in both formal and informal forums.

6 The Research Platform

"Research is what I'm doing when I don't know what I'm doing."
- Wernher von Braun

This chapter describes the two prototypes of playable pervasive learning games, *Nuclear Mayhem* and *HiNTHunt*, which have been developed during this Ph.D. work and used as a research platform for the research presented in this thesis.

In addition, it describes the commercial product freeFromNicotine.com, an online pervasive smoking cessation course, where game design and the use of real-world events and real-world physical locations were used as part of the concept/game, and where we have conducted a case study to see and learn how real-life events, which cannot be detected automatically by the game client, can be implemented in a pervasive learning game.

All three of these games/products are presented in the articles, but here I give a more holistic and complete description due to the limited format in the articles.

In order to be able to conduct research to address the overall topic of this thesis and the three research questions as stated in chapter 1.3, it is essential to have access to a research platform suitable for exploring these issues through the Design Science method as described in chapter 4.13. The overall topic of this thesis is to investigate how to motivate and ensure player participation and player activity in long-lasting pervasive learning games. Players need to participate actively and as much as possible in these games to achieve learning. Furthermore, pervasive learning games have the potential to make learning pervasive, to be something that happens everywhere all the time. If this is to be achieved, we must know as much as possible about how we can motivate the players to get involved in this type of game.

There has been conducted a lot of research on how pervasive games may be used as a learning tool. However, we were not able to find any existing long-lasting pervasive learning games that were suitable as a research platform to address our research questions; hence it was decided to design and develop playable prototypes of pervasive learning games specific to this research project.

As mentioned in chapter 4.13, one factor that can decrease player participation and player enjoyment is if the game suffers from technical problems such as GPS positioning problems. Even if all three games used as a research platform in this Ph.D. work are location-based – meaning that some game activities only take place in specific locations - none of them are directly dependent on the use of GPS technology. GPS technology can be used as a second means to locate areas of interest in the games, but there is always another way that does not rely on technology, to locate places of interest

in the games. Not using GPS technology as an essential part of the game play has been a design choice in the two prototypes that have been developed as a part of this Ph.D. work. The product freeFromNicotine.com, which I have used in a case study, does not rely on GPS technology.

6.1. Prototype 1: 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. Most of the course is a Flash ActionScript 3.0 programming course. Previous experience has shown that the students find programming difficult and that they do not have the motivation to use the necessary amount of time on this topic. The pervasive game, *Nuclear Mayhem*, addresses this problem by providing 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 only mandatory activity the students had to do during the course was to participate in the game, and to be allowed to attend the exam, they had to complete the game within a given time limit.

There would seem to be something of a paradox in a game that requires that participation in the game is mandatory in the face of the frequently cited definition of a game offered by Bernard Suits [161] as “the voluntary attempt to overcome unnecessary obstacles”. However, when new applications of games arise – and more and more games are used, not only as entertainment or leisure activities, but to solve complex problems and as innovative tools for learning, there may be a need to expand the definition of what a game is and is not, and perhaps "voluntary participation" should not be a part of the domain that defines if something is *a game*.

The game story in *Nuclear Mayhem* was constructed from the ability to support the story by referring to real-life events that had already happened (reality hack) and the likelihood that there would happen something 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. At the time, Iran's alleged nuclear weapons program was often mentioned in the news. There had already been several different events that could be used to substantiate the game story, and the issue seemed to be so relevant that there was a significant probability that one or more events could happen during the duration of the game that would be featured in the news media and after that could be implemented in the game. 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". Based on these considerations, the theme chosen for the game story was Iran's nuclear program - which, related to the game, now, of course, was a most real situation and not just a suspicion; hence the game and the prototype were named *Nuclear Mayhem*.

Another aspect important for the game story was that the players had to play the game as themselves and not pretend to be some type of game character but rather an extended version of themselves. This design choice was based on the idea that – by letting the players play the game as themselves – it would be easier to create a 360° illusion and

make the game a part of the players' everyday life. To achieve a 360° illusion is easier if the game history is set in the present day [2].

6.2. The Nuclear Mayhem Game Story

The overall game story used in Nuclear Mayhem was designed to support the following four basic guidelines. The game story should ...

1. ... enhance the “pervasiveness” of the game.
2. ... help to create awareness about the game in “non-game related situations”.
3. ... be believable / something that could happen (not little green men from Mars).
4. ... be dynamic so that if “something” related to the history happened in real life, the Game Master could incorporate the event in the game story to motivate game-related actions or just as a history reinforcing element.

The overall game story was the basis of the above, constructed as follows:

Iran has a nuclear weapons program aiming to develop nuclear weapons (this storyline was supported by referring to actual news broadcasts on YouTube and articles in major Norwegian Newspapers reporting about this [162-164]). A group of agents (we do not know the members of this saboteur group) has been asked to delay and sabotage the weapons program so that Iran fails in developing nuclear weapons. The saboteur group has previously managed to delay the nuclear program by liquidating key personnel (this storyline was supported by referring to real news broadcast on YouTube reporting about Iran's nuclear scientist killed in bomb blast [91]) this is no longer a feasible option.

However, in an underground bunker in Iran, a supercomputer is currently conducting computations that are absolutely necessary for the Iranian nuclear weapons program. Without these calculations, it will not be possible for Iran to develop nuclear weapons, and the saboteur group's mission is to sabotage the super computer before these calculations are completed.

To gain access to the super computer, the saboteur group has to hack into Iran’s government's internal computer network. The group has managed to gain access to an Iranian government office in which there is a computer connected to the internal computer network, but they do not have the codes and passwords necessary to penetrate the network and get access to the super computer.

These codes are, however, known to a former Iranian nuclear physicist who fled to the United States (this storyline is supported by referring to an online article in Norwegian largest newspaper VG, that reports about an Iranian nuclear physicist who has defected to the United States and is now assisting the CIA [165]). Iranian agents are out to liquidate him, and to protect him from assassination, he is, therefore, in consultation with the Norwegian and American government, in utmost secrecy been placed in Steinkjer, Norway - where he has been given a new secret identity as an Afghan asylum seeker (this was “reality hack” used to explain that the story unfolded at the same

physical place where the students that are going to participate in this game are located).

The former nuclear physicist is willing to help penetrate the Iranian government data network, but he will not have any direct contact with the saboteur group to protect himself. He has instead chosen to hide the codes at different places in Steinkjer and to prevent them from being discovered and understood by random people; he has hidden the codes behind or as part of technical challenges that not anyone will understand.

Apart from this, the former Iranian nuclear physicist will not help in any way. He fears for his life and will not do anything that could cause the Iranian authorities to become aware of him.

This means that the saboteur group has to find someone in Steinkjer who they can use to find and transmit the codes to them so they can use the codes to penetrate the computer network and sabotage the supercomputer before it has completed the calculations.

The codes that are hidden in several places in Steinkjer turn out to be hidden behind or as part of ActionScript 3.0 programming code and Flash applications. Via searches on Google, and after that on the university's website, the saboteur group discovers that there is an ongoing ActionScript 3.0 programming course at the SPO program at Nord-Trøndelag University College in Steinkjer, and they decide to contact the students there to get help to find the codes.

The saboteurs' group creates a false G-mail account under the name Amir Ahangar (a typical name in Iran) and uses this to contact students.

The game has begun.

Based on the four basic guidelines for the story, the following generic game model was developed (see Figure 6). This is a model that is designed to provide the opportunity to implement actual events from the real world as part of the game story and the game plot during play.

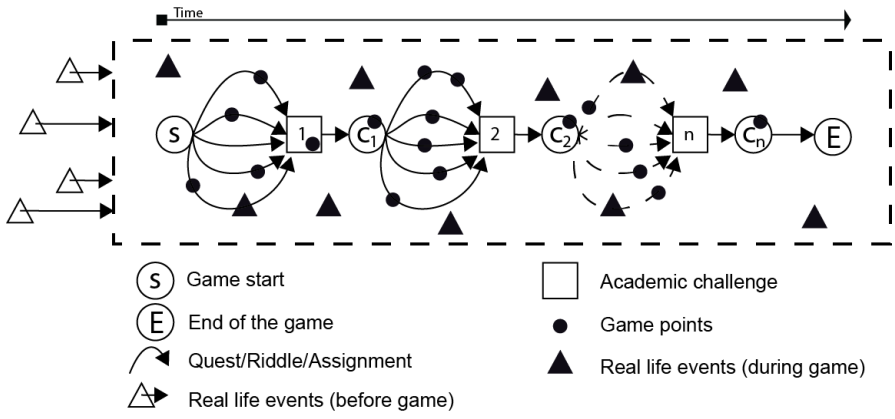

Figure 6 - Design Principles in Nuclear Mayhem

The dotted line that encloses the model symbolizes the game story. The game story is built up and supported by real-life events that happened before the game started (the white triangles) and by real-life events that will occur during the game (the black triangles). All the events in the game are motivated by the game story.

In the model, time passes from left to right, and the game starts on the left side of the model indicated by the symbol “Game start” and ends when the player reaches the end of the game indicated with the symbol “End of the game” on the right side of the model. The Time arrow indicates the total game time and the order of the game's plot and events.

Each Quest/Riddle/Assignment arrow symbolizes a quest consisting of different puzzles to be solved and tasks that must be performed. All quests lead to an academic challenge (the white squares labelled 1, 2 .. n) that must be solved/conducted to reveal a code which shall then be registered in the game client symbolized by C1, C2 .. Cn. The fact that there is more than one Quest/Riddle/Assignment arrow means that there are several different paths towards the goal. Still, all the players have to solve the same academic challenge no matter what way they play the game (the academic challenge will be related to the subject taught in the course that the game is designed to support).

Some of the events in a quest lead to the player being awarded Game points. Players also are awarded Game points when an academic challenge is completed or when a code is registered in the game client. The player that has the most game points at the End of the game wins the game.

To implement real-life events that happen during the game is conducted as part of the game - the game has to be controlled by a Game Master.

The overall game story – described above - was created based on real-life events that had already happened (as referenced in the description – illustrated by the white triangles in Figure 6). The story functions as a “guide” for the game master during the game. New events that are to be used in the game shall support the overall story.

6.3. Distributed Narrative

One of the design choices for storytelling in Nuclear Mayhem was to use distributed narrative where the story is told fragmentally across different media types, so the story is revealed a little by little to the players. When the game begins, the players don’t know anything about this. The idea behind this was motivated by the approach used in *The Beast* and *Savnet Harry Hole* (described in chapter 2.3) to try to “trigger” the students' curiosity making them think, “What is this?” and hopefully get them interested in finding out what this is all about.

The black triangles in Figure 6 illustrate events that are related to the “Iranian Nuclear weapons program” that (hopefully) occurs in real life in the duration of the game and that can be incorporated in the game story and game plot to either:

- enhance the overall game story

- motivate some type of activity in the game
- create in-game-awareness
- make the game story more "real"

When the players experience that serious media, such as the newscast on the Norwegian national television channel, or major Norwegian or international newspapers, reports on a topic related to the game story, and when they see this in the comfort of their own home or at the front page of the newspapers at the grocery store – the story also becomes pervasive according to their everyday life. When something is featured in the nine o'clock news in real life, and that event later is experienced by the players as an incorporated part of the game or game story, this would hopefully also have a positive and reinforcing effect.

6.4. Nuclear Mayhem as a Pervasive Learning Game

The synchronization between the progress of the game *Nuclear Mayhem* and the course is done by aligning the game story and the seven levels of security that has to be breached so there is one code/password to discover for each week of lecturing. The code/password is hidden in the academic assignment for each week of lecturing (see chapter 6.5).

At the end of the seven-week of lectures, the students/players would have revealed all the seven codes needed and has provided them to the saboteur group in Iran.

The last two weeks of the course is an exam where the students must design, develop, and program a functioning game. Only the students that have provided all the correct codes are allowed to take the exam, therefore participation in the game replaces traditional mandatory assignments.

The connection between the course (the exam) and the game is illustrated by the following twist of the game's story, revealed to the students by an email from the fictive *Amir Ahangar* – the person they have communicated with though all of the game - towards the end of the game:

> *Subject: We need you to produce a web-game*
>
> *Hi,*
>
> *We got the security code for level 7, but we are not able to use it. The code has to be entered on a PC that we don't have access to. We need your help to get access.*
>
> *The situation is as follows:*
>
> *The PC where we need to enter the security code is located in a room at the end of a long hallway. The hallway is guarded by a security guard. To be able to pass the hallway without being detected, we need to distract the security guard.*

We know for a fact that the security guard is hooked on web-games. If we can get him to play a web-game, we are convinced that he will be distracted long enough to give us time to pass by him without being detected.

Then we can get access to the PC and use the security code to penetrate security level 7.

When security level 7 is penetrated, we have full access to the supercomputer and can stop the calculations.

The problem is that the guard has played almost all the existing web-games, so we cannot distract him with a game that already exists. It has to be a new game.

We need you to use your programming skills to produce a new and exciting web-game that we can use to distract the guard.

You have to publish the web-game on a website and give us the URL address. You must register the URL address at www.plohn.com/gaming before the countdown reaches zero.

Amir

The students then have two weeks to make the game and publish it and submit the URL address in the game client. Correspondently in the course, they have to submit the project report, the source files, etc., before the deadline (see Figure 8). The students that don't submit a URL in the game client do not get their exam project evaluated and don't get a grade hence the demand that they have to play and finish the game.

When the deadline expired at 3 pm the last day of the exam period, the players who have submitted a URL address before the deadline get the following SMS from Amir Ahangar:

We got the URL and have now used your game to distract the security guard. We managed to gain access to the supercomputer and have now stopped the calculations. Our mission has been successful. But we still have some unfinished business to do.

There is someone you have to meet.

Come to the restaurant Dolly Dimple`s in Kongensgate 37, Steinkjer the 21. October at 1600 (Norwegian time). Don't be late and come alone.

This ends both the game and the course. There are no more game-related activities. When the player comes to the restaurant at the given time, there is a social happening with free pizza to all the players (Figure 7).

Figure 7 – Social happening when the game was finished.

Winning *Nuclear Mayhem* was not just for the honour. There were prizes for 1st, 2nd and 3rd place. First place was rewarded with a gift certificate for the value of NOK 1000,00. Second and third place is rewarded with an iPod Shuffle. The winner was the player with the highest score when the game ended. If more than one player had the same score; the prize would be divided between them.

Nuclear Mayhem was designed to be used in all the three different ways games can be used in higher education (as described in chapter 2.5). The game was used instead of mandatory/traditional assignments, it was designed to increase participation and motivation of the students, and as a part of the game the students had to develop their own game, hence learning about topics such as game development, programming, game design and software development.

6.5. Synchronization the Game and the Course

The connection and synchronisation between the game *Nuclear Mayhem* and the University course in Multimedia and Web-game technology are illustrated in Figure 8 below.

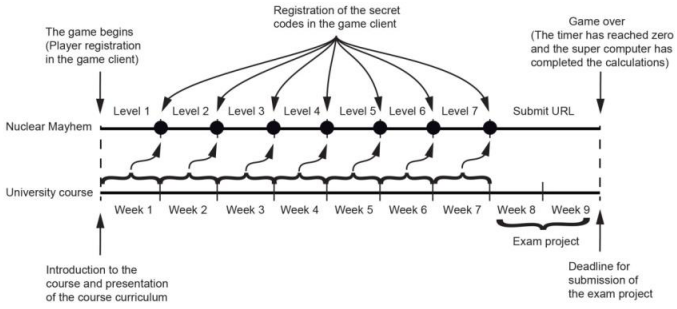

Figure 8 - Nuclear Mayhem and the Curriculum

The top line in Figure 8 represents the game Nuclear Mayhem, and the bottom line represents the university course. The game and the course both start and end on the same dates. The course begins with a presentation of the course curriculum 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 take the exam. After this information, the teaching of the course begins with the curriculum of week 1.

To complete level 1 in the game and register the secret code in the game client at the end of the level, the student/player has to learn the topics 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.

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 very start of a pervasive game often makes or breaks the whole game experience and, hence, should be crafted very carefully [2]. Both *The Beast* and *Savnet Harry Hole* used the strategy of "Rabbit hole" (see chapter 2.3), where players had to – by themselves – discover the first artifact that led them into the game. This strategy was not appropriate in terms of ensuring synchronization between the progress of the game and the course. If the students did not understand that the first artifact was a "rabbit hole" they would not be able to get started with the game; hence the students – on the first day of the course/game - were told to "keep an eye on whether they received a strange email" and to act upon it. To support the strategy "this is not a game", this was the only time that the lecturer or any other person involved in the game openly talked about or discussed the game with the students while the game lasted.

6.6. The Nuclear Mayhem Game Framework

Pervasive games are either *technology-sustained* or *technology-supported* games. Technology-sustained pervasive games rely on a computerized simulation where the computer maintains the game state through monitoring and reacting to player activities. In technology-sustained games, the game content and rules are defined based on what can be traced by the simulation. In technology-supported pervasive games, information technology is used to support some but not all game activities, and the system might not even contain a complete rules engine. The latter has an advantage over the first in that the technology is a part of the game. Still, it is not the whole game, and this approach offers richer opportunities for immediate experiences [2].

Nuclear Mayhem is a technology-supported pervasive game. The technical platform used in this game was mainly a website that functioned as the central game hub (Figure 9), an SMS (TEXT-message) service, a false email account on Gmail in the name of Amir Ahangar, and a false Facebook profile in the same name. A video produced to be

used in the game was uploaded to YouTube and could be watched there when discovered[36].

The website (the game hub) was where the students had to register as players in the game. It was also where they had to register the codes/password (Figure 9, A-B-C), it displayed a countdown timer (Figure 9, E) showing the remaining time before the super computer had completed the calculations (the computer had to be sabotaged before the timer reached zero) which exactly matched the deadline for delivering the exam project in course *Nuclear Mayhem* was designed to support.

Similar to *The Beast* and *Savnet Harry Hole, Nuclear Mayhem* was run under the principle; this is not a game. People (actors) that had a role in the game were instructed not to admit that it was a game, or even that a game even existed, but always pretend that every event was real and all-natural. As a result, the students could not ask the lecturer for help with the game since the lecturer did not know that a game was going on (even though the lecturer and the game master were the same person). However, *Nuclear Mayhem* uses a balanced approach by providing means for the players to get help or hints if they got stuck in the game. If the players were stuck in the game, they could ask for assistance through the game hub (the website). Asking for help was awarded minus points, so if one intended to win the game, one should only use this feature if there was no other choice.

The players could also at any time see how many points they have and how they are doing in the game compared to the other players in the game high-score list that was displayed in the game hub (Figure 9, D).

The game hub also provided a link to a webpage, "Rules of Engagement" [166], that provided the players with the "rules" of the game and tips and hints on how to progress in the game. Here the players would get an overview on how to earn game points in Nuclear Mayhem, the consequence of trying to register a wrong code, how to use the game "Cheat-function" (ask for help), and other information necessary to play the game.

[36] https://www.youtube.com/watch?v=lXQ3m869T1c

Figure 9 - The Central Game Hub in Nuclear Mayhem

The SMS service was set up to display Amir Ahanger (the nickname used by the sabotage group in Iran) as the sender of the messages. The service could be used to send TEXT messages to one specific player, to a selected group of players, or to all of the players. The players could also use this service to contact "Amir" sending TEXT messages to him.

The false email account on Gmail was used to give the players assignments, to communicate with the players, and to reveal parts of the story little by little. Facebook was used to make the game more pervasive (the game is everywhere) and to give information the players needed to solve some of the riddles in the game, but also to provide specific tasks that had to be solved on Facebook (Figure 10).

Figure 10 - Nuclear Mayhem on Facebook

Nuclear Mayhem was designed according to the design principle; "Come into the players' lives in every way possible" [2] by spreading the story and gameplay across real websites, emails, ordinary mail, via television, SMS, real people (actors), hence the game engages in the player's everyday life in many ways. Clues and tasks are found on Facebook, are sent on email or 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, see Figure 11), 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 - and these websites were not mock-ups, but serious and genuine websites such as, e.g., a website belonging to the police in Steinkjer, the website of 24nettbutikk.no - Norway's largest supplier of online store solutions and the homepage of Marisletta Barnehage (Kindergarten) in Steinkjer.

Figure 11 - A Tag with a Game Clue in Shop Window

The prototype *Nuclear Mayhem* was used as a research platform to learn more about how a pervasive game can be used to expand the area for learning into the students' everyday life and enable learning to be anytime and anywhere, how storytelling and awareness can support player activity in pervasive learning games and how to integrate real-life events and the real world in pervasive learning games. Some of the results of this research are presented in publications P2 and P4 that are included in this thesis (see chapter 1.5).

6.7. Prototype 2: HiNT Hunt

At the start of the academic year, all new students attending a university must familiarize themselves with the study program, the schedule, the lecturers, the campus, and the area (city) where the campus is located, they have many administrative tasks that must be performed (getting their student ID, activate their username on the IT systems, etc.) and it is important that students socialize and get to know their fellow students.

This is *basic knowledge* that new students need to acquire as quickly as possible to get the best possible start to their new student life and get started with their studies. Getting new students to acquire this *basic knowledge* is considered so important that most (if not all) universities and university colleges conduct different activities at the beginning of a new semester to get the new students to absorb this *basic knowledge* as quickly as possible.

At Nord-Trøndelag University College (HiNT), the entire first week of the academic year is set aside for this type of activity for new students. The activities are part of a

prescribed program called *Oppstartsuken* (*Startup Week*). As part of *Startup Week* at HiNT, concerts are held, information meetings are conducted, excursions, barbecues on campus, and many different social activities, just to mention some of the things that are going on. These activities are carried out during the daytime and in the afternoons and evenings in the students' leisure time. It is preferable that students become more motivated to participate in activities that provide them with the necessary *basic knowledge*.

HiNTHunt is a prototype of a pervasive game designed to support and motivate students to participate in the activities during *Startup week* and acquire the *basic knowledge* to prepare themselves, in the best possible way, for their new life as students at a university.

6.8. HiNTHunt – Design Choices

Five areas that participation in the game HiNTHunt should contribute positively to were defined. Playing *HiNTHunt* should:

- help the students get to know their new fellow students (socialisation)
- help the students become familiar with the campus
- help the students get to know the city where the campus is located (the town of Steinkjer)
- help the students to become acquainted with the lecturers
- motivate students to complete the administrative tasks as soon as possible during the first days of the academic year, such as activating their personal user on the school's IT systems.

This is implemented as a treasure hunt game where players have to look for and discover diamonds and place them on the game board (Figure 12).

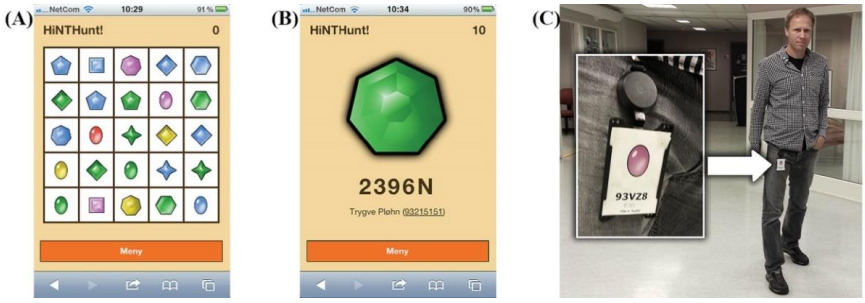

Figure 12 - The Game Board in HiNTHunt

Figure 12 above are screenshots from the game that illustrates (A) the game board in HiNTHunt, (B) that each player is assigned a unique personal diamond that can be shown from within the game client, and (C) that all the lecturers is assigned a personal unique purple diamond.

The diamonds were "hidden" in activities and locations that the players had to discover or in activities they had to perform or conduct in relation to the game's defined objectives. Diamonds could be found at the following locations or activities:

- Green diamonds could be found on the other students
- Red diamonds were hidden in various locations in Steinkjer town
- Blue diamonds could be found by participating in the various social programs and activities during the first week
- Purple diamonds were hidden among the lecturers and professor
- Yellow diamonds were hidden on campus or in the IT systems at HiNT.

In conjunction with other information given on the first day of the academic year, the students were given a brief introduction to the game, how to register as a player, about the prizes they could win if they are among the top players, and they were encouraged to register and participate in the game.

Each player is assigned an automatically generated personal game board when he or she registers as a player in the game (as shown in Figure 12 – A). During registration, the player is also given a personal diamond that can be "found" by other players in the game (Figure 12 - B). The personal diamond is displayed in the players' game client and must be shown to the other players when requested. All the lecturers were assigned a unique diamond attached physically to their ID card and carried in a visible way (Figure 12 – C).

Each player can only register a specific diamond once, but a specific diamond can be registered by many different players. There can only be registered one diamond on each square on the game board, and it has to be a diamond of precisely the same type as shown in the square. The player gets points for every diamond that is registered on the board. An additional bonus is achieved by finding specific configurations of diamonds such as a row, all diamonds along the board's edge, or when the board is filled.

The game client is used to register diamonds when they are found and gives the player an overview of which diamonds are found and which are still missing, the number of points the player has gained, and a high score list showing the ranking of the best players. To do well in the competition, the player must find as many of the diamonds on the game board as possible (naturally). Still, it is also important to be first since the bonus points are weighted so that the first player that obtains an entire row, frame, or picture will get the most points, the second one somewhat less, and so on. If more than one player has the same score, the player that first achieved the score wins the game.

HiNTHunt lasts all *Startup Week*, and the game ends with an award ceremony on the last day where the top three players are rewarded. The winner gets a prize with a value of approximately NOK 1000 (2nd and 3rd place a little less).

The game is designed to be played on the students' smartphones. However, since students have various types of smart phones, it will be far too big a task to develop dedicated apps for all the different types of smart phones and operating systems (Android, iOS, Windows). To ensure that as many students as possible can play *HiNTHunt* on their mobile phones, the game was designed to be played in a web

browser, and the game client is therefore developed in HTML and adapted for use on smartphones.

This technical design choice also makes it easier to implement and adapt new research ideas, game design, and game play in the game as the research evolves. This proved helpful as the game was further developed – for a second run the following year - based on findings made in the first run. On the *HiNTHunt* research platform, technology is not the interesting part, but concepts, game play, and game design, and this simple technology platform made it easy to implement new research ideas.

This solution also enabled that even if the game were designed to be played on a mobile phone, it could also be played in a web browser on a computer. This meant that all the students had the opportunity to participate in the game regardless of what type of smartphone they had.

HiNTHunt was run during *Startup Week* in two different versions over two consecutive years. In the first run, the game was run as an individual game without a game history. In the second run, new moments were introduced, such as group competition, social gameplay, and a game history.

The prototype *HiNTHunt* (version 1 and version 2) was used as a research platform to learn more about how a pervasive game can be used to expand the area for learning into the students' everyday life, how storytelling can support player activity in pervasive learning games, how social game play can be used to support and increase player engagement in pervasive learning games and how one can integrate real-life events and the real world into a pervasive learning game. Some of the results of this research are presented in publications P1, P3, and P6 that are included in this thesis (see chapter 1.5).

6.9. Case Study: freeFromNicotine.com

freeFromNicotine.com (FFN) was a commercial gamified web-based smokers' cessation program designed as a 50-day long real-time pervasive learning game. FFN was developed by the companies Active Software ANS (discontinued) and MT Master ANS (now Sincos Software AS).

The course program in FFN was tailored to the individual participants' specific situation based on information collected from a questionnaire that each of the participants must fill in on the first day of the course.

Quitting smoking is a difficult process, and FFN is designed to help the participants through this process. During the course, the participants are led through three different phases distributed over the 50-day course program as follows:

1. Habit breaking – 25 days (day 1 - 25)
2. Quitting smoking - 21 days (day 26 - 46)
3. Follow-up care - 4 days (day 47 - 50)

Smoking consists mainly of habits that smokers must break. This is the focus in the first phase, where participants are motivated to quit and learn techniques to resist the craving to smoke. Breaking habits is difficult, and this phase lasts for 25 days. Towards the last part of this phase, the participants have to reduce their smoking so that by the start of phase 2, they are free of smoking. In the second phase, the participants are no longer allowed to smoke, and this phase is mostly about how to handle the craving for smoking and how to remain smoke-free. Even though physical nicotine dependence disappears after 3-7 days, psychological dependence lasts for 15-20 days (which is why this phase lasts for 21 days). The third and last phase is the shortest but is just as important. Statistics show that a large number of those who manage to quit smoking will take up the habit again within the first year, and the final phase deals with how to establish attitudes and create a plan for the next 12 months.

6.10. Gamification as a Tool to Control Progress

FFN is a real-time course. This means the course, once it is started, will continue regardless of whether the participants log in or not. The nature of smoking cessation makes it important for users to participate fully in a defined period. However, suppose a participant for some reason is unable to log into the course for a period of a few days. In that case, all tasks and assignments are made available as "Uncompleted daily exercises" (as illustrated in the screenshot in Figure 13), and the participants will have the opportunity to complete them when they log in.

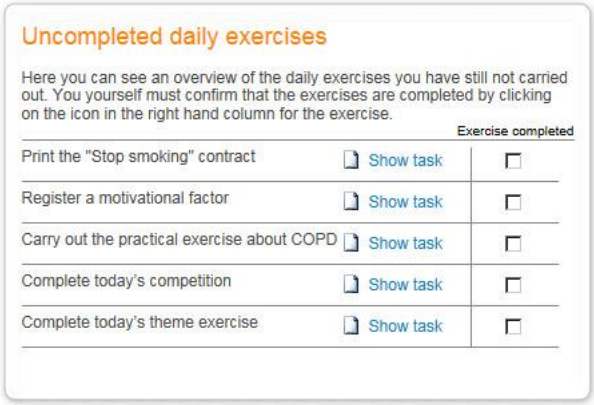

Figure 13 - Uncompleted Daily Exercises (Assignments)

Gamification is an important design feature of FFN, and components such as game points, levels, and a high score list are key elements. There are three levels corresponding to the phases of the course described above. The user cannot advance from one level to the next unless specific requirements are fulfilled within given time limits. Upon failure to accomplish this, the user will be prompted to restart the course (equivalent to "die" in a game and restart from a given point). During the course, if there is a risk that this situation may occur, the user will receive warnings and will be advised on how to avoid failing. To monitor user activity and provide feedback, FFN

uses the total game points achieved so far and compares this to the ideal sum a user could have achieved at this stage (Figure 14).

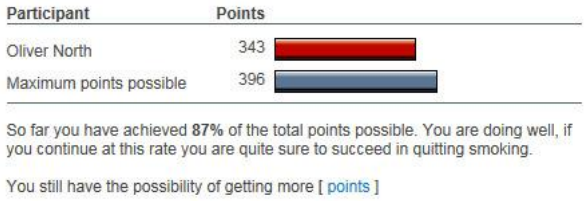

Figure 14 - Game Points Compared to Maximum Points Possible

Each day of the course, the participants can achieve a given sum of points; hence game points are a good indicator of participation. The percentage of total possible points gained is used to evaluate progress and participation (Figure 14) and give feedback and follow-up to the user. For example, a low percentage over time may indicate a lack of motivation of a user who is less likely to quit smoking at this stage in life, and the user should be informed that he/she should restart at a later time when they are more motivated.

FFN uses game points to enable competition both between individuals and groups. Single users can compete against themselves by trying to achieve the highest score possible at all stages (Figure 14). For those who participate as part of a group, the scores are presented so that the group members compete against each other.

6.11. Adapted Learning but Fair Competition

The course program in FFN is built up as a series of different types of assignments that the user has to complete (Figure 15). Some typical examples of tasks are:

- Print out and sign a "Quit Smoking" contract with friends and family
- Different types of practical exercises (one example is the practical exercise about a chronic obstructive pulmonary disease where the users have to breathe through a straw for ten minutes)
- Theme days where the user learn more about various topics and must answer questions to prove that they have understood the topic
- Writing about different topics in the forum
- Register and work with their motivational factors (a recurring task throughout the course)
- Competition on knowledge of smoking-related questions (quiz)

There are different principles and considerations behind the design of FFN and the assignments given in the duration of the course. The gamification aspects of the design are based on the following principles:

1. FFN shall be designed as a game where users have the opportunity to compete against themselves or others in completing the course (competition).

2. The course shall be tailored to individual users smoking habits and life situation

3. The course program shall be composed of various theoretical and practical tasks (assignments) that the user must perform each day of the course

4. All users should have the possibility to participate in the overall competition on equal terms

5. It shall be possible to earn points (compete) each day of the course

6. It must be easy to add and remove tasks (for the developers)

Requirement 2, 3, and 6 led to a module-based framework with a core "skeleton" to which modules are attached. The framework includes the overall behaviour such as which modules each user shall perform on each given day of the course, user data, game points, leader boards, dependencies between the modules, the course's progress, the user interface, etc. The modules are the individual assignments users have to perform, and modules are connected through a common interface. This module-based design is illustrated in Figure 15.

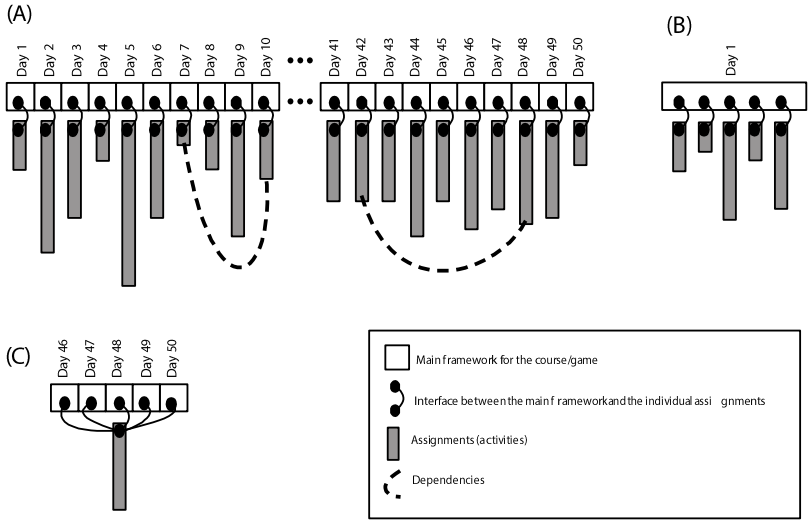

Figure 15 - FFN Framework and Modules (Module-based Design)

In Figure 15A, we see the 50 days long period with assignments for each day of the course. The dotted line illustrates dependencies between assignments; for example, the task given on day ten is depended on how the user completed the task given on day seven. Figure 15B illustrates that there can be many different assignments given on the same day, and Figure 15C illustrates that the same assignment can be given on many different days of the course. The different length on the assignments illustrates that some are small and easy to complete, and others require more effort.

The course program can be tailored to each user (requirement 2) by selecting assignments from a pool of assignments when generating personal course programs.

Assignments can be chosen according to information each user register about smoking habits and specific life situation. Each tailored course program consists of only a selection of the assignments available in the pool.

To provide the possibility for all users to participate in the overall competition on equal terms (requirement 4), the principle of *core assignments* and *individual assignments* was introduced (see Figure 16). C*ore assignments* have to be performed by all participants and generate game points (requirement 1) when completed. *Individual assignments* do not generate game points. This design enables users to compete on equal terms since all users have the same *core assignments* as a part of their course (requirement 4). *Individual assignments* are given to users based on their smoking habits and personal life situation; hence it is the *individual assignments* that are used to tailor the course to each user's preference (requirement 2). To ensure that the users perform all assignments in their course and not only those that award game points, users are not told until after the assignments are completed how many game points (if any) this assignment generated. Any given day of the course may consist of at least one *core assignment* and zero or more *individual assignments* (requirement 5).

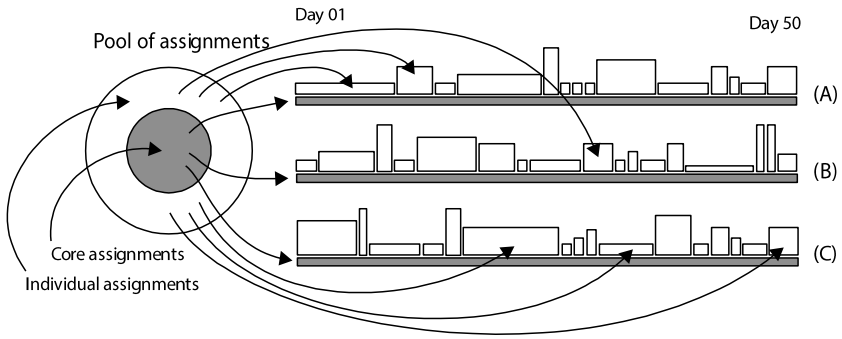

Figure 16 - Pool of Assignments and Individually Tailored Course Programs

Figure 16 illustrates how the course program from day 1 to day 50 is tailored to individual users A, B, and C by combining the same *core assignments* (the grey areas) and different *individual assignments* (the white areas) selected from the *Pool of assignments.*

The fact that there is a "solid core" of scoring assignments (core assignments) also means that there is a fixed maximum score for each day of the course. This is used as a control mechanism to measure how well the user is conducting the course (Figure 14).

To motivate the user to participate in the course as it is designed, the highest score is given for *core assignments* completed the same day as they are given. A lower score is given for assignments completed a day after and even lower after two days. After more than two days, the user will still have the opportunity to complete the task (Figure 13) but without being rewarded with game points.

The diversity of assignments used also means that gamification can be applied to many types of normal everyday activities such as "*The user is from this day not allowed to smoke inside his/her home and must now go outside to smoke. The task of today is*

finding an outside spot where the user has to go to smoke, and the apartment/house must be properly cleaned to remove all odours of smoke". This assignment is a part of the *habit-breaking phase* and is a game point awarding assignment. However, there is no means to automatically detect that this task is performed, and the system relies on the user being honest when these assignments are marked as completed. The completion of other types of assignments such as "*writing in the FFN forum*" or "*writing in the users personal journal*" is automatically detected by the system and will contribute to the feeling of interaction and feedback.

The companies behind FFN experienced that the product was successful in order to support smoking cessation but found it very difficult to generate a profit. Different business models were tried to make it commercially profitable, and the product was advertised on the Internet, national TV, and national radio. Licenses were sold to individuals and businesses that wanted their employees to quit smoking. Many licenses were given away for free as advertisement and different price and payment models were tested. There are many possible reasons for the lack of commercial success. A primary reason could be that people (at this time) expect products on the Internet to be free of charge.

The case study of *freeFromNicotine.com* was conducted to learn more about how a pervasive game can be used to expand the area for learning into the players' everyday life, how social gameplay can be used to support and increase player activity, and how one can integrate real-life events and the real world into a Pervasive Learning Game. It also provided insight on how to design a fair competition in a game, where all participants shall have the same opportunity to succeed even if the tasks in the game are individually customized. Some of the results of the case study are presented in publication P5 that are included in this thesis (see chapter 1.5).

7 Results and Discussion

"Small daily improvements over time lead to stunning results."
- Robin Sharma

This chapter describes the most important contributions from this research project. First, the publication references of the six papers are presented before the research questions are revisited. The main results of each paper are presented in separate subchapters.

This thesis includes the following papers that were written during different stages of this research project:

1. P1: Pløhn, T and Aalberg, T. *HiNTHunt – a Pervasive Game to Support and Encourage Desired Activities for New Students*. Paper presented at the 4th International Conference, Serious Games Development and Applications, SGDA 2013, Trondheim, Norway, 25-27 September 2013.

2. P2: Pløhn, T. *Pervasive Learning – Using Games to Tear Down the Classroom Walls.* Paper published in e-Journal of e-Learning, EJEL 2014, June 2014 Volume 12 Issue 3, pp227 – 311

3. P3: Pløhn, T and Aalberg, T. *Increasing Player Participation in Pervasive Educational Games.* Paper presented at the 8th International Conference, European Conference for Game Based Learning, ECGBL 2014, Berlin, Germany, 9-10 October 2014.

4. P4: Pløhn, T, Louchart, S and Aalberg, T. *Dynamic Pervasive Storytelling in Long lasting Learning Games.* Paper published in e-Journal of e-Learning, EJEL 2015, March 2015 Volume 13 Issue 3, pp149 – 206

5. P5: Pløhn, T and Aalberg, T. *Using Gamification to Motivate Smoking Cessation*. Paper presented at the 9th International Conference, European Conference for Game Based Learning, ECGBL 2015, Steinkjer, Norway, 8-9 October 2015

6. P6: Pløhn, T, Iversen, K and Aalberg, T. *A Dynamic Bonus System to Increase Player Participation in Pervasive Learning Games*. Paper presented at the 14th International Conference, European Conference for Game Based Learning, ECGBL 2020, Brighton, UK, 24-25 September 2020

The papers are listed in the order they were published and reflect the progress throughout the PhD project. The overall project and the published papers are influenced by discussions with colleagues, fellow researchers within Game-Based Learning, students, and supervisors; hence all papers should be considered collective products,

also those where I am the sole author. The listed papers investigate the three research questions outlined in the introduction in chapter 1.3:

RQ1: What are the effects and challenges in using pervasive learning games to engage and motivate students outside the classroom?

RQ2: How can storytelling and the use of real-life and real-life events in the narrative design contribute to player engagement in Pervasive Games?

RQ3: How can social gameplay support and increase player engagement in pervasive learning games?

As mentioned in chapter 5.1 the design science research approach is to extend the knowledge in the research field by building and evaluating new artifacts. Answering the research questions through knowledge and understanding of a problem and its possible solutions, are achieved in the building and application of the designed artifact.

An overview of the designed artifacts developed in this research project and their relation to the research questions and published papers are listed in Table 5 on page 58.

In the following subchapters from 7.1 to 7.6 each paper, and which of the three research questions that it addresses, are presented. The subchapters also list the main contributions and other significant findings presented in each paper.

7.1. Paper 1: HiNTHunt – a Pervasive Game to Support and Encourage Desired Activities for New Students

This paper addresses research questions 1 and 3. It presents the first of the primary artifacts used in the research presented in this thesis, the first instantiation of the prototype of the pervasive learning game *HiNTHunt*. The research platform HiNTHunt is explained in detail in chapter 6.7.

HiNTHunt is an experimental pervasive game designed to encourage students to socialize and perform various desired activities during the first week as new students at a university. HiNTHunt was adapted to the following objectives:

- help the player become acquainted with fellow students
- help the player become familiar with the campus
- help the player become familiar with the city where the campus is located
- help the player get an overview of the academic staff

Furthermore, since player enjoyment is perhaps one of the most important issues in successful game design, an important goal was that the players should experience HiNTHunt as a fun game to play.

The overall objective of this first instantiation of the artifact *HiNTHunt* was to learn whether this type of pervasive game was suited as a tool to fulfil the specified objectives and to identify problems and challenges in conducting this type of game.

Although this is the first edition of the game's physical version, there have been several theoretical iterations of the game at the design level. Theoretical models of the game were presented to fellow researchers and colleagues and discussed. In this process, several design ideas and game concepts were introduced, some were rejected, and others were further developed. This was an iterative process until we had a theoretical model of the game that we considered suitable as a basis for developing a functional executable prototype of the game.

This paper, published at The International Conference on Serious Games Development and Applications (SGDA), presents the prototype and its first implementation.

As mentioned in chapter 5.7, design science is not necessarily about the design and construction of artifacts that have a significant impact on existing practice but also about artifacts that represent a relevant and valid starting point where further progress can be made through iterative processes to expand the scope of the design problem [155]. This first implementation of the prototype of HiNTHunt, presented in this paper, provides such a starting point.

The main contributions and results presented in this paper were:

- To understand the reasons for and identify different levels of player participation in the game, two groups of players were identified, *active players* and *passive players*. In order to increase player engagement in obligatory pervasive learning games, both these groups must be taken into account. To increase player participation, the game must provide features that target both groups of players.
- An instantiation of the artifact HiNTHunt, which provides a valid starting point for further research on how to increase player participation in long-lasting learning games.

Other significant findings were:

- The results of this experiment show that the game was very successful in terms of satisfying the defined learning goals for those players that were defined as *active players*. Still, there is a need to provide features in these types of games that target *passive players* to create increased player engagement and learning outcomes in this group.
- Several specific reasons why some players did not participate actively in the game were identified, and solutions and improvements were suggested.

The contribution of the authors of this paper:

- Trygve Pløhn – Designed and developed the artifact *HiNTHunt* and the research project, conducted the experiment described in this paper. Collected and analysed data from the experiment. Wrote the paper presenting the experiment.
- Trond Aalberg – Guided me in the process of designing the artifact *HiNTHunt* and the research project presented in the paper. Assisted in writing the paper.

7.2. Paper 2: Pervasive Learning – Using Games to Tear Down the Classroom Walls

This paper addresses research questions 1 and 2 and presents the prototype and the instantiation of the pervasive learning game *Nuclear Mayhem*. The research platform Nuclear Mayhem is presented in detail in chapter 6.1.

The artifact Nuclear Mayhem is a playable prototype of a pervasive game designed to support university studies in Multimedia and Web-game technology at Nord-Trøndelag University College (HiNT).

The overall objective of this instantiation of the artifact Nuclear Mayhem was to investigate if a pervasive game could expand the area for learning into the student's everyday life and enable learning to be anytime and anywhere? Other research objectives were similar to the artifact HiNT Hunt - to identify problems and challenges in conducting this type of game. Again - similar as with the development of the artifact HiNT Hunt - there have been several theoretical iterations of the game at the design level before the playable prototype of Nuclear Mayhem was developed.

The prototype Nuclear Mayhem supported the course by providing gameplay that was strongly related to the course syllabus, as illustrated in Figure 8 on page 72. To be successful in the game, the players had to understand and master the topics in the syllabus.

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

One significant artifact within Nuclear Mayhem was the dynamic game story. The game story was designed to incorporate events that happened in the duration of the game as a part of the game story. This concept is illustrated in Figure 6 on page 68.

This paper was published in e-Journal of e-Learning and was an extended version of a paper published at the 7th European Conference for Game Based Learning, where it was awarded "among the best papers at the conference".

As mentioned in chapter 5.7 and repeated in chapter 7.1, design science is also about artifacts representing a relevant and valid starting point for further research. This implementation of the prototype of Nuclear Mayhem, presented in this paper, provides such a starting point.

The main contributions and results presented in this paper were:

- The use of real-life events that were featured in newspapers and in the 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 and proved to be a valuable technique to create increased player engagement.

- 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 generally 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 is 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.
- An instantiation of the artifact Nuclear Mayhem which provides a valid starting point for further research.

Other significant findings were:

- 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 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.
- Analyses of log files indicating that the game succeeded in becoming pervasive in relation to the player's everyday life in the period the game lasted. 87% of logins in the game client was outside the period devoted to teaching the course, suggesting that the game managed to expand the area for learning beyond the boundary of the lecture hall.
- Unintended gameplay by some players was identified. Analyses showed that some players did not play the game according to the planned schedule, which is unfortunate because they will not experience the intended relationship between the game and the course. The paper provides suggestions to overcome this problem.
- 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 favourable to this type of game 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.
- All interviewees mentioned that they got a learning benefit from participating in the game. Still, several of them pointed out that they felt they would have had a greater benefit with an ordinary arrangement of compulsory exercises. Simultaneously, several of the interviewees mentioned that their participation in the game resulted 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. All players who finished the game managed to pass the exam, but there is still a need for a stronger connection between the game and the course and better adapted academic challenges in the game relative to the individual players' academic level.

Nuclear Mayhem has shown that this type of game has the potential to expand the learning space towards being pervasive and facilitate pervasive learning. Still, to better

evaluate the educational benefits of participation in the game, there is a need to develop a model to measure the educational 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.

The contribution of the authors of this paper:

- Trygve Pløhn – I am the only author of this paper. I designed and developed the artifact *Nuclear Mayhem* and the research project in which this game was used. I programmed and designed the *Nuclear Mayhem* game hub and conducted the experiment described in this paper. I game-mastered the game for the whole duration of the game. I was also lecturing in the university course the game was designed to support. I collected and analysed data from the experiment and authored the paper presenting the experiment and the findings.

7.3. Paper 3: Increasing Player Participation in Pervasive Educational Games

This paper published at the 8th European Conference for Game Based Learning addresses research questions 1, 2 and 3. This is the second run of the artifact HiNTHunt, and it addresses some of the problems that were identified during the first run.

To increase player participation in the second version/run of HiNTHunt compared to the first version/run, several new artifacts were introduced:

- A game story to explain/motivate the actions the players/students had to perform in the game and raise awareness and curiosity about the game
- Social gameplay with intergroup competition
- The-Last-Shall-Be-The-First-Bonus-System (TLSBTF)

All our indicators confirmed a significantly higher level of player activity in the second run of HiNTHunt compared to the first run; hence we conclude that the artifacts introduced had a positive impact on player participation.

The main contributions and results presented in this paper were:

- The artifact, Intergroup Competition, can easily be adapted into similar types of games to increase player participation. The introduction of this artifact led to increased player engagement compared to the previous version of the game.
- The artifact, The-Last-Shall-Be-The-First-Bonus-System (TLSBTF), targets passive players to get those players more engaged and active in the game. The introduction of this artifact led to increased player engagement in the player group, defined as *passive players* transferring many of them to the *active players'* group. *Passive players* that were targeted and successfully participated in TLSBTF became more motivated and more engaged in the ordinary gameplay.
- An updated instantiation of the artifact HiNTHunt with several new features to increase player participation. This artifact has addressed some of the previously

identified problems and provides a good foundation for further research on how to increase player engagement in pervasive learning games.

Other important findings were:

- Social gameplay and the intergroup competition had a positive impact on player participation, but some unintended effects were identified. One negative effect was that the intergroup competition had a negative impact on the level of engagement in TLSBTF because the group which was in the lead did not want to engage the players from the other group.
- TLSBTF had a positive impact on player participation. However, as mentioned in the previous bullet point, the intergroup competition had a negative effect on TLSBTF, and TLSBTF was also used less than optimally because the players did not know each other by name, and it, therefore, was difficult to identify the targeted players were only identified by name. The published paper discusses both these issues and suggests several solutions/adjustments to the TLSBTF system to avoid them.
- Using a fun game story that connects the game to the players' situation can motivate the players to engage and participate at an earlier stage in the game. Observations conducted of the students during the game story presentation and the questionnaire's data clearly indicated that the students found the story to be fun. Observations and analyses of the log files showed that players engaged earlier and more actively in this version of the game than the previous version conducted without a game story.

The importance of the different artifacts introduced in this instantiation of HiNTHunt needs to be better weighted towards each artifact. The introduction of TLSBTF led to regular gameplay becoming less important for the first and middle part of the game. A winning strategy in the game could be to not participate in the “normal gameplay” until the very end of the game. This is an unwanted effect of TLSBTF and must be addressed.

The contribution of this paper is to show how to increase player participation in pervasive games using some simple strategies and gameplay. The presented strategies can easily be adapted and implemented into almost all types of social games to motivate and increase player participation.

The contribution of the authors of this paper:

- Trygve Pløhn – Designed and developed this second iteration of the artifact *HiNTHunt*, designed and wrote the game story, designed the artifact *intergroup competition* and the artifact *The-Last-Shall-Be-The-First-Bonus-System*, conducted the experiment described in this paper. Collected and analysed data from the experiment. Wrote the paper presenting the experiment.
- Trond Aalberg – Guided me in the process of redesigning the artifact *HiNTHunt* and the two new artifacts *intergroup competition* and *The-Last-Shall-Be-The-First-Bonus-System*. Guided me in designing the research project in which these artifacts were used and tested. Assisted in writing the paper.

7.4. Paper 4: Dynamic Pervasive Storytelling in Long lasting Learning Games

This paper was published in e-Journal of e-Learning and was an extended version of a paper published at the 8th European Conference for Game Based Learning, where it was awarded "among the best papers at the conference". The paper addresses research questions 1, 2, and 3.

This paper presents the Dynamic Pervasive Storytelling (DPS) model, a theoretical iteration of the dynamic strategy for storytelling used in the artifact Nuclear Mayhem (see chapter 6.1). Specifically, the paper presents the use of DPS as a strategy to create a game story, using real-life and real-life events, to be used in pervasive games, and methods to support both in-game awareness and to increase the pervasiveness of the game, which is an important success criterion in designing long-lasting pervasive games.

DPS, as a model, is oriented towards increasing the pervasiveness of the game and supporting a continuous level of player in-game awareness through the use of real-life events (RLE).

DPS uses RLE as building blocks both to create the overall game story before the start of the game by incorporating elements of current affairs in its design and during the unfolding of the game as a means to increase the pervasiveness and in-game awareness of the experience.

The main contributions and results presented in this paper were:

- The artifact Dynamic Pervasive Storytelling (DPS)
- The DPS strategy of using a current news story with the potential that timely and related real-life events could happen and be featured in the news media within the duration of the game proved to be successful in increasing player engagement and in-game awareness. In the nine weeks the game lasted, several real-life stories were featured in the news media. These were used in different ways in the game to increase the pervasiveness of the game and maintain the players' in-game awareness.

Other important findings and contributions were:

- A practical example of using DPS for storytelling and narrative creation in a long-lasting pervasive game.
- A detailed description of DPS's design principles and the approach to incorporate it in a long-lasting pervasive learning game.

We concluded that DPS is a promising approach for creating a game story that increases the game's pervasiveness and supports in-game awareness to facilitate increased player participation in long-lasting pervasive games.

The contribution of the authors of this paper:

- Trygve Pløhn – Designed and developed the artifact *Dynamic Pervasive Storytelling* (DPS) used in the artifact *Nuclear Mayhem*. I game-mastered the game for the whole duration of the game and designed and wrote the game story according to the DPS framework and principles. Conducted the experiment described in this paper. Collected and analysed data from the experiment. Wrote the major parts of the paper presenting the experiment.
- Sandy Louchart – Participated in designing and developing the artifact *Dynamic Pervasive Storytelling* (DPS). Wrote most of chapter 2 in this paper and provided valuable guidance for me in the writing process of the remaining parts of this paper.
- Trond Aalberg – Guided me in designing the research project in which these artifacts were used and tested. Assisted in writing the paper.

7.5. Paper 5: Using Gamification to Motivate Smoking Cessation

This paper published at the 9th European Conference for Game Based Learning addresses research questions 1, 2, and 3. It presents a case study of the commercial web-based *freeFromNicotine* course, which provides a game-based approach to smoking cessation. The research platform *freeFromNicotine.com* is presented in detail in chapter 6.9.

freeFromNicotine.com (FFN) uses gamification both as a control mechanism to measure how well the participants follow the course and to motivate the participants to complete the course according to the scheduled program. An essential motivational element included in the design is the opportunity for participants to compete against themselves and others based on game points awarded for completing goals and assignments during the course. In this paper, we specifically focus on the gamification approach adapted in the course and how this affected and was perceived by the course participants.

The main contributions and results presented in this paper were:

- The principle of *core assignments* and *individual assignments* was successful in ensuring that all users could participate in the overall competition on equal terms while still have a unique tailored personal course program to follow.
- Using tasks and assignments from real life as a part of FNN that could not be automatically detected by FNN as completed but relied on the participants themselves registering the assignments as completed was also a good design choice that facilitated the use of real-life events which otherwise would not be possible to use as a part of FNN. Analyses of the data from FNN indicated that the participants have been honest when manually registering tasks and assignments as completed and that "cheating" has not been a strategy to gain game points. The possibility to rely on users registering correct information makes it easier to include everyday tasks in learning games.
- The presentation of the artifact *freeFromNicotine.com* (FFN) demonstrates that a gamification approach where everyday activities are included in the game as assignments is a promising approach for including everyday types of activities in a pervasive learning game.

Other important findings and contributions were:

- Three user groups were identified; the curious, the opportunist, and the motivated – each of these groups needs to be targeted differently to increase player participation in each group.
  - The curious were the ones that got a free license on FFN and only logged in once or a few times just to see what it was all about with no intention to follow the course.
  - The opportunists also got a free license but registered and showed a higher level of commitment. They were not very motivated but used the free license as an initiator to "give it a try" and see if this could help them stop smoking. However, they did not follow the course as intended; they did not log in every day, and most of them failed to complete it.
  - The motivated showed a high level of commitment by logging in every day and completed the tasks and assignments given throughout the whole 50 day period of the course.
- More than 50 percent of the participants in the motivated group managed to quit smoking. When analysing the achieved game score in this group, we find that all of the users achieving 80% or more of the total game points managed to quit smoking. Knowing that less than one out of ten managed to quit smoking without help, indicates that FFN was a success in assisting people in quitting smoking provided that the course was followed as intended.
- The competition was identified as a high motivational factor. All quotes from users that mention the competition indicate that the competition/gaming elements of FFN were perceived as important by the users and that they were motivated by the competition. Just as important is the fact that we were unable to find any negative comments about the competition element in FFN in any of the data from the 181 users we analysed.
- The gamification elements were also successful in ensuring the pacing of FFN such that participants completed the assignments as intended, not delaying or postponing the tasks given to them.

freeFromNicotine proved successful in getting people to quit smoking, but it was not a commercial success due to marketing problems and has therefore been removed from the market.

The contribution of the authors of this paper:

- Trygve Pløhn – Conducted the case study of the artefact *freeFromNicotine*. Identified and described the artifact *The principle of core assignments and individual assignments*. Collected and analysed data from the case study. Authored the paper presenting the case study and the findings.
- Trond Aalberg – Guided me in conducting the case study of the artefact *freeFromNicotine*. Assisted in writing the paper.

7.6. Paper 6: A Dynamic Bonus System to Increase Player Participation in Pervasive Learning Games

This paper presented the artifact *The-Last-Shall-Be-The-First Dynamic Bonus System* (TLSBTF) and was published at the 14th European Conference for Game Based Learning. The paper addresses research questions 1 and 3.

TLSBTF is applied as a part of the artifact HiNTHunt and is a method to activate passive players to get them more engaged in the game (increase player participation). TLSBTF was designed, developed, and used in the second run of HiNTHunt, as presented in chapter 7.3. This paper is a theoretical iteration of TLSBTF from a static to a dynamic model and addresses some of the identified problems.

A dynamic TLSBTF model is better suited to be used in different types of pervasive games and will also provide better opportunities to conduct research on the effect it has on player participation as well as allow for further systematic development of the method.

The main contributions and results presented in this paper were:

- The artifact The-Last-Shall-Be-The-First Dynamic Bonus System (TLSBTF)
- TLSBTF is refined and presented as mathematical formulas. A formula makes it easier to integrate the method into similar types of games and provides a good platform for further development of the TLSBTF method.

Other important findings and contributions were:

- The clarification of the model's elements behind the method makes it easier to research the effect of individual parameters in relation to increased player participation in long-lasting pervasive learning games.

This paper has described the model, the challenges, and how to use variables common in all long-lasting pervasive games to construct mathematical formulas for calculating TLSBTF scores in run-time. As a result, we have a dynamic model that can be explored in further research and development of the TLSBTF method, as well as research on the effect of the individual parameters on player participation.

The contribution of the authors of this paper:

- Trygve Pløhn – Designed and developed the static version of the artifact *The-Last-Shall-Be-The-First-Bonus-System.* Refined and developed this artefact into a dynamic system using mathematical formulas which makes it easier to integrate the artefact into similar types of games. Wrote the major parts of the paper presenting this work.
- Kjærand Iversen - Participated in redesigning and developing the artifact *The-Last-Shall-Be-The-First-Bonus-System* from a static into a dynamic system. Assisted in writing the paper.
- Trond Aalberg – Assisted in writing the paper.

7.7. Results Summarized

RQ1: What are the effects and challenges in using pervasive learning games to engage and motivate students outside the classroom?

This question was addressed in particular with the development and evaluation of the artifacts *Nuclear Mayhem* and *HiNTHunt*, and is answered in various ways in all published papers.

We found that the use of pervasive games may have a positive effect on where and when students engage in learning activates. Both *Nuclear Mayhem* and *HiNTHunt* proved that pervasive gaming has the potential to make learning pervasive and expand the area for learning into the student's everyday life and enable learning to be anytime and anywhere. The case study of data from freeFromNicotine showed similar results.

One major challenge identified was that not all students have the same interest or motivation to participate in the game. This was expected but one significant result from the experiments with the artifacts *Nuclear Mayhem* and *HiNTHunt* was the strategy of dividing students into one of two categories; active players and passive players. Passive players are those that were negative or less interested in participating in the game and thus needed other types of motivation for participation. Active players are those that were self-driven and motivated by playing the game and doing well in the competition. This group had a very high level of participation in the, and the use of gaming was successful in supporting these students achieve the defined learning outcome.

The experience with these different types of players led to the development of a strategy for pervasive gaming where active players are used to motivate passive players and thus increase the player engagement in the passive group. This strategy was explored and tested in later iterations of *HiNTHunt* and proved to be efficient. The artifact, *The-Last-Shall-Be-The-First-Bonus-System*, was designed, developed and implemented into *HiNTHunt* specifically for this purpose. The introduction of this strategy led to increased player engagement. Passive players that were targeted became more motivated and more engaged in the ordinary gameplay transferring many of them into active players.

RQ2: How can storytelling and the use of real-life and real-life events in the narrative design contribute to player engagement in Pervasive Games?

This research question is addressed in P2, P3, P4 and P5. The designed artifacts *Nuclear Mayhem, HiNTHunt, Dynamic Pervasive Storytelling, The Principle of Core Assignments* and *Individual assignments* have provided insights to this question.

Nuclear Mayhem used real-life events to construct an overall game story with events that were featured in newspapers and TV while the game was in progress. This proved to be a valuable technique to increase player engagement.

All players that completed the game passed the exam, and interviewees concluded with as positive learning benefit from participating in the game but also pointed out a need for a tighter connection between the game and the course as well as adapting academic

challenges to the individual players' academic level. This can be done for instance by implementing the principle of core assignments and individual assignments that was explored in the study of *freeFromNicotine.com* to ensure that all players could participate in the overall competition on equal terms while still have a unique tailored personal course program to follow.

In a story-driven game like Nuclear Mayhem, where real-life events occurring while the game is in progress are to become a part of the game story and the game plot, a main challenge is to design an overall game story where real-life events suitable for the game is likely to occur during the playtime. In *Nuclear Mayhem*, this was done by the game master continuously monitoring the news feed to identify events to be used in the game and then manually implementing them in the game story. This was very labour intensive. In future implementations of similar types of games, it would be an advantage if an automatic method was developed to monitor the news and generate a game history following the principles of *Dynamic Pervasive Storytelling*, perhaps with the help of artificial intelligence, of which we have recently seen examples of use in various other contexts such as e.g. ChatGPT[37].

Experiences with *HiNTHunt* showed that having a story as framework for the game activity led to players engaging earlier in the game.

The case study of *freeFromNicotine.com* proved that tasks and assignments from real life and the real world outside that game, that cannot be automatically detected by the game as completed or uncompleted, facilitated the use of real-life events which otherwise would not be possible to implement in the game and game story.

RQ3: How can social gameplay support and increase player engagement in pervasive learning games?

This research question is addressed in P1, P3, P5 and P6. The design, development, and evaluation of the artifacts *HiNTHunt*, *The-Last-Shall-Be-The-First Dynamic Bonus System* and *Intergroup Competition* has helped to shed light on this issue and answer the research question.

The first iteration of *HiNTHunt* inspired the definition of different types of players which led to the design of methods to increase player engagement among passive players. In the second iteration of *HiNTHunt*, social gameplay with *Intergroup Competition* was introduced and proved effective in engaging players to participate. Unfortunately, this also introduced some unintended and negative effects since members of the leading group did not want to engage players from the other group to avoid giving them game points.

The-Last-Shall-Be-The-First Bonus System (TLSBTFBS) introduced in the second iteration of *HiNTHunt* was designed to motivate active players to engage passive players in the game. The targeted passive players received a special bonus that – given

[37] https://chat.openai.com/

that they from this point on actively participate in the game – gave them the opportunity to get ahead and even win the game. The strategy proved successful and gave a positive impact on player participation by transforming passive players into active players.

One challenge with our use of TLSBTFBS was that players were new students who did not know each other by the name which was used in the game. Hence it was difficult for the active players to identify targeted players. One solution for future iterations of *HiNTHunt* could be to identify players with name and personal picture.

Another minor issue with TLSBTFBS is that it may open for an unintended strategy for winning the game. For instance, a player may choose to actively remain in the passive group and only towards the very end of the game engage in ordinary game play after being targeted. The second iteration of TLSBTFBS addressed this by adding a dynamic method to award game points to passive players making the previous winning strategy impossible. However, the second iterations named *The-Last-Shall-Be-The-First Dynamic Bonus System*, needs to be further tested to measure its effect on player participation and how it is exploited by players.

7.8. Ethics

The purpose of research ethics is to promote free, reliable, and responsible research. Research ethics contributes to fostering good scientific practice[38]. Good ethical behaviour protects communities and individuals.

The General Data Protection Regulation (GDPR) is the toughest privacy and security law in the world[39]. It was published by the European Union (EU) and put into effect on May 25, 2018. GDPR regulates how organizations can use, process and store personal data when they target or collect data related to people in the EU.

All the experiments and collections of data used in this research project were conducted before GDPR was introduced and made part of Norwegian legislation through the Personal Data Act on 20th of July 2018[40], hence GDPR is not directly used as a guideline in this research. Instead, data collection was carried out in accordance with the regulations and guidelines of The Norwegian National Research Ethics Committees (NREC)[41].

> *"The role of the Norwegian National Research Ethics Committees is to promote high-quality, ethical research, and to use preventive measures and*

[38] https://www.forskningsetikk.no/globalassets/dokumenter/4-publikasjoner-som-pdf/guidelines-for-research-ethics-in-the-social-sciences-and-the-humanities.pdf
[39] https://gdpr.eu/
[40] https://lovdata.no/dokument/NLE/lov/2018-06-15-38
[41] https://www.forskningsetikk.no/en/

investigations to help ensure that research in both the public and private sectors adheres to generally accepted ethical norms."[42]

The ethical aspect of the research presented in this thesis can and should be discussed from multiple perspectives:

The anonymity and privacy of the participants

Three different artifacts have been the basis for experiments and data collection; *Nuclear Mayhem, HiNTHunt* and *freeFromNicotine.com*.

freeFromNicotine.com was a commercial gamified web-based smokers' cessation program. Users accepted the monitoring of activities in the program and the reviewing of anonymized log files. No data that could identify the user, such as e-mail, name, place of residence etc., was stored in the log files. After completing research and analysis of the log files, all data was deleted.

Nuclear Mayhem and *HiNTHunt* are two pervasive games where the participants were students at the North University. Due to the nature of the games (high score list, finding and collaborating with other players etc.) the participants were not anonymous. In both games, the participants were informed in advance that data from the games would be used as a basis for research, but all data would be anonymised before publication.

Participation in *HiNTHunt* was voluntary while participation in *Nuclear Mayhem* was mandatory. *Nuclear Mayhem* was integrated into the curriculum and participation in the game replaced compulsory exercises (which would have been the alternative). Compulsory exercises are not anonymous and are mandatory to complete in order to be allowed to take the exam; hence the same rules were applied for participation in *Nuclear Mayhem*. However, the students were informed that the exam grade did not depend on the performance in the game. The only requirement was that they needed to complete each level and progressed to the next within a certain time (corresponding to what would have been the deadline for submitting compulsory exercises).

Interviews with selected players were conducted after exam to make sure that students would feel freer to express attitudes towards the game. All interviews were voluntary and informed that data would be anonymised in the publication and deleted when the research project ended.

In both projects, both *HiNTHunt* and *Nuclear Mayhem*, a voluntary web-based survey was conducted after the games were finished. These were not anonymous as data from the survey had to be linked to log data from the game for the analysis of players' attitudes towards the games, motivation, participation etc. Participants who responded to the questionnaire were informed that all data would be anonymized before publication and deleted when the research project ended.

[42] https://www.regjeringen.no/en/dep/kd/organisation/kunnskapsdepartementets-etater-og-virksomheter/Subordinate-agencies-2/forskingsetiske-komiteane/id733378/

All log files, data from surveys etc. from *freeFromNicotine.com, HiNTHunt* and *Nuclear Mayhem* have been processed and deleted as agreed.

Moral issues related to using real events as part of a game

The use of stories from real life, where real people have been killed or injured[43], 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 did any objections. The following quotes published in paper P2, illustrates the participants attitude towards the use of real events in the game story.

> *"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."*
>
> *"It was good. It made it the more exciting ..."*
>
> *"The story itself was well supported, it was well made, and the details were good. It was exciting, it was. It increased the atmosphere of the game."*
>
> *"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."*

All the students who were interviewed were positive to the use of real events in the game, even those who do not like this type of game or were negatively 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 fact that no one reacted to the fact that serious and tragic events had been used as part of the game 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 alienate 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 and more abusive and offending. This is an issue one should be aware of when using real life events to design a game story.

[43] AFP. 2010. Iran nuclear scientist killed in bomb blast [Online]. YouTube. Available: http://www.youtube.com/watch?v=topDudOCaqs [Accessed August 2010].

Ethics of Gamification in Education

An issue mentioned in the research community when it comes to gamification in education, beyond what is mentioned previous, is that the introduction of gamification and competition can lead to less successful learning experiences [167].

The students/players may prioritize the competition (individual or team-based) to try to top the leaderboard and/or get in-game rewards, and this could damage the overall goals, e.g. learning [168]. Intense competition among the students could also result in less collaboration. Furthermore, group competition can cause students to feel pressured to do things they don't want to do. When games and competition are used in education there is also a risk that the division between “good” and “bad” students will be emphasized and result in increased inequality between the students [169].

The game story in a learning game could also favour the majority of the players, ignoring the (gender or ethnic) minorities’ interests or values [169]. In *Nuclear Mayhem* this could have been an issue if one (or more) of the students were from Iran or had family or other connections to Iran since the game's story portrayed Iran as "the bad guys".

The players of *Nuclear Mayhem* and *HiNTHunt* had to conduct game-related activities in the real world. None of these activities broke Norwegian legislation, or what is considered normal decency or behaviour, hence the players did not have to, as part of the games, perform actions that were illegal or that violated the moral attitudes.

Students are not a homogenous group when it comes to personal characteristics and preferences. While some students respond well to a challenge, others may be discouraged. Teachers should consider how it may affect all the students in a class if they plan to include games and gamification as a learning tool [167]. As demonstrated in this research, games and gamification also needs to include strategies and methods to compensate and adapt for students with different attitudes.

8 Implications

"I've always been motivated to innovate where the implications are significant."
- Blythe Masters

As a part of the research project, several new artifacts have been developed to provide answers to the research questions and then evaluated to learn their effects. The research presented in this thesis has led to increased knowledge on how to design and implement features to increase player participation in long-lasting Pervasive Games. This chapter discusses the implication of the artifacts and lessons learned.

Dynamic Pervasive Storytelling (DPS) can be used as a means to create an engaging, dynamic narrative using real-life events, to motivate players to engage in the game, and to provide awareness features to support and maintain "in-game awareness". In-game awareness preserves the players "feeling" of being in a game while not actively participating in any specifically related game activities. In-game awareness is an essential feature in long-lasting Pervasive Games where there can be long periods without game-related actions. DPS has also highlighted the importance of implementing awareness features in these types of games. Like Computer Supported Cooperative Work (CSCW), Pervasive Games are dependent on many different types of awareness information to best succeed. DPS was used as the design principle in the artifact *Nuclear Mayhem* (NM), and there demonstrated that we succeeded in selecting a suitable media event/news story to be used in the DPS approach to creating a game story with the properties required.

The-Last-Shall-Be-The-First Dynamic Bonus System (TLSBTF) has shown effectiveness to re-engage players who have intrinsic motivation to assert themselves in competitions and can be implemented and used in most, if not all, types of long-lasting pervasive games. As a result of the research presented in this thesis, we have a dynamic model that can be explored in further research and development of the TLSBTF method, as well as research on the effect of the individual parameters on player participation. Scoring functions based on this model are easy to implement and can be developed further in other long-lasting pervasive games.

The principle of core assignments and individual assignments that was identified as a design method in the case study of *freeFromNicotine* (FFN) was a successful and valid strategy for generating individually tailored game sequences while at the same time ensuring fair competition between the individual participants. The case study also revealed that users are honest when they mark assignments as completed and that cheating was not applied as a strategy to gain game points. The possibility to rely on users registering correct information makes it easier to include everyday tasks in learning games. The design principles used in FFN can easily be adapted and

implemented in other types of learning games where there is a need to provide individually tailored courses while using gamification and competition as a motivational element.

Inter-Group-Competition is social gameplay that has shown effectiveness in engaging players to participate in pervasive learning games. Our approach to this - implemented, demonstrated, and tested in the artifact *HiNTHunt* - can easily be adapted and further developed/refined in other types of pervasive games.

The artifact *HiNTHunt*, the prototype of the pervasive treasure hunt game designed to help new students get the best possible start to their new student life and get started with their studies is both a research platform and a game project. The game part of the artifact is available for use, and after the research project was finalized, the game has been run several times on the students' initiative. In these runs, conducted by the second and third year students, the intention was not to conduct further research but to use the artifact only as a game to help new students get a good start at their student life. The game part of the artifact was also run at the 9th European Conference on Games Based Learning, which was hosted by the Nord-Trøndelag University College (HiNT), as a means for the participating researchers to socialise and get to know the Campus. Even if no further research was conducted at this run of the game, this gave the participating researchers, who are all interested in the research field of game-based learning, a direct experience of participating in this type of pervasive learning game, which they may be able to benefit from or adapt, into their research. The research part of the artifact has given new knowledge on how to engage players in long-lasting pervasive games. We have learned that a suitable (relatable) and fun game story causes players to engage earlier in the game. We have identified two types of players, *Active Players*, and *Passive Players*, and different methods to engage these groups in the game. For instance, the artifact TLSBTF was explicitly designed and implemented into *HiNTHunt* to get *Active Players* to interact with *Passive Players*. After the research presented in this dissertation was completed, the research idea behind *HiNTHunt* was taken further by other researchers as a part of Centre for Excellent IT Education (ExcIted), which in 2018 published the paper, *NordHunt – gamification for a smooth start of university life*, at the EdMedia + Innovate Learning international conference in Amsterdam, Netherlands [158], presenting further research work on the HiNTHunt/NordHunt project. All source code and information about the game and the research platform *HiNTHunt* belong to Nord University and will be made available on request.

The design principles used in *freeFromNicotine.com* (FFN) that facilitates a highly reusable design core and individual assignments which enables both tailored courses for each user and competition on equal terms between the users can easily be adapted and implemented in other types of learning games where there is a need to provide individually tailored courses while using gamification and fair competition as a motivational element. Lessons learned in FFN have also taught us how to use a gamification approach were "not automatically detected" everyday activities are included in the game as assignments. Analyses of user data in FFN indicate that users are honest when they mark assignments as completed and that cheating is not applied as a strategy to gain game points. The possibility to rely on users registering correct information makes it easier to include everyday tasks and real-life events as a competition element in pervasive learning games.

The prototype of the experimental pervasive learning game *Nuclear Mayhem* (NM) has shown that this type of game has the potential to expand the learning space towards being pervasive and facilitate pervasive learning. In the run of the nine-week-long experimental game NM, we demonstrated how to implement and use real-life events, as they occurred, in the DPS design approach as narrative building blocks to support in-game awareness and create an engaging game story. Even though the pedagogical and learning aspect of NM was not the main focus of the research project, NM still demonstrates that pervasive games used in a learning content have the potential to make the learning process pervasive, to be something that happens at any time anywhere and is not only confined within the classroom walls. Participants in NM reported that they believe they gained a learning benefit from participating in the game. Furthermore, 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). NM provides a promising start to learn more on how to implement learning in pervasive games and how to use these types of games as a learning tool.

In total, all the artifacts that were developed, designed, tested, and further improved in this research project have all provided new insight on the overall topic of this thesis;

to investigate how to motivate and ensure player participation and player activity in pervasive learning games.

We have done this by addressing the three research questions and, at the design level, looking specifically at how game design, storytelling, awareness, game mechanics, and gameplay can be used to increase player engagement in long-lasting pervasive learning games.

9 Concluding Remarks

"There is no real ending. It's just the place where you stop the story."
- Frank Herbert

The research presented in this thesis was conducted at Nord University and examined different methods and techniques used in long-lasting Pervasive Learning games to increase player engagement. If players do not participate in learning games, it will be challenging to get the learning benefits that the game is designed to provide; hence it is essential to enhance knowledge on how to get players to be as active as possible in this type of game.

Several artifacts were developed to answer the research questions: what are the effects and challenges in using pervasive learning games to engage and motivate students outside the classroom, how can storytelling and the use of real-life and real-life events in the narrative design contribute to player engagement in Pervasive Games and how can social game play support and increase player engagement in pervasive learning games? All the research questions were designed to investigate how to motivate and ensure player participation and player activity in long lasting pervasive learning games.

The research was conducted on three primary artifacts; two Pervasive Learning game prototypes designed and developed specifically for this project, *HiNTHunt* and *Nuclear Mayhem*, and a case study of *freeFromNicotine.com*, a commercial web-based smokers' cessation program designed as a 50 day long real-time pervasive learning game.

We found that the artifacts and methods we developed and tested provided valuable learning and insights in how to motivate players to participate in long lasting learning games. All the artifacts designed during this research project helped to increase player participation in the games where they were applied.

The lessons learned and artifacts developed in this research project are not limited to the three primary artifacts used as the research platform but can be implemented and used in all types of similar long-lasting pervasive games to increase player engagement.

The artifacts and knowledge produced in this research project provide a solid foundation to progress this research field even further.

9.1. Limitations

The focus of the research presented in this thesis was not the learning aspect. Yet *Nuclear Mayhem¸ HiNTHunt* and *freeFromNicotine.com* have still provided insight into using pervasive games as a learning tool. We have learned that these games have a potential within Game-Based Learning to "tear down the walls of the classroom" and make learning pervasive, to be something that is not only a classroom activity but also something that happens anywhere, all places at any time. However, a lot of research is required to learn how to make the best possible pedagogical use of pervasive games for learning purposes so that the desired learning goals are achieved.

A Design Science research method was applied to investigate how storytelling, real-life locations, real-life events, awareness enhancing, social game play, as well as other types of game play and game design, can be implemented in long lasting learning games to motivate and improve player participation.

It is of course normal to have more iterations and testing of the various artifacts in the Design Science method than what has been conducted in this project. This must be seen in the light of the framework under which the doctoral work has been carried out. I would like to mention that, despite the narrow framework, I have managed to carry out up to three iterations of some of the artifacts, which should be sufficient for a doctoral thesis (although ideally it should be much more extensive). It is also worth noting that this project has focused on design for motivation and participation. In the research, emphasis has been placed on experimental testing of methods and techniques, but the design process itself has not been a central theme.

In the user studies I have used both qualitative and quantitative methods. The test group regarding the research platform *Nuclear Mayhem* were 2nd year students at Bachelor Studies in Multimedia and Web-game technology at Nord-Trøndelag University College. Based on the responses in the questionnaire five people were chosen for in-depth interviews to learn more about the respondents' general attitude towards games and *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 questions about what they perceived as good or bad during the game. There were too few participants in the survey to provide statistically significant results. Even though the answers provide an indication of the players' attitudes and opinions, there is no doubt that the research would have benefited from a larger user group.

Regarding *HiNTHunt*, and the two experimental runs of the game, there were a total of 94 students that played the games and 79 of them answered the questionnaire. This provides a much larger test group than the *Nuclear Mayhem* experiment and a much better foundation for the survey to provide statistically significant results. However, also this research would have benefited from a larger user group.

In this context, it is important to mention that the research presented in this thesis is based on experimental development and the number of respondents is not as important as if I were to conduct a user-oriented study.

9.2. Future work

In computer-supported cooperative work (CSCW), awareness is regarded as a critical element of any collaborative work. Therefore, a lot of research has been done on how different types of awareness can support CSCW. The artifact *Dynamic Pervasive Storytelling* (DPS) has shown that pervasive games also will benefit from increased knowledge and research on awareness in pervasive games (in-game-awareness), and the work that has been done on DPS provides a starting point for further work in this field of research. The DPS approach also seemed successful in incorporating the academic tasks in the game in such a manner that the players felt that the academic assignments were a natural and integrated part of the game; however, future versions of DPS should address how to design good learning tasks that are tailored to the individual players' knowledge level.

Nuclear Mayhem (NM) has shown that pervasive games can expand the learning space towards being pervasive and facilitate pervasive learning. Still, to better evaluate the educational benefits of participation in the game, there is a need to develop a model to measure the educational 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. Given the low budget of NM and technological limitations, a discussion should take place as to the potential impact of advanced technologies (i.e., Artificial Intelligence, Gaming technologies) on the overall user experience. The emerging domain of DPS for education is, as of today, confined to ad hoc and low technology designs but would undoubtedly benefit from research in synthetic agent actors and advanced digital interactive storytelling systems. In this context, synthetic agents could effectively play autonomous roles within the storyline's remit and choose to communicate on their own accord with participants, thus facilitating the concept of in-game awareness that we have identified as an essential feature in long-lasting pervasive games. Such technologies are already available and could be effectively deployed within the context of this work.

The primary strategy of the DPS approach is to use real-life events that are featured in the news media as building blocks to design the overall game story, to create in-game awareness, and increase the pervasiveness of the game. There is a need to develop a method to analyse the current media scene to identify elements and events suitable for use in the DPS approach.

We have identified some problems when using *inter-group-competition* and *The-Last-Shall-Be-The-First Dynamic Bonus System* (TLSBTF) simultaneously in a long-lasting pervasive game and have suggested some solutions, but this area needs further work, especially on how to implement TLSBTF and generate the bonus list without causing the group competition to have a negative effect on TLSBTF or the opposite. These problems need to be addressed in future research and development of the TLSBTF method.

freeFromNicotine.com (FFN) taught us how to provide individual and differentiated learning tasks and assignments while still facilitate fair competition between the various participants. Being a pervasive game that lasted for 50 days, FFN could have provided facilities for supporting in-game awareness, which has proven to be an essential

property to increase player participation in pervasive games. Furthermore, FFN was conducted without a game story. Research has shown that the use of a game story may help to increase both player participation and player motivation, and designing and applying a suitable game story to FFN may have helped to motivate the users. In FFN, we learned how to incorporate “not automatically detected tasks” in the gameplay. However, there is a need to conduct further research on how best to include manual tasks where the game system/engine cannot automatically detect the status of the task as a part of the gameplay in long-lasting pervasive games

10 References

"Everything I do references something that influenced me."
- Virgil Abloh

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Paper Collection

Paper I

HiNTHunt – a Pervasive Game to Support and Encourage Desired Activities for New Students

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Abstract. Gameplay has proven to be a useful tool in many types of training and learning situations. This paper presents the game *HiNTHunt*, an experimental pervasive game designed to encourage students to socialize and learn the basics about the campus when they arrive as new students at a university. Our analysis of the game usage and gameplay experience shows that this approach for motivating students to perform specific activities is well accepted, but we have also identified some challenges that must be considered in the development of such games.

Keywords: serious games, pervasive gaming, learning, training

1 Introduction

At the start of the academic year, all new students attending a university must familiarize themselves with the study program, the schedule, the campus and many other aspects related to their new life as student. Furthermore, it is important that students socialize and get to know their fellow students. Most (if not all) universities and university colleges conduct different types of activities at the beginning of the academic year to achieve this, but a main challenge with ordinary training such as plenary meetings, is that the learning outcome often is poor. Gameplay has proven to be a useful tool in many types of training and learning situations [2] and can potentially be used in this scenario as well.

This paper presents a pervasive game designed to encourage new students perform various desired activities during the first week of their study. The game is characterized as pervasive because it influences the ordinary life of the player [1]. It is entitled HiNTHunt because it was conducted at the Nord-Trøndelag University College (HiNT) and is a treasure hunt game where players discover diamonds on other players, on various locations on the campus or during events. The general nature of the gameplay means that it easily can be adapted to different types of activities. Our first experimental run of the game was during the first week of the academic year 2012 and the game was adapted to the following objectives:

- help the player become acquainted with fellow students
- help the player become familiar with the campus
- help the player become familiar in the city where the campus is located
- help the player get an overview of the academic staff

In addition, player enjoyment is perhaps the most important issue in successful game design [2] and accordingly we included the following requirement:

- the players shall experience the game as a fun game to play

The overall objective of the experiment was to learn whether this type of pervasive game is suited as a tool to fulfill these objectives and to identify problems and challenges in conducting this type of game.

2 Related work

Games are played all over the world and have evolved and changed along with the evolution of mankind. In modern time games has proven to be useful to support teaching and learning [3] and research has shown that gameplay in education can improve skills in many different areas. Pervasive games are a specific type of games that potentially can be very useful for training purposes. They are staged in reality and their main attractiveness is the use of reality as a resource in the game [4].

The definition of the term *pervasive game* is not unambiguous. Some researchers use a technological approach [5] and others use the physical space [6] or the contractual magic circle of play [1] as the basis for the definition. This paper uses a technology independent view and defines a pervasive game as *"a game that is pervasive according to the player's everyday life"*. This means that pervasive gaming is not limited to the contractual space of the traditional magic circle of gameplay, but participating in a pervasive game influences the player's ordinary life directly [1].

Related research in this area includes *"The search for the professor"* which was used to introduce social web technologies and support team building in a university course [7]. This game showed promise as a tool to get new students actively involved in exploring social media tools. Another example is *Nuclear Mayhem* which is a pervasive game designed to support learning in higher education by providing a gameplay that expands the area of learning to the player's everyday life [7]. The game supports this transformation, but there is a need to better evaluate the learning benefits for player participation in this type of game. Additionally, there has been done some research towards understanding player enjoyment in pervasive gaming [2] by evaluating the GameFlow model [8] in relation to pervasive games. This research concludes that the GameFlow model is promising and appropriate in gaining understanding of player enjoyment in pervasive game and outlines the Pervasive GameFlow model. The suggested pervasive game flow model has later been validated resulting in an adjusted model that can be used as both a heuristic guideline for designers and as evaluation criteria in user-centered evaluation of pervasive games [9].

3 HiNTHunt

The pervasive game HiNTHunt is a framework for encouraging users to perform defined tasks or activities. This is implemented using diamonds on a game board where diamonds of different shape and color represents different activities that one wants the user to perform or participate in. Users must find missing diamonds and fill in their personal game board. Each diamond in the game is assigned a unique code and to "find" a particular diamond the player has to register the diamonds unique code in the client.

Each player is assigned an automatically generated personal game board when he or she registers as a player in the game (as shown in Fig. 1A). During registration the player is also given a personal diamond that can be "found" by other players in the game (Fig.1B). The personal diamond is displayed in the players' game client and must e.g. be shown to the other players when requested. Each player can only register a specific diamond once, but a specific diamond can be registered by many different players. There can only be registered one diamond on each square on the game board and it has to be a diamond of exactly the same type as shown in the square. The player gets points for every diamond that is registered on the board and additional bonus is achieved by finding specific configurations of diamonds such as a row, all diamonds along the edge of the board, or when the board is filled.

The game client is developed in HTML and adapted for use on smart phones. Players can be mobile and use either their smart phone or an ordinary web browser to play the game, according to what suits the player best. The game client is used to register diamonds when they are found and gives the player an overview of which diamonds that are found and which that are still missing, the number of points the player has gained and a high score list showing the ranking of the best players. To do well in the competition the player must find as many of the diamonds on the game board as possible (naturally), but it is also important to be first since the bonus points are weighted so that the first player that obtains a full row, frame or picture will get the most points, the second one somewhat less and so on. If more than one player has the same score, the player that first achieved the score wins the game.

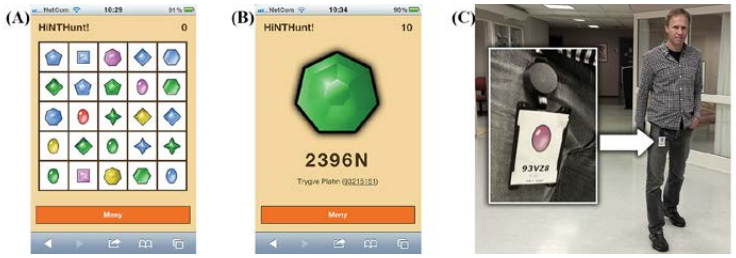

Fig. 1. (A) The game board in HiNTHunt – (B) Each player is assigned a unique green personal diamond – (C) All the lecturers is assigned a personal unique purple diamond

Our experiment with the game was conducted during the first week of the academic year 2012. Diamonds were "hidden" in activities and locations that students had to discover, or in activities they had to perform or conduct in relation to the defined objectives of the game. All the lecturers were assigned a unique diamond which was attached physically to their personal ID-card and carried in visible way as shown in Fig. 1C. Diamonds could be found at the following locations or activities:

- Green diamonds could be found on the other students
- Red diamonds were hidden in various locations in Steinkjer town
- Blue diamonds could be found by participating in the various social programs and activities during the first week
- Purple diamonds were hidden among the lecturers and professor

Yellow diamonds were hidden on campus or in the IT systems at HiNT In conjunction with other information given on the first day of the academic year, the students were given a brief introduction to the game, how to register as a player, about the prizes they could win if they are among the top players and they were encouraged to register and participate in the game. The game ended with an award ceremony where the top three players were rewarded

4 Evaluation

Participants in the game were the first year students on the Bachelor's Degree Program for Multimedia Technology and the Bachelor's Degree Program for Games and Experience Technology. Two methods were used to gather data:

- a questionnaire
- analysis of system logs of user activities

The game was played during a nine day period and all interactions with the game client were logged. To finish the game, each player had to complete a questionnaire with both open-ended and multiple-choice questions. A total of 61 students were invited to play the game. 53 of the invited students registered as a player and 38 of the registered players answered the final questionnaire (28 men and 10 women). This gives a response rate of 71.3%. All the students were full-time students and 71.1% had no previous experience in pervasive gaming.

In the statistical analyze the players were divided into two groups according to their participation in the game. *Passive players* consist of the players who did not participate or participated very little in the game (less than 100 game points) whereas *Active players* consist of the players who were active (100 game points or more). The overall evaluation shows that the majority of the *Active players* found participating in the game to be helpful in terms of the defined objectives and it can therefore be concluded that the game has met these goals. However, the experiment also showed that many students chose not to participate or to participate very little in the game.

In the questionnaire all of the players were asked to provide three adjectives that they think describe the game. These responses were used to generate the tag cloud

shown in Fig. 2 below. Furthermore, textual analysis of the responses shows that a total of 29 respondents were positive, 5 respondents were neutral and only 4 respondents were negative. This indicates that a majority of the players (including the *Passive players*) had a positive attitude towards the game.

Fig. 2. Tag cloud describing the game generated from adjectives given by respondents

Results also show that 100% of the *Active players* indicate that they think HiNTHunt was a fun game and that only 27,5% of the *Passive players* did not think the game was fun (82,5% of the *Passive players* were either neutral or positive). Analysis of the responses to the questionnaire has identified some of the reasons why students chose not to participate actively in the game:

1. They did not understand the game
2. They did not get enough information about the game
3. They got a bad start and lost their motivation when they got too far behind the other players in the competition
4. They had "old" mobile phones without Internet connection
5. They prioritized other activities

Reason one, two and three can be addressed by providing more and better information about the game. Reason three can be addressed by providing a game play that gives "slow starters" an opportunity to catch up with the other players. Reason four is not that easy to address, but the trend is towards that more and more people own and uses smart phones and is a problem that is becoming less and less relevant. Reason five can be that the students did not think that participation in the game was important. A total of 89.5% of all the players state that they consider themselves to be motivated students who will do their best to complete their studies in the best possible manner. This means that there may be much to gain when it comes to motivating the students to participate in the game by "selling" participation in the game as something that is important, useful and highly recommended in order for them to get the best possible start on their studies. This topic was not mentioned at all in the information that was given to the students when the game started, and can easily be addressed in the next version of the game.

5 Conclusion

This paper has presented the concept and the prototype of the pervasive treasure hunt game HiNTHunt that is designed to help new students to get the best possible start to their new student life and get started with their studies. This was manifested into five specific objectives that game should support.

The results show that the game has been very successful in terms of satisfying the defined goals for those players that actively participated in the game, but it is a challenge that many students choose not to participate in the game even if they are positive to the game. The active players think the game was fun to play and that the game helped them to get to know their fellow students, to get an overview of the academic staff and to become familiar on Campus and in Steinkjer City.

The game shows to be a promising tool to help new students, but too many students choose not to participate and this is the main challenge that must be addressed in the next version of the game.

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Paper II

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 where 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

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.

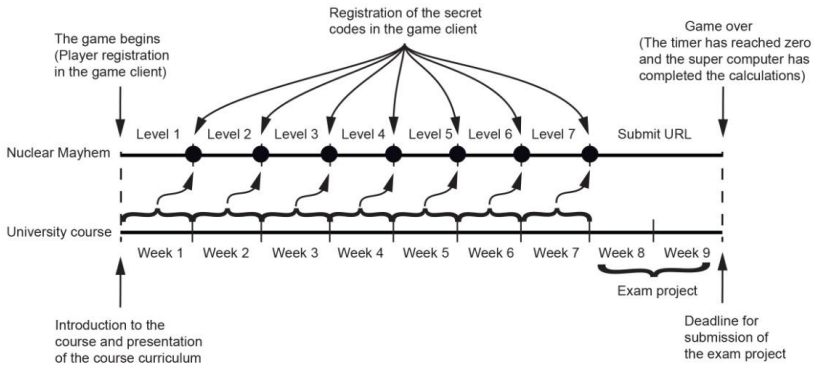

Figure 3: The alignment between the curriculum of the course and the pervasive game Nuclear Mayhem

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.

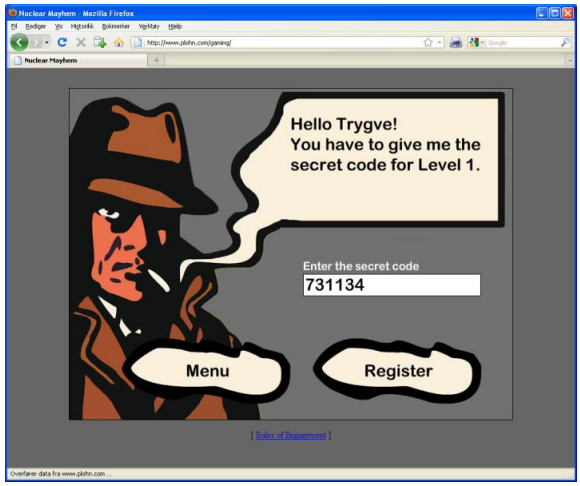

Figure 4: Each plot ends with a secret code that has to be registered in the web-client

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 Mayhems* 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).

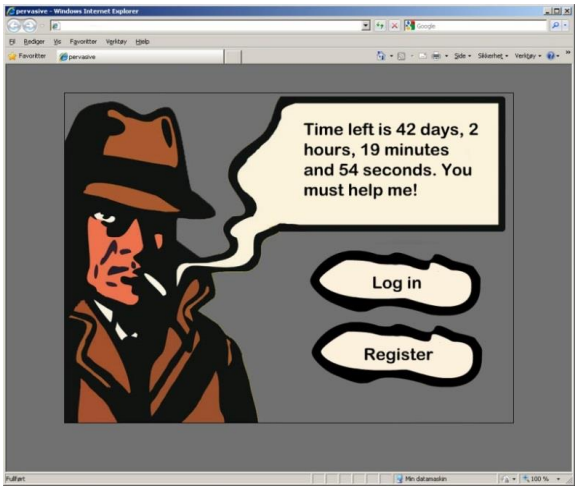

Figure 5: The game client shows the countdown towards the deadline for both the game and the course

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 where 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).

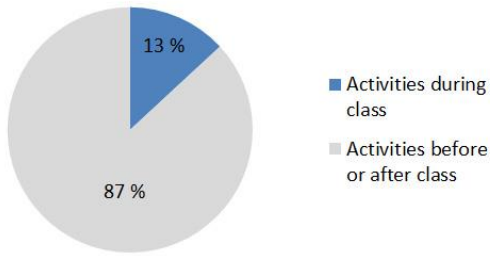

Figure 6: The percentage distribution of logins in the game client within and outside of the time period allocated to lectures in the course

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.

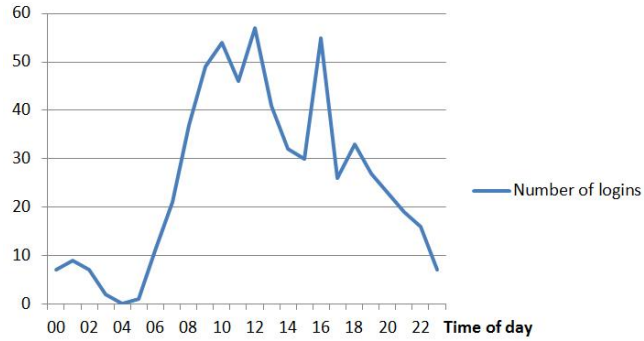

Figure 7: Number of logins in the game client during day and night time

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.

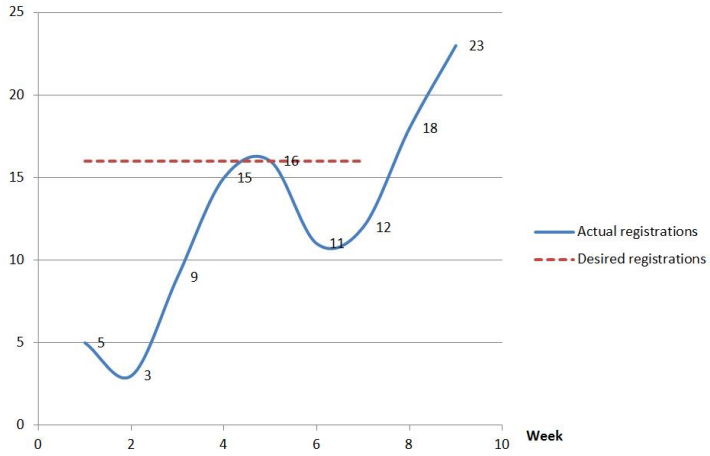

Figure 8: Registration of the seven secret codes (level codes) in the game client

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 marked - 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

It makes it all the more realistic ... or more real ... *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.* *- Subject A*
It was a good plot, there was a lot of work put in it. *It was good. It made it the more exciting ...* *- Subject B*
The story itself was well supported, it was well made, and the details were good. *It was exciting, it was. It increased the atmosphere of the game.* *- Subject C*
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. *- Subject D*
... story was perhaps a little too serious ... and then it might be a bit difficult to take it seriously *… I think it might be good ... then it becomes a little more realistic ...* *- 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 think it was awesome *I liked it a lot* *... I thought it was fun.* *- Subject A*
I don't like this type of games. *... I have never had a taste for RPG games, and maybe this game it's more like an RPG.* *... It was very well made, but it was not for me.* *- Subject B*
... when you entered the code in the game client ...that was very exciting. It really was the highlight. That was fun. *- Subject C*
... it was exciting to enter the code ... I knew it was correct but it was still ... hehe *... I would recommend next year students to participate in the game.* *- Subject D*
... my biggest motivation was to win the game. *- 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

... the academic assignments were too easy *... I knew that the assignments were taken directly from the textbook* *- Subject A*

... to solve the problems in the game I used the textbook to compare the programming code and I learned something by doing this *... I did not understand until later that the game levels were following the lectures.* *... 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.* *- 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 programmingfiles 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 easyer 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 apperars to be dependent on their level of expertice. 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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Paper III

Increasing Player Participation in Pervasive Educational Games

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Abstract: In recent years, games have gained much attention in education and it is widely recognized that Game Based Learning can help engage students to learn. Educational gameplay with various levels of "forced participation" works well in the classroom where games are played for a limited time period under the supervision of a teacher. Participation in educational games played outside of the classroom, on the other hand, is less predictable or reliable. This is particularly a problem for pervasive games, where most of the gameplay takes place outside of the classroom in the player's leisure time. Pervasive games have shown potential within GBL, but experience has shown that active participation is a major challenge. Even if the players have a positive attitude towards the game and experience the game as a fun and exciting to play, it is still difficult to motivate students to participate sufficiently to reach the defined learning outcomes. For Game Based Learning to take the step out of the classroom and into the players' everyday life, making learning pervasive, it is important to understand the gaming elements and features that motivate the players to engage in the game play and consequently the learning process. This paper presents the results of the experimental pervasive game HiNTHunt2013 which extends a previous version of the same game with specific features intended to increase player participation. The extended features can easily be adapted and integrated into other types of games used in Game Based Learning. The aim of the experiments documented in this paper is to explore and evaluate different types of motivational features in game play and the effect these features have on player participation. The results presented in this paper show that the extensions introduced in order to increase player participation had a positive impact. These findings will contribute to the understanding of how to motivate player participation in pervasive games.

Keywords: Player participation, Game Based Learning, Pervasive Gaming, Game development

1. Introduction

It is widely recognized that Game Based Learning (GBL) can help to engage students to learn and many different types of games and game genres have been used within GBL. Experiments conducted with Pervasive Games (PG) have shown that the genre has potential within GBL (Pløhn 2013), (Pløhn and Aalberg 2013), but that – even if the players perceive the games as fun games – too many students choose not to participate, or participate very little in the game, and these students don't achieve the learning goals of the game.

PG is a gaming genre which extend the gaming experience out into the real world (Benford, Magerkurth et al. 2005). Researchers have approached the genre from different perspectives which led to multiple definitions of the term *pervasive game* (Nieuwdorp 2007). This paper follows a technologically independent definition:

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

Most of the activity in PG used in GBL is in the students' leisure time hence PG needs other types of motivators for player participation than "classroom games" where player participation are being supervised by a teacher.

HiNTHunt is a PG that is designed to encourage new students to perform various desired activities during the first week of their study. HiNTHunt 2013 extends a previous version of the same game with features intended to increase player participation and this paper presents the extensions and their impact on player participation.

Our paper is organized as follows. First we provide an overview of related work and provide a background on evaluating enjoyment in games. In section 3 we introduce the game and in section 4 we present the extended features that are implemented to increase player participation and their intended impact on player engagement. Section 5 provides a short description of methods and procedures and in section 6 we present the results of the experiment and discuss the impact the extensions had on player participation. Finally we conclude and suggest further work.

2. Related work

Pervasive gaming is a fairly new gaming genre and not much work has so far been done on the topics of player engagement in pervasive games. However, even if one cannot directly equate the terms *player engagement* and p*layer enjoyment*, the correlation between these two terms is strong. Players that perceive a game to be fun are more likely to participate in the game, and vice versa. If one can increase a player's experience of *fun* one will most likely also increase that player's level of engagement in that particular game. In that respect *player enjoyment* is perhaps the most important issue in successful pervasive game design.

One way of understanding enjoyment and measure player enjoyment in games can be based on the work of Mihaly Csikszentmihalyi on "optimal experience" where he revealed that what makes an experience genuinely satisfying is a state of consciousness called *flow* - a state of concentration so focused that it amounts to absolute absorption in an activity (Csikszentmihalyi 1990). During flow, people typically experience deep enjoyment, creativity, and a total involvement with life. The concept of *flow* is a well-established construct for examining experience in any setting (Cowley, Charles et al. 2008) and game researchers has used this construct as a foundation for understanding player enjoyment in games.

The pervasive gameflow model (PGF) is a model based on the *general gameflow model (Sweetser and Wyeth 2005)* with the aim of increasing the understanding of player enjoyment in pervasive games (Jegers 2007). PGF consist of eight core elements (Jegers 2009) and our game HintHunt is designed according to the core elements in the PGF model with special focus on the element of social interaction by supporting and allowing meaningful and purposeful social interaction within the gaming system and by providing a game play that motivate the players to communicate and interact socially.

Alternate Reality Games (ARG) is a sub-genre of pervasive gaming and work done by Macvean and Riedl on evaluation of enjoyment within ARG (Macvean and Riedl 2011) question the suitability of PGM due to the unique demands of these types of games. Many of the criteria in PGF do not apply to ARG and as a consequence Macvean and Riedl therefore outlined five key principles that they believed must be adapted to make an enjoyable ARG experience. The strong narrative focus in this evaluation method (three of the five principles focusing on the story and how this is to be structured throughout the game) makes this model less suited for evaluation of HiNTHunt where the story is less important. The two remaining criteria that focus on interactivity and skill level are fully adapted in HiNTHunt.

3. HiNTHunt

At the start of the academic year, all new students attending a university must familiarize themselves with the study program, the schedule, the campus and many other aspects related to their new life as students. The pervasive game HiNTHunt is a framework for encouraging new students to perform defined tasks or activities during the first week of their study. This is organized as a treasure hunt where the players have to find the diamonds they are missing on their personal game board. These diamonds are "hidden" in locations that students have to discover and in activities they have to conduct. When the game is finished, the three players with the most game points will be awarded.

HiNTHunt was first run during the start-up week of the academic year in 2012 and the main conclusion of the experiment was that the game was very successful in terms of satisfying the defined goals for those players that actively participated in the game but that too many students did not participate as much as desired (Pløhn and Aalberg 2013). In the following year (2013) the game was extended with features intended to increase player participation

4. Extended features in HiNTHunt 2013

HiNTHunt 2013 extends the previous version with three specific features intended to increase player participation:

- a game story
- intergroup competition
- a gameplay that motivates active players to interact with passive players to get them engaged in the game

4.1. Game story

HiNTHunt 2012 was conducted without a game story and the experiment with the game showed that the players were late both registering and starting playing the game. Storytelling is commonly used in games to motivate players to engage in the game. Lazzaro (Lazzaro 2004), Fullerton (Fullerton, Swain et al. 2004) and Yee (Yee 2005) have all identified storytelling as a key motivation for players in entertainment games. To motivate players to engage in the game as early as possible, HiNTHunt 2013 was extended with a game story that uses humour and irony to raise awareness and curiosity about the game among the students. In brief, the story is about how the boss of the department loves to dress up as Elvis Presley and sing old Elvis songs. To stop the boss from singing, someone has stolen all the “diamonds” from his costume and the students are given the task of finding the stolen diamonds (each student are assigned 25 diamonds to find). The game story was presented as a part of the presentation of the game, with pictures of the boss in his Elvis Presley costume (**Figure 1**A) and a video were he performs a version of “Love me tender” (Sigurðardóttir 2013). Observations conducted of the students during the presentation of the game story and the data from the questionnaire clearly indicated that the students found the story to be fun.

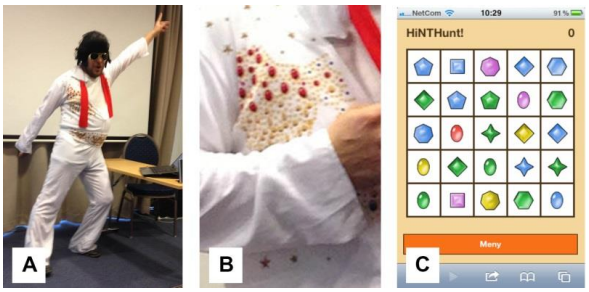

Figure 1 – (A) The boss of the department in his Elvis Presley costume. The diamonds (B) has been stolen and each student is assigned a personal game board (C) with 25 diamonds they have to find.

4.2. Intergroup competition

Work done by Bornstein, Gneezy and Nagel (Bornstein, Gneezy et al. 2002) found that intergroup competition improved collective efficiency and that intergroup competition produces significantly better results than in groups with no intergroup competition. To increase player participation HiNTHunt 2013 was extended with features that emphasize intergroup competition.

The players were divided into two groups based on which study program they belong to. Group1 consisted of the players from the first year students on the Bachelor Degree Program for Multimedia Technology (MMT) and Group2 was the players from the first year students on the Bachelor Degree Program for Games and Experience Technology (SPO). By creating an "us against them" feeling in each group by facilitating intergroup competition this would hopefully motivate the players in each group (you are not only playing for yourself but also for the group) and increase player participation. Each group received game points (group points) based on all of the group members' overall activity in the game. When HiNTHunt 2013 was presented the students were oriented about the intergroup competition, how to collect group points and how they can check their group status in the competition. They were told that the group that wins the intergroup competition will be served free pizza and soft drinks during the closing ceremony of the game, and that the losing group doesn’t get anything.

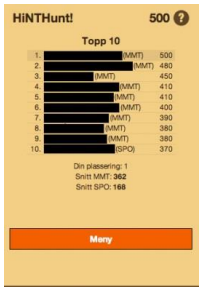

Figure 2 - The high score list from HiNTHunt 2013 showing the topp-10 players (the names have been anonymized in this screenshot due to privacy rules) and the status in the intergroup competition of Group1 (Snitt MMT) and Group2 (Snitt SPO).

4.3. The-Last-Shall-Be-The-First-Bonus-System

The purpose of this bonus system is to engage the passive players by providing a game play that motivates active players to engage the passive players and get them to perform actions in the game. The bonus system provides weighted game points giving the passive player more game points than the active player that initiated the contact. The passive player will, in this bonus system, receive enough game points to advance significantly on the result list and thereby see that they – if they continue to engage in the game – will have a reasonably chance to do well in in the game. It actually gives passive players a chance to advance from the bottom to the top of the result list given that they become engaged in the game. Hence the name of this strategy is *The-Last-Shall-Be-The-First-Bonus-System*.

The bonus system is based on an algorithm that generates a list of the 10 least engaged players at the given time (passive players). Active players can approach the players on this list and engage them in the game by making them register a unique code in their game client and both players will then receive game points but the passive player will receive significantly more bonus points than the active player To give the players' time to engage in HiNTHunt 2013, the bonus system was not enabled until the second day of the game. Hence this feature did not affect the level of activity in the game in the first 24 hours of game play.

Figure 3 – (A) The dynamic bonus list shown in the game client (the names have been anonymized due to privacy rules). (B) The active player has clicked on one of the passive players listed and reviled a five digit unique code that the passive player has to register in his/her game client. (C) The passive player is registering the code in his/her game client after being told the code by the active player.

5. Methods and procedure

HiNTHunt 2012 (HH12) and *HiNTHunt* 2013 (HH13) was conducted at the Nord-Trøndelag University College (HiNT) on Campus Steinkjer during *Startup week* 2012 and 2013. Participants were the first year students on the Bachelor Degree Program for Multimedia Technology (Group1) and Bachelor Degree Program for Games and Experience Technology (Group2) in 2012 and 2013.

In 2012 a total of 49 of students registered as players in the game (39 men and 10 women) and in 2013 a total of 45 students registered in the game (34 men and 11 women).

Three methods were used to gather information and data:

- a quantitative questionnaire
- analysis of system logs of user activities
- observations

Both 2012 and 2013 HiNTHunt were played during a nine-day period. In this period, all the activities that were done by the players to interact with the game were logged. A quantitative 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. In 2012 38 of the registered players answered the questionnaire (28 men and 10 women) (n=38) and in 2013 41 of the registered players answered the questionnaire (30 men and 11 women) (n=41).

6. Results and discussion

For players to engage in a game where participation is voluntary, they must perceive the game as fun. Both in 2012 and in 2013 it is clear that the players perceived the game as a fun game. In the questionnaire all of the players were asked to provide three adjectives that they think describe the game. The responses were used to generate the tag cloud shown in **Figure 4** below and the tag cloud for both 2012 and 2013 clearly illustrates that the players perceived the game to be *Fun*.

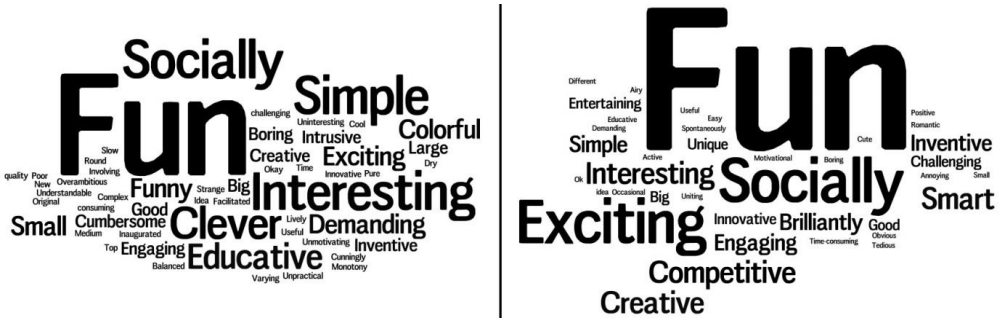

Figure 4 - Tag cloud describing the respondents' opinion about HiNTHunt in 2012 (to the left) and 2013 (to the right) generated from adjectives given by the respondents.

One of the main motivations for introducing a game story in HiNTHunt 2013 was to make the players engage in the game as early as possible. In 2012 42% of the registered players registered as players during the first day of the game. In 2013 66% of the players registered as players during the first day of the game. The increase in early player registration is significant and the only difference between 2012 and 2013 that could have this effect is the introduction of a game story. It appears that the game story in 2013 made the students curious about the game and that they therefore more quickly registered as players compared to 2012. The quotes shown in Table 1 below also indicate that the players think that the game story motivated them to start playing the game.

Table 1: Some representative quotes from the questionnaire on the topic of the game story and if the game story in HiNTHunt 2013 motivated them to play the game.

It was a very funny story and it motivated me to start playing
The way the game was presented was fun and created interest
Thought it was funny. Got the desire to play it after hearing the story

To evaluate the level of player participation we use two indicators that are directly comparable between 2012 and 2013. The game board is identical between the two versions of the game. In both versions the players has to register 25 diamonds and the assignments and tasks needed to do that has not been changed, hence one indicator that says something about the level of player participation is the *(1) average number of diamonds that each player has registered on the game board*. Another indicator is the players' interests in the status of the game and this indicator can be measured by *(2) the average number of times each player has opened the high score list in their game client*. When we

look at these two indicators, it is clear that there is a significant increase of player participation in 2013 compared to 2012.

Table 2: The number of times the high score list has been opened on average pr. registered player.

GROUP2 2012	GROUP1 2012	Total 2012	GROUP2 2013	GROUP1 2013	Total 2013
5.00	11.25	7.55	20.53	63.15	45.16

In Table 2 we can see that both in 2012 and 2013 Group1 was more active in the game than Group2. The reason for this is not easily identified but one factor that certainly played a role in the HiNTHunt 2013 run was the fact that there were a fairly large group of international students in Group2 and many of them did not yet have a Norwegian mobile number that was a prerequisite for being able to register in the game. Because of this a relatively large group in Group2 was not able to register as players in the game and this had a negative impact on the level of player participation in Group2. However, the numbers show clearly that even with this problem, the activity in Group2 is higher in 2013 than 2012 and when we look at Group1 the level of activity is significantly higher in 2013 than in 2012. When we look at the numbers in total we see that in 2012 each player on average opened the high score list 7.55 times and in 2013 this number has increased almost six times, to each player on average opening the high score list 45.16 times.

In **Figure 5** the findings indicated in Table 2 are confirmed. The columns show the percentages of the players that collected different number of diamonds at the end of the game. The white columns (HH12) in **Figure 5** shows that the player participation in 2012 was low since many players registered none or very few diamonds on their game board and few players found many diamonds. The black columns (HH13) show the activity in 2013 and that this is significantly higher than in 2012.

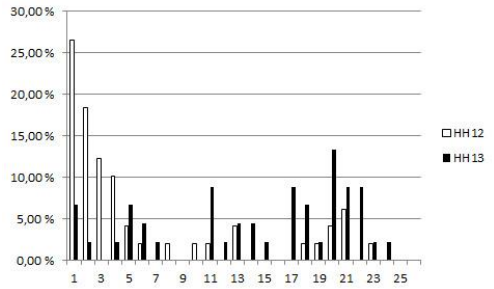

Figure 5 – The total percentage of players who have collected the different number of diamonds

Figure 5 also shows that some players did not participate in 2013. If we break the numbers up and look at player participation in each of the groups the reason for this becomes clearer.

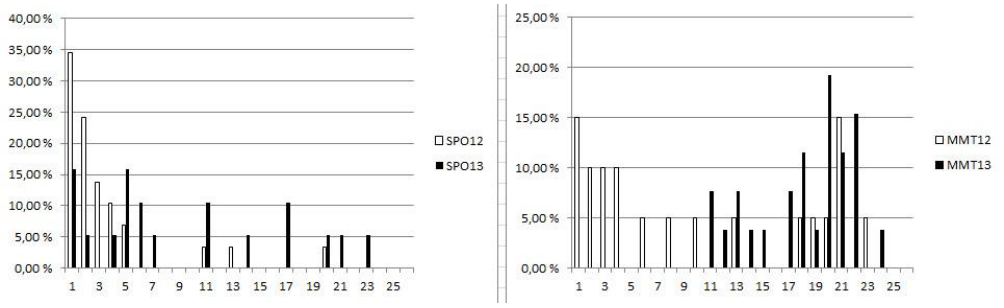

Figure 6 - The percentage of players who have collected the different number of diamonds shown for each class

Figure 6 clearly shows that the columns illustrating low activity in 2013 in **Figure 5** is caused by low activity in Group2 (SPO13), but still the player participation in Group2 was higher in 2013 (SPO13)

than in 2012 (SPO12). Regarding Group1 **Figure 6** shows that there are no black columns on the low numbers in 2013 (MMT13) and that player participation is significantly higher than in 2012 (MMT12).

Analyses of the answers from the questionnaire suggest that one of the reasons for the different level of player engagement in Group2 and Group1 in 2013 was how important they perceived the intergroup competition. 100% of the respondents in Group1 (n=25) stated that to win the intergroup competition was perceived as very important in their class, and 100% of the respondents in Group2 (n=16) stated that it was not perceived as important in their class to win the intergroup competition. Table 3 shows some of the quotes from the questionnaire to illustrate the different attitude towards the class competition between the classes.

Table 3: Some representative quotes from the questionnaire on the topic of if winning the group competition was perceived as important in their class.

Very important. This led to collaboration between everyone in the class. (Group1*)*
*Very important! (*Group1*)*
*Very little (*Group2*)*
*On a scale of 1-10 I would say 1 for over half the class and 2 for the rest (*Group2*)*

The fact that the intergroup competition was perceived as less important in Group2 than in the Group1 is quite certainty one of the reasons that the player activity was much higher in Group1 than in Group2, hence we can conclude that intergroup competition clearly had a positive effect on player participation but only for those that perceived the intergroup competition to be important.

In the duration of HiNTHunt 2013 *The-Last-Shall-Be-The-First-Bonus-System* was successfully used 111 times. When we look into the details we see that each player in Group2 on the average used it 1.6 times and that each player in the Group1 on the average used it 3.1 times.

Analyses of the data from the questionnaire suggest that the passive players that were approached by the active players and that successfully participated in *The-Last-Shall-Be-The-First-Bonus-System* also became more motivated to participate in the game. 63.3% (n=41) of the passive players that participated stated that this led to them becoming more motivated to play the game.

It is clear from **Figure 6** and Table 3 that participation in *The-Last-Shall-Be-The-First-Bonus-System* also led to the passive players to become more engaged in the ordinary game play (collecting diamonds). We see this clearly when we look at the Group1 activity illustrated in **Figure 6**. Here we can see that all of the Group1 players collected diamonds in 2013 (which was clearly not the case in 2012).

We can conclude that the extensions introduced in 2013 have had a positive effect on player participation compared to 2012. The game story led to higher numbers on “early player registration” in the game. The intergroup competition led to high activity in the group where this competition was regarded as important and *The-Last-Shall-Be-The-First-Bonus-System* resulted in higher activity during the game in both groups and did transform many of the passive players into active players.

However, there are still too many players that participate too little in the game. Analysis of the data and observations done during the game has identified some of the reasons for this:

- The intergroup competition had a negative impact on the level of engagement in *The-Last-Shall-Be-The-First-Bonus-System* because the group which was in the lead did not want to engage the players from the other group on the bonus list because the most important was not to win the individual contest but the intergroup competition.
- The intergroup competition was regarded as more important in Group1 than in Group2 (as shown in Table 3) and this led to the players in Group1 collaborating to a much greater extent to collect points. This again led to that even the most avid players from Group2, becoming demotivated when they - though they were very active players - quickly discovered that they would have very little chance of winning the individual competition.

- *The-Last-Shall-Be-The-First-Bonus-System* was used less than optimal because the players did not know each other by name and it therefore was difficult to identify the players on the bonus list (which only displayed the name of the players).
- 12.8% stated that the cost of using the mobile network had a negative impact on their participation in the game.

6.1. Unintended effects

To Group1 the intergroup competition became so important that they to a very little degree competed individually. This meant that not everyone in Group1 did the tasks or participated in the events that they received game points for. The question is whether this is unwanted activity (cheating). The main reason that *the startup week* is held is for the new students to socialize and get to know each other. This means that although there are different learning objectives defined in HiNTHunt, the main goal for the game is the socialization process. In Group1 the "cheating" led to less activity on the tasks that were designed to acquaint students with campus, the lecturers and the town, but to greater activity in social terms between the students since they spent a lot of time talking and sharing information with each other. In pervasive games the boundaries of play are ambiguous. What type of activity that is within the rules of the game or not is not always clear and this gives the players the possibility to be creative within the framework of their common understanding of the boundaries of play. Work done by Ejsing-Duun, Hanghøy and Karoff (Ejsing-Duun, Hanghøj et al. 2013) discussed this type of unintended activity among the players of a pervasive game on global coffee trade and concluded that this type of activity is positive and should be facilitated as long as it is productive in relation to both the goals of the game and the learning objectives. In HiNTHunt 2013 this unintended game play facilitated even more social activities among the players, which is clearly in relation to both the goals and learning objectives of the game.

The importance of the different parts of the game needs to be better weighted towards each other. The introduction of *The-Last-Shall-Be-The-First-Bonus-System* led to normal game play (collecting diamonds) becoming less important for the first and middle part of the game and that a winning strategy in the game could be to not participate in the "normal game play" until the very end of the game to be able to stay on the bonus list as much as possible to receive bonus points, and then collect all of the ordinary game points in the game towards the end of the game (the player that came second in the individual competition followed this strategy). This is not a wanted situation since this shifts the normal activity in the game to take place towards the end of the game instead of evenly through the game period, which is the wanted situation.

7. Conclusion

The main contribution of this paper is to show how to increase player participation in pervasive games by the use of some simple strategies and game play. This paper has showed that by using a fun game story that connects the game to the situation of the players, we can motivate the players to engage and participate at an earlier stage in the game. The introduction of intergroup competition clearly had a positive impact on player engagement and the strategy of providing a gameplay that motivated the active players in the game to engage the passive players did successfully transform many of the passive players into active players and led to increased player participation in the game. All our indicators confirmed a significantly higher level of player activity in the game in 2013 compared to 2012 hence we conclude that the extensions introduced in 2013 had a positive impact. The presented strategies can easily be adapted and implemented into almost all types of social games to motivate and increase player participation.

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Paper IV

Dynamic Pervasive Storytelling in Long Lasting Learning Games

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Abstract: Pervasive gaming is a reality-based gaming genre originating from alternative theatrical forms in which the performance becomes a part of the players' everyday life. In recent years much research has been done on pervasive gaming and its potential applications towards specific domains. Pervasive games have been effective with regards to advertising, education and social relationship building. In pervasive games that take place over a long period of time, i.e. days or weeks, an important success criterion is to provide features that support in-game awareness and increases the pervasiveness of the game according to the players' everyday life. This paper presents a *Dynamic Pervasive Storytelling* (DPS) approach and describes the design of the pervasive game *Nuclear Mayhem* (NM), a pervasive game designed to support a Web-games development course at the Nord-Trøndelag University College, Norway. NM ran parallel with the course and lasted for nine weeks and needed specific features both to become a part of the players' everyday life and to remind the players about the ongoing game. DPS, as a model, is oriented towards increasing the pervasiveness of the game and supporting a continuous level of player *in-game awareness* through the use of real life events (RLE). DPS uses RLE as building blocks both to create the overall game story prior to the start of the game by incorporating elements of current affairs in its design and during the unfolding of the game as a mean to increase the pervasiveness and in-game awareness of the experience. The paper concludes that DPS is a promising approach for creating a game story which increases the pervasiveness of the game and supports in-game awareness.

Keywords: pervasive games, game based learning, in-game awareness, interactive storytelling, media analysis, game mastering

1. Introduction

Pervasive gaming is a gaming genre in which the game is not confined to a virtual world but extend the gaming experience out into the real world (Benford et al. 2005). Many types of games, toys and experiences are labelled as pervasive (Magerkurth et al. 2005) and the boundaries between pervasive games and other types of games are unclear. Researchers have approached the genre from different perspectives which led to multiple definitions of the term *pervasive game* (Nieuwdorp 2007). This paper follows a technologically independent definition:

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

A pervasive game is therefore required to be both spatially and temporally pervasive relative to the player's everyday life for the whole duration of the game. Given these characteristics, pervasive games can be suited to blend learning into students' everyday life and thereby bring a pervasive property to learning (Pløhn 2014). However, pervasive games face specific challenges that traditional board games or ordinary digital games do not have. While playing a non-pervasive digital game, the player is aware at all times of the fact that he/she is playing a game. In the case of pervasive games; where the game is a part of the players everyday life and last for days or even weeks (with potentially long periods of times without any game related activities), players can easily forget that they are participating in a game. Pervasive games need features to support *in-game awareness*:

> *In-game awareness is the player's feeling and awareness of participating in an ongoing game.*

Given the definition, features that support *in-game awareness* are everything that helps to remind the player about the ongoing game's existence.

In this paper we argue that an important success criterion in designing pervasive games is to provide features that 1) support in-game awareness and 2) increases the pervasiveness of the game. Since an important feature of pervasive games is the use of the real world as a part of the game, it seems natural to use the real world and real world events to support these two properties and the research question is therefore as follows: How can real world events be implemented in a pervasive game to provide support for in-game awareness and to

increase the pervasiveness of the game? To address this research question we developed the *Dynamic Pervasive Storytelling* (DPS) model/approach. DPS was used to design the game story in the game Nuclear Mayhem (NM), a playable prototype of a pervasive game designed to support a university course in the development of Web-games at the Nord-Trøndelag University College, Norway (Pløhn 2013). The duration of the game was nine weeks. Participation in the game was the only mandatory activity during the course and the students had to complete the game to be allowed to attend the exam. The requirement for mandatory participation contradicts one of the most frequently cited definitions of a game offered by Suits (Suits 1978) as "the voluntary attempt to overcome unnecessary obstacles". New applications of games, such as e.g. Game Based Learning, where participation often is obligatory, suggests that this definition is too narrow and consequently there is a need to revise the definition of "what makes a game" to include the new areas of application in the definition. This discussion is beyond the scope of this paper and we define Nuclear Mayhem as a game according to the six requirements proposed by Juul (Juul 2003), stating that an activity is a game if the following six features are included:

1. A set of fixed rules
2. A variable and quantifiable outcome
3. Valorization of the outcome
4. Player effort
5. Player attached to outcome
6. Negotiable consequences

This definition does not emphasise or include "voluntary participation" for an activity to be defined as a game. All the six features in this model are included in Nuclear Mayhem.

This paper presents the use of DPS as a strategy to create a game story to be used in pervasive games and methods to support both in-game awareness and to increase the pervasiveness of the game. Section 2 provides an overview of the narrative considerations in DPS and section 3 discusses the design requirements for the design of NM. Sections 4 and 5 present our evaluation and results.

2. Narrative considerations in dynamic pervasive storytelling

Storytelling or narrative is commonly used in both digital entertainment and serious games in order to motivate players in first engaging and then keep them engaged. Work by Lazzaro (Lazzaro 2004), Fullerton (Fullerton et al. 2004) and Yee (Yee 2005) all identified storytelling elements as key motivations for players in entertainment games. Storytelling, for similar reasons, is also regarded as a key element for the design of serious games and Lim and Louchart (Lim et al. 2014) identified a schemata (Purpose, Process, Structure) through which narrative serious game mechanics can be identified and described. In the particular context of NM, the story represents an important design factor for player motivation and keeping the player engaged, but also in terms of pervasiveness and its ability to out-reach beyond the remit of in-game awareness. For these reasons, not only does the story need to engage and motivate players like any other digital entertainment/serious game approach, it also needs to be current and timely so as to be part of the player's world outside the game. Thus gaining relevance within the real-world in which players actually live. Contrary to most gamification approaches where competition is of the essence (Deterding et al. 2011), NM's interest in blending virtual and real presences is primarily motivated by the desire to achieve narrative immersion and create an omnipresent story-world through which learning outcomes can be put into context and achieved.

In conceptualising a DPS approach, it is essential to adopt a narrative mechanism in which the story can reflect events, which cannot be pre-determined or planned. From an experiential perspective, the overall main game story should be pre-written and set within the traditional storytelling branching practices seen in most entertainment games (Wei 2011). From a pervasive perspective, however, elements of story related to the depth of the experience require some level of active, on-the-fly interventions in order to bridge or blend virtual and real worlds. Technically speaking, a DPS experience, requires, for its whole duration to be monitored and authored from the perspective of an active game-master (GM) whose role is to facilitate the integration of story elements and the experience of players (Tychsen et al. 2009). Parts of the story therefore become emergent in nature and require the interventions of an author in real-time so as to maintain a balance or exploit opportunities (Temte and Schoenau-Fog 2012). This approach is common in the designs of modern table-top Role Playing Games (RPGs) such as Dungeons and Dragons (D&D) Series (D&D 2014) and Nordic Live

Action Role Play (LARP 2014). In cases (Kanner and Lassila 2012), the game world is set in the real world in which people are oblivious to the game played by participants. The game articulation, in such a context is achieved by the combination of GM interventions and actors whose role is to exploit opportunities arising from the unfolding play or events in the real physical world over which neither the GM nor the actors have any control. NM follows a similar approach in which the GM monitors player actions within the game and the real physical world for opportunities that could be exploited or reported to players via out-of-the-game media such as e-mails, mobile phone texts or social network.

3. Design principles for NM

One of the main challenges for the story in NM was to increase the pervasiveness of the game and provide in-game awareness. The pervasive aspect of the game story is to provide a live information background contributing to player motivation rather than direct the players towards performing specific actions during the game. For instance, the NM scenario features a plot line set in the context of the escalating international diplomatic conflict related to the Iranian nuclear programme. A timely current affair topic at the time of running NM in which there was growing international scepticism on the legitimacy of the Iranian nuclear programme (RT 2009). In this context, computing students play the role of cyber-saboteurs in the wake of the Stuxnet virus attack on Iranian nuclear facilities in 2010 (CNN 2010). In this scenario, Iranian agents are sent from Iran to find and eliminate the saboteurs and as the game unfolds they are gradually getting closer to the players. During the game the "agent story" motivated several SMS messages in which players were informed about the status and whereabouts of the agents. While these messages helped to build and develop this aspect of the story, the main intention was to remind the players about the game (create in-game awareness) and help to increase the pervasiveness of the game (most people will read SMS even if they are occupied with other things) by linking game actions to real news bulletins related to this particularly current topic at the time. To this purpose, a set of specific principles was put together so as to achieve a state of story omnipresence for the duration of NM (Figure 1).

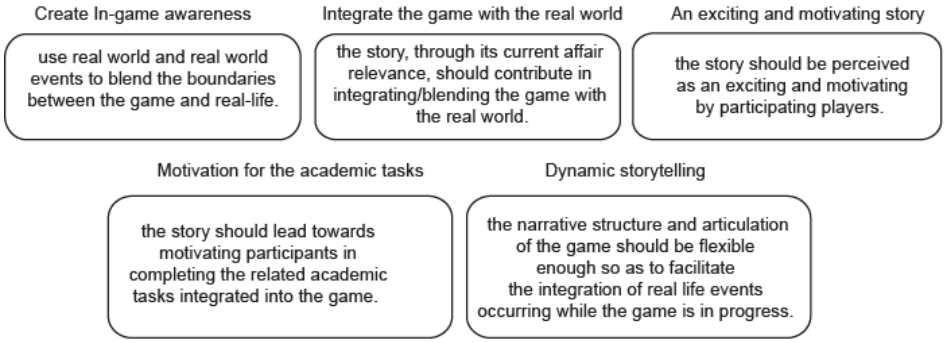

Figure 1: NM story principles

3.1 Create in-game awareness

NM is a 9 weeks long pervasive game and there are necessarily long periods with little or no game related activities. The player needs to develop a kind of information awareness so as to preserve the "feeling" of being in a game whilst not actively participating in any specifically related game activities. We refer to this as in-game awareness in the sense that a player will access or process information from the perspective that it might be related to the game and thus relevant. In-game awareness in pervasive gaming has many similarities with awareness in computer-supported cooperative work (CSCW). Awareness as an achieved outcome is a critical element of any cooperative work situation (Fitzpatrick 2003). Surveys within the CSCW community have identified up to nineteen different types of awareness information (Cabitza and Simone 2007), but one type of awareness that is special for pervasive games is related to the fact that one is participating in a game (in-game awareness) as opposed to the awareness that one is at work which is the case for CSCW.

The pervasive game *SupaFly* supported in-game awareness by using the players' geographical proximity to each other to make the players aware of other players in the surrounding geographical area (Jegers and Wiberg 2006). This approach is not relevant in *NM* since the game play does not put the same emphasis on the

players` physical location towards each other - the main feature in NM to support in-game awareness is the game story itself.

Since pervasive gaming is a new genre, there is still a lot of research needed to find out how in-game awareness can be supported in pervasive gaming. Our techniques to support *in-game awareness* are identified in Figure 2:

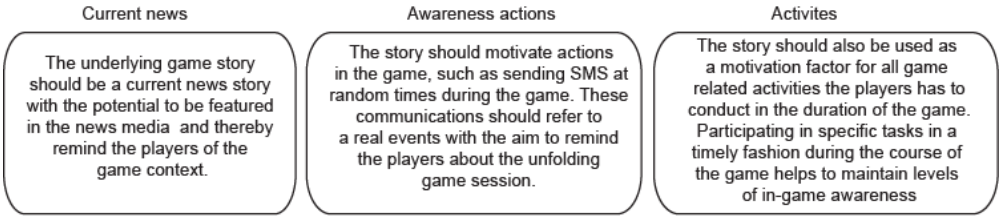

Figure 2: In-game awareness story techniques

3.2 Integrate the game with the real world

One way to achieve this is to create a game story that incorporates real life events as a part of the game story. Many of the design methods used to support in-game awareness will also contribute towards increasing the pervasiveness of the game and blend the game into the players' everyday life.

For instance, when the player, in the evening is watching the news on TV and see a news story directly related to the game story, this will remind the player of the game in a non-game related situation (create in-game awareness) but will also help to blend the game story into the players everyday life and thereby increase the pervasiveness of the game. The same properties of the game story that support in-game awareness will therefore also help to increase the pervasiveness of the game, but – to be able to create an overall game story that is based on real life events – the following properties should also be supported in the chosen story (Figure 3):

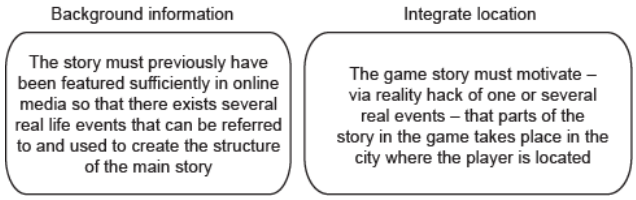

Figure 3: Story blending techniques

3.3 An exciting and motivating story

The game story is an important design factor to create player enjoyment and motivation to play the game. Player enjoyment is a crucial factor in successful game designs but little work has been done in the research area of pervasive gaming to address this. The *Pervasive GameFlow Model* (PGM) (Jegers 2007) which is derived from the general *GameFlow Model*, was introduced to develop a better understanding of player enjoyment in pervasive game. PGM does not mention storytelling specifically but outlines the following eight elements as important factors to create player enjoyment in pervasive games:

- Concentration (the game should require concentration and the player should be able to concentrate on the game)
- Challenge (the game should be sufficiently challenging and match the player's skill level)
- Player skills (the game must support player skill development and mastery)
- Control (players should feel a sense of control over their actions in the game)
- Clear goals (the game should provide the player with clear goals at appropriate times)
- Feedback (players must receive appropriate feedback at appropriate times)

- Immersion (players should experience deep but effortless involvement in the game)
- Social Interaction (the game should support and create opportunities for social interaction)

PGM is not a final and fully comprehensive model but can be regarded as a starting point for further empirical studies on player enjoyment in pervasive games. However, even if the model is not yet complete, it is thus far the most valid model dealing with player enjoyment in pervasive games. Thus, in order to support player enjoyment, we argue that a game story should support, as best as possible, the eight elements in PGM.

3.4 Motivation for the academic tasks

In many games used in game-based learning (GBL), the ludic experience is often suddenly interrupted in order to feature an academic section in which the player must perform some academic. We believe that the "educational part" of the game used in GBL should be an inherent and integrated part of the game and not be perceived as something different or unrelated by the player. To achieve this, the game story must provide clear motivations for the completion of related academic tasks. In NM, this is achieved through the established fact that the academic tasks are the main reason as to why the player is "contacted" and asked to "play the game".

3.5 Dynamic storytelling

Since we planned to feature relevant real-life events during the game, the game story had to be flexible so as to accommodate those events as an inherent part of the game story. As discussed in section 3.1, this is an important strategy towards in-game awareness and the approach undertaken in NM was to create an overall game story based on previous real life events (as mentioned in chapter 3.2) that form the complete game story (if nothing happens in the real world that can be related to the story) or offer opportunities to explore different aspect of the game topic. If such a case occurs, the technique selected is the classic digital game approach in which the main storyline can be put aside temporarily in order to allow for the development of an arising story line (based on timely real-life events) until the story branches back again to the main overall storyline as shown in the figure below. This is in itself a very common digital game technique in which micro-narratives are inserted within the overall macro-level narrative of the game (Grant and Bizzocchi 2005). In the particular case of NM, the narrative at the macro-level is not per se flexible as its elements are designed to appear in sequence according to the demands of the educational curriculum. The micro-level narrative however can be slotted in as they occur in real-time in the real-world current affairs. The role of the game master (GM) is thus both opportunistic and creative in the sense that it is up to the GM to scrutinize media for relevant news reports and assess the opportunities these could provide with respect to enriching the pervasive game experience.

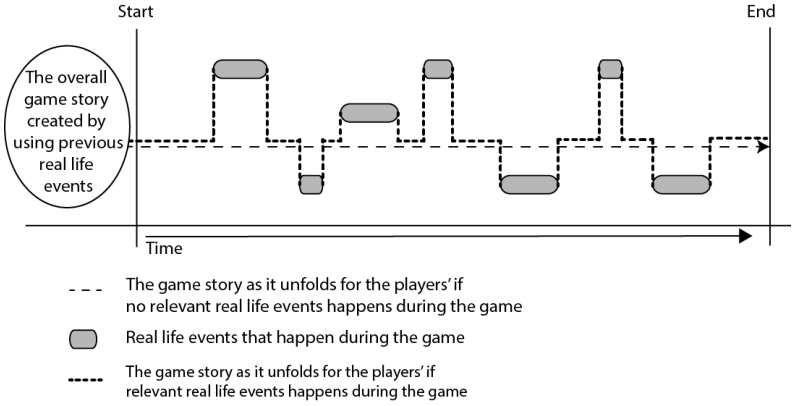

Figure 4: Using real life events to create the game story

4. The game story – DPS in practical application

In this chapter we describe the overall game story and examples of the game story to illustrate the DPS approach described in section 3.

Media analyses of the current and former media landscape suggested that Iran's alleged nuclear weapons program was a relevant candidate as the theme for the game history. 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, and the issue seemed to be so relevant that there was great probability that one or more events could happen, in the duration of the game, that would be featured in the news media and thereafter could be implemented in the game (Figure 1). On the basis of these considerations the theme chosen for the game story was Iran's nuclear program.

4.1 The overall game story

The overall game story was constructed from the ability to support the story by referring to real life events that had already happened (reality hack), and the likelihood that there would happen something 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 (Figure 2). Based on the above, the overall game story was constructed as follows:

> Iran has a nuclear weapons program which aims to develop nuclear weapons (RT 2009, Nettavisen 2004, Dagbladet 2010). A group of agents has been asked to delay and sabotage the weapons program so that Iran does not succeed in developing nuclear weapons. We do not know the identity of the members of this saboteur group but they use the identity of a non-existing person, Amir Ahangar, as their contact. The saboteur group has previously managed to delay the nuclear program by liquidating key personnel (AFP 2010), but this is no longer a feasible option.
>
> In an underground bunker in Iran there is a supercomputer that is currently conducting computations that are absolutely necessary for the Iranian nuclear weapons program. Without these calculations, it will not be possible for Iran to develop nuclear weapons and the saboteur group's mission is to sabotage the super computer before the calculations are completed.
>
> To gain access to the super computer, the saboteur group has to hack into Iran's government internal computer network. The group has managed to gain access to an Iranian government office in which there is a computer connected to the internal computer network, but they do not have the codes and passwords necessary to penetrate the network and get access to the super computer.
>
> These codes are however known to Shahram Amiri, a former Iranian nuclear physicist, who fled to the United States in a CIA coordinated operation (VG 2010). The saboteur group has to somehow contact Shahram Amiri to get the secret codes to the gain access to the super computer.

4.2 Integrate location

The probability that the selected theme for the game story unfolds at the same physical location as where the players live their daily lives, is most likely very small. A very important part of pervasive games is to use the players' surroundings, i.e. the city, school/work, home, as an integrated part of the game play; hence there is a need to co-locate the game and the players. The game story must therefore substantiate that the game (i.e. the part of the game where the players has to get involved) happens where the players live their everyday lives, even if most of the game story (what the players can see on national TV, read about in newspapers etc.) unfolds somewhere else in the world. The game was co-located (figure 3) with the players by the following twist in the game story:

> The Iranian nuclear physicist, Shahram Amiri, which fled to USA (VG 2010), is regarded as a traitor by the Iranian government. They have sentenced him to death and Iranian agents have been sent out to locate and liquidate him. To protect Shahram Amiri from assassination, he has, in consultation with the Norwegian and American government, in utmost secrecy been placed in Steinkjer with a new and top secret identity as Afghan asylum seeker.

This part of the game story, which is designed on the basis of both real and fictional events, integrates the game with Steinkjer (the city where the Nord-Trøndelag University College and the players are located) and provides the reason for why the players must be involved in the game. The "Amir Ahangar" saboteur group, which is located in Iran, needs help from someone located in Steinkjer.

4.3 Provide motivation for the academic tasks

The game story should provide motivation for the academic tasks that the students have to perform in the duration of the game and integrate the academic tasks in the game in such a way so that the players (figure 1) perceive them as an integrated and natural part of the game. Following the DPS approach the academic tasks in Nuclear Mayhem is integrated in the game (Pløhn 2014) by the following part of the game story:

> The former nuclear physicist, Shahram Amiri (VG 2010), who now lives in Steinkjer under a false identity as an Afghan asylum seeker, is willing to help penetrate the Iranian government data network by providing the passwords and codes necessary, but to protect himself, he will not have any direct contact with "Amir Ahangar" saboteur group. He has instead chosen to hide the codes at different places in Steinkjer, and to prevent them from being discovered and understood by random people, he has hidden the codes included in a technical challenges that not just anyone will understand. Apart from this, Shahram Amiri will not help in any way. He fears, with good reason, for his life and will not do anything that could cause the Iranian authorities to become aware of him.
>
> The codes turn out to be hidden behind, or as part of ActionScript 3.0 programming code and Flash applications.
>
> This means that the "Amir Ahangar" saboteur group has to find someone in Steinkjer, with knowledge of Flash and ActionScript 3.0 programming, which are willing to help the saboteurs by revealing and transmitting the codes to them so they can penetrate the computer network and sabotage the super computer before it has completed the calculations.
>
> Via searches on Google and thereafter on www.hint.no, the "Amir Ahangar" saboteur group discovers that there is an ongoing ActionScript 3.0 programming course at the SPO program at Nord-Trøndelag University College in Steinkjer, and they decide to contact the students there to get help to find the codes. The saboteurs group creates a false G-mail account under the name Amir Ahangar (a normal name in Iran) and use this to contact the students. The game has begun.

This part of the game story integrates the educational part with the game by making the academic tasks the only reason why the players are contacted by the saboteur group and asked to help (play the game). Everything else in the game, the riddles, the tasks, the assignments, etc. is only a result of this.

4.4 Awareness and Pervasiveness actions

One criterion for choosing the current theme as the basis for the game story was the likelihood that relevant real-life-events related to the theme and referred to by the news media, would happen in the duration of the game (section 4.1). However, there is no guarantee that such events will occur, and the game story should therefore provide a motivation for pervasiveness and in-game awareness enhancing actions in the duration of the game (figure 2). To meet this requirement the Iranian secret agents (introduced in section 4.2) were included in the game story:

> The Iranian government has sentenced Shahram Amiri (VG 2010) to death and has therefore sent secret Iranian agents out in the world to locate Shahram Amiri and kill him. When the game begins the secret Iranian agents are still in Iran but for each week of the game they come nearer and nearer in locating Shahram Amiri and identifying his helpers (the players) and they also come closer and closer to Steinkjer for each week. The last period of the game the Iranian agents are in Steinkjer and at some point, even at the University Campus (YouTube 2014).

In the duration of the game this part of the game story motivated several pervasiveness and in-game awareness enhancing actions by sending emails and SMS to the players informing them about topics such as: "The Iranians have sent two agents to Europe to locate and eliminate Shahram Amiri and anyone who helps him"; "...we now have confirmed information that the Iranian agents are located somewhere in Scandinavia", "...the agents are now in Norway", and so on.

4.5 Incorporating occurring real life events

In the duration of the game several real life events occurred that was incorporated in the game story and used to motivate several different game related actions. Due to limited space, only one example is presented in this section.

Some weeks into the game Farzad Farhangian, an Iranian diplomat at the Iranian embassy in Brussel, Belgium, defected to Norway, seeking asylum on the ground that his "life was in danger in Brussels" (BBC 2010). This became a major news story in Norway and was featured in newspapers and national radio and TV. This real life event was incorporated in the game by the following game story:

> Farzad Farhangian had been the source to information about the Iranian secret agents and their whereabouts. Farzad was in fact a member of the "Amir Ahangar" saboteur group and acted as a double agent. He had been revealed as a spy by Iranian authorities and had – at the last possible minute – escaped from the embassy in Brussels and fled to Norway to save his life. The disclosure of Farzad as a double agent has led to that the "Amir Ahangar" saboteur group have lost control of the whereabouts of the Iranian agents.

This event was used in many different ways in the game. It was featured in the early morning news on the radio and the game master who rated this as an event with large probability to be featured in the evening news on national TV and from this assessment sent the following SMS to all the players two hours before the newscast on national TV picked this up:

> One of our main information sources to Iranian internal Intelligence is Mr. Farzad Farhangian, a diplomat at the Iranian embassy in Brussel. Mr. Farhangian has provided us with Intelligence about all types of Iranian activity in Europe. His connection to us has now been exposed and to save his own life he had to flee from Brussel seeking asylum from Norwegian authorities. More about this at the news broadcast on Norwegian TV tonight.

This SMS had several purposes in the game. The SMS itself helped to increase the pervasiveness of the game and helped to create in-game awareness about the ongoing game. The SMS also functioned as a narrative since it revealed a new part of the game story to the players. The SMS led all the players to watch the evening news on national TV where the event was one of the headlines and received major focus. When the players could watch the game story "unfold" on national TV this clearly helped both to make the game more real/exciting and to increase the pervasiveness and in-game awareness properties of the game. Furthermore, this event was used as a motivation for the players to perform a practical task to ensure that they were not followed or revealed by the secret Iranian agents. This part of the game story and the practical task did not exist before this real life event occurred and could be incorporated in the game story and game play while it happened due to the DPS approach.

5. Participants, methods and procedure

17 male students were attending the University Course that *NM* is designed to support and all registered as players in the game. None had any previous experience of pervasive gaming. Amongst registered participants two did not participate in the game and did not attend the lessons or lab-exercises. One completed the game but did not attend the final exam giving a total of 15 who played and completed the game and 14 who attended and passed the final exam.

We gathered four different types of evaluation data (qualitative questionnaires, interviews, log recording, GM observations) during the nine weeks it took to play NM. All participants answered the questionnaire (n=15). While such a small sample will not allow for statistically significant results, the analyses of responses may still provide an indication of the players' opinion for the design of future pervasive. Based on the responses, five people were chosen for in depth interview. The five interviewees were chosen based on their attitude towards the game (two positive, two negative, one neutral). The in-depth interviews were conducted after the exam grade was set and mainly dealt with the participants' general attitude towards their experience of participating

in the game *NM*, the individual game plots, the use the real world as part of the game and what they perceived as motivation or demotivation factors in the duration of the game.

6. Results and discussion

The strategy of using a current news story with the potential that timely and related real-life events could happen and be featured in the news media within the duration of the game proved to be successful. In the nine weeks period during which the game lasted, several real life stories were featured in the news media. These were used in different ways in the game in order to increase the pervasiveness of the game and maintain the players' in-game awareness.

The quotes in Table 1 illustrate how players perceived the relationship between the game and real-life news stories. They also seem to indicate that the validity of this strategy as a good design choice and an efficient and recognised way to support *in-game awareness*. Players were, at the time of consuming relevant information, in a non-gaming situation (watching the news or reading the newspaper in the comfort of their own home). They were, however, still aware of the game when reading newspapers or watching TV-news as they developed the expectation that "something was going to happen in the game" when they felt news events would be relevant to the game (see Table 1 (subjects B and E)).

However, many participants were less aware of current affairs and paid very little attention to news broadcasts on TV or newspapers. Thus, these players did not experience the same level of *pervasiveness* and *in-game awareness* as those who witness the "game story" being featured in real life news media. Our approach to remedy to this problem was for the game master to send SMS-messages informing participants to watch the evening news when there was a high probability that something was going to be featured in one of the news stories. One example of such an event was the story of an Iranian diplomat at the Iranian embassy in Brussels seeking asylum in Norway (i.e. where NM happened) (BBC 2010). This event was considerable and would almost certainly be featured as a main story to be reported during that evening's TV news show at 9 p.m. To motivate players a SMS reminding participants to watch the news show was sent to all of participants at 5 p.m.

The intention behind this SMS was to connect the real life event to one of the stories in the game (the secret Iranian agents that are constantly getting closer and closer), to create *in-game awareness* (the SMS itself) and to increase the pervasiveness of the game by motivating the players to watch the evening news and witness the "game story" being featured as one of the headlines.

Table 1: Quotes from participants about the use of the real world events in the game.

I was aware of that what I saw in the videos, the news clips etc. used in the game were real life events. I think that the use of real life events as a part of the game makes it all the more realistic ... or more real ... I think that, for my part, that the fact that real life events that occurred while the game was going on – like the Iranian diplomat who defected – was used in the game made it more real ... when you connect it to more realistic stuff so ... it increases the tension as well. I tried to play the game as if it was for real. My main motivation to play the game was the whole "concept" of the game. I think the story was exciting and fun. - Subject A (positive)

I think the story was a good plot and there was a lot of work put into it. The story matched with a lot of things that was going on at once. There were real things going in the current news that the game linked to. When I received links or tips from the game I paid more attention to the news stories about Iran, and there was a good timing on some of it. I think that the use of real life events in the game was good. It made it the more exciting ... thus … I am not just negative to the game, I can see the relevance of the game but I don't like this types of games I saw something about it on the news broadcast on TV and then I knew that things were going to take place in the game also. - Subject B (negative)
The story was well substantiated, it was well made and the details were good. I am negative to many things in the game but regarding the storytelling in the game, I am positive, The use of real life events in the game story was exiting and it increased the atmosphere of the game. - Subject C (negative)
I think the story was relevant. It was very relevant when they hacked the Iranian nuclear facilities with the Stuxnet virus. Then I thought of the game when I saw it in the news. My participation in the game made me become more aware of this type of news. I think that the use of real life events (such as the Iranian embassy employee that fled) was good because it made the story more believable. Being able to read it in the newspapers made it a bit more credible. Real. - Subject D (neutral)
When I saw the story featured in the newspapers I knew that something was going to happen. My participation in the game made me become more aware of news that could be related to the game. The story was exciting. I think the use of real life events as a part of the story might be good ... then it becomes a little more realistic ... - Subject E (positive)

The quotes presented in Table 1 above indicate that the DPS approach was successful in creating a game story that incorporates real life events so as to support in-game awareness and game pervasiveness. All players noticed that real life events were used in NM and viewed this as a positive aspect that made the game more realistic and exciting.

A minority of players expressed a negative attitude towards NM but observations during the game and in-depth interviews showed that dislike was not caused by the game story but by other factors:

- They did not appreciate that participation in the game was obligatory (but so are the alternative which is obligatory assignments)
- The fact that they had to play a game led to them disliking the game
- Some judged that there was not enough "academic learning" in the game (curriculum issue rather than the game design).

Any complaints from the players regarding the academic tasks were, as mentioned in the bulleted list above, related to curriculum issues, and not how the academic tasks where incorporated in the game and game play. None of the players indicated, neither in the duration of the game, in the questionnaire nor the in depth interviews, that the academic tasks felt as an alienated or an unnatural part of the game.

Some players reported that their participation in the game led to increased attention if the story was featured in the media. Higher awareness about the news broadcasts was not an intended goal but it indicates that the use of real life events featured in the news media did increase the pervasiveness of the game and helped to create in-game awareness among the players.

After this experimental run of *NM*, 46.7% answered they preferred the game to the obligatory assignments, 33.3% still preferred obligatory assignments to the game and 20.0% indicated that they don't know or that it is not important. The fact that more participants preferred the game is a very good result considering that the "academic challenges" could have been designed in order to reflect on individual skill levels better. NM was a "low budget" experimental game with limitations and could have been better (some of the plots were too similar, there were periods in the game with little activity and too few assignments, game mastering was done manually and player events was sometimes not detected by the game master causing the affected players to fall behind in the game). Academic tasks could have been incorporated better and a more "fancy" and better use of technology towards a fun game-play experience would most likely make a difference too.

7. Conclusion and future work

The main contribution of this paper is the outline of a *Dynamic Pervasive Storytelling (DPS)* approach which can be used within a story creation process towards dynamic game stories in which real-life events support game pervasiveness and help to create and maintain in-game awareness.

NM demonstrates that we succeeded in selecting a suitable media event/news story to be used in the DPS approach to create a game story with the properties required.

The DPS approach also seemed successful in incorporating the academic tasks in the game in such a manner that the players felt that the academic tasks were a natural and integrated part of the game. Future versions of the game should address how to design good learning tasks that are tailored to the individual players' knowledge level.

Given NM's low budget and technological limitations, a discussion should take place as to potential impact of advanced technologies (i.e. Artificial Intelligence, Gaming technologies) on the overall user experience. The emerging domain of *Dynamic Pervasive Storytelling* for education is, as of today, confined to ad hoc and low technology designs but would certainly benefit from research in synthetic agent actors (Weallans et al. 2012) and advanced digital interactive storytelling systems (Thue et al. 2010). In this context, synthetic agents could be effectively playing autonomous roles within the remit of the storyline and choose to communicate of their own accord with participants, thus facilitating the concept of in-game awareness presented in this article. Such technologies are already available (Keysermann et al. 2012) and could be effectively deployed within the context of this work.

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Paper V

Using Gamification to Motivate Smoking Cessation

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Abstract: Smoking cessation represents the single most important step that smokers can take to enhance the length and quality of their lives. In this paper we present a case study of the commercial web-based *freeFromNicotine* course, which provides a game-based approach to smoking cessation. Participants follow a 50 day long program tailored to their individual situation. Gamification is used both as a control mechanism to measure how well the participant follow the course and to motivate the participants to complete according to plan. An important motivational element included in the design is the opportunity for participants to compete against themselves and others based on game points awarded for completing goals and assignments. Research within GBL has shown that in Pervasive Educational Games, competition has a positive impact on player participation. However, offering individually tailored courses while providing all users the opportunities to participate in the overall competition on equal terms is a challenge. This paper presents the gamification approach adapted in the course and how this affected and was perceived by the course participants. *freeFromNicotine* proved to be successful in getting people to quit smoking, but was no commercial success due to marketing problems. However, participants that managed to quit smoking after completing the course mention the competition as an important motivational factor and we can conclude that the gamification and design principles proved successful and can be deployed in other types of learning games.

Keywords: Gamification, Pervasive games, Game Based Learning, Health games

1. Introduction

Smoking is one of the leading causes of preventable death globally and compared to the rest of the world, the WHO European Region has one of the highest proportions of deaths attributable to tobacco (WHO 2015). The estimated costs of smoking for EU/EFTA countries is € 97.700.000.000, of which the direct costs of smoking are €49.83 billion, and the indirect costs of smoking are €47.87 billion (SFP 2015). Hence there is much to gain by getting people to quit smoking. A Norwegian survey shows that 72% of those who smoke want to quit (Helsedirektoratet 2014), however only about 4% - 7% are able to quit smoking without medicines or other help (ACS 2014).

freeFromNicotine (FFN) was developed by the companies Active Software ANS (discontinued) and MT Master ANS (now Sincos Software AS) as an attemp to adress this problem by providing a web based "quit-smoking-course" using gamification as an important design element. FFN was available online in the period 2006-2012 (but with less activity in the last part of the period). Huotari and Hamari (Huotari and Hamari 2012) define gamification as "*A process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation*". This definition focuses on user perspective and gamification used to increase participation and motivation. A more technical perspective that focuses on game mechanics and game concepts (Deterding, Dixon et al. 2011) defines gamification as "*The use of game design elements in non-game context*".

Being addicted to smoking cigarettes is a pervasive habit, hence designing a smoking cessation course as a pervasive game is a reasonable strategy. We define FFN as a pervasive game according the following technologically independent definition (Pløhn 2014): "*A pervasive game is a game that is pervasive relative to the player´s everyday life*". On the basis of this definition a pervasive game must, for the whole duration of the game, be both temporally and spatially pervasive relative to the player's everyday life. Given these characteristics, pervasive games may enable a pervasive property to learning (Pløhn 2014).

2. Related work

Gamification has been used in many different types of environments and for different reasons such as education, pervasive health care, e-commerce, human resource management and many more (Meder, Plumbaum et al. 2013). Studies have provided imperical evidence that including game design elements increases participation (Thom, Millen et al. 2012) and enjoyment (Herzig, Strahringe et al. 2012). Research has shown that games can be used to increase participation and motivation of the students in higher education (Wang and Wu 2009) and competition has been identified as an motivational factor in learning games (Pløhn and Aalberg 2014). *freeFromNicotine* encompasses both gamification and competition as key design principles.

Pervasive gaming is a research area that is becoming increasingly popular and some research on the use of pervasive game to support learning has been done. Pervasive games such as *HiNTHunt* (Pløhn and Aalberg 2013, Pløhn and Aalberg 2014), *Nuclear Mayhem* (Pløhn 2013, Pløhn 2014, Pløhn, Louchart et al. 2014) and *The Search for the professor* (Spikol, Pettersson et al. 2009) has proven that pervasive games can be used to motivate students and support learning within higher education.

3. freeFromNicotine (FFN)

freeFromNicotine (FFN) is a web-based smokers' cessation program designed as a 50 day long real time pervasive learning game. The course program is tailored to the individual participants' specific situation based on information collected from a questionnaire that each of the participants fill in on the first day of the course.

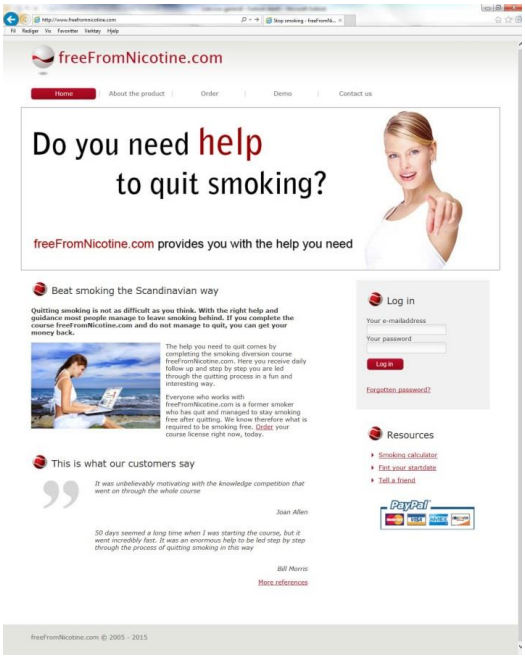

Figure 1 - The web-based smokers' diversion program freeFromNicotine

Quitting smoking is a difficult process and FFN is designed to help the participants' through the whole of this process. During the course the participants are led through three different phases distributed over the 50-day course program as follows:

1. Habit breaking – 25 days (day 1 - 25)
2. Quitting smoking - 21 days (day 26 - 46)
3. Follow-up care - 4 days (day 47 - 50)

Smoking consists mainly of habits that smokers must break. This is the focus in the first phase where participants are motivated to quit and learn techniques to resist the craving to smoke. Breaking habits is difficult and this phase lasts for 25 days. Towards the last part of this phase the participants have to reduce their smoking so that by the start of phase 2 they are free of smoking. In the second phase the participants are no longer allowed to smoke and this phase is mostly about how to handle the craving for smoking and how to keep free. Even though physical dependence on nicotine disappears after 3-7 days, the psychological dependence lasts for 15-20 days (which is why this phase lasts for 21 days). The third and last phase is the shortest, but is just as important. Statistics show that a large number of those who manage to quit will take up the habit again within the first year and the final phase deals with how to establish attitudes and create a plan for the next 12 months.

FFN is a real time course meaning the course once it is started will continue regardless of whether the participants log in or not. The nature of smoking cessation makes it important for users to participate fully in a defined period of time. However, if a participant for some reason is unable to log into the course for a period of a few days, all tasks and assignments are made available as “Uncompleted daily exercises” (Figure 2) and the participants will have the opportunity to complete them when they log in.

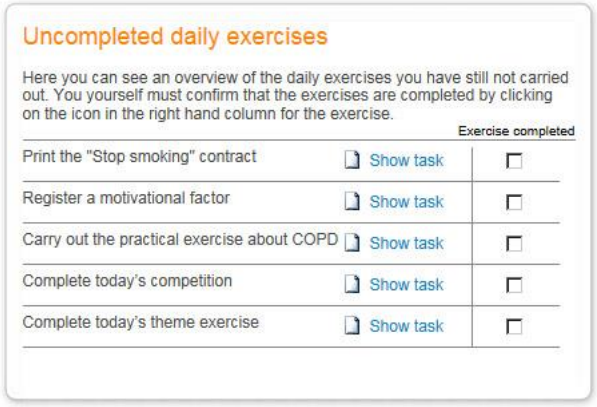

Figure 2 - Screenshot from FFN showing uncompleted daily exercises (assignments)

Gamification is an important design feature of FFN and components such as game points, levels and a high score list are key elements. There are three levels corresponding to the phases of the course described above. The user is not allowed to advance from one level to the next unless certain requirements are fulfilled within given time limits. Upon failure to accomplish this, the user will be prompted to restart the course (equivalent to “die” in a game and restart from a given point). During the course, if there is a risk that this situation may occur, the user will receive warnings and will be advised on how to avoid failing. To monitor user activity and provide feedback, FFN uses the total game points achieved so far and compares this to the ideal sum a user could have achieved at this stage (Figure 3).

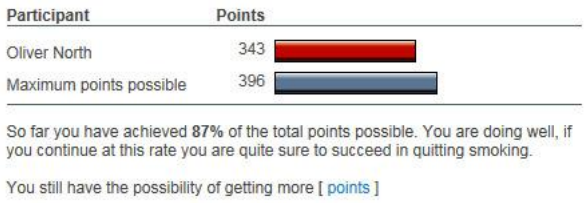

Figure 3 - Screenshot from FFN showing the participants game points compared to maximum points possible

Each day of the course the participants can achieve a given sum of points, hence game points is a good indicator for degree of participation. The percentage of total possible points achieved is used to evaluate progress and participation (Figure 3) and give feedback and follow-up the user. For example a low percentage over time may indicate lack of motivation of a user that is less likely to quit smoking at this stage in life and the user should be informed that he/she should restart at a later time when they are more motivated.

FFN uses game points to enable competition both between individuals and groups. Single users can compete against themselves by trying to achieve the highest score possible at all stages (Figure 3) and for those who participate as part of a group, the scores are presented so that the group members compete against each other.

The course program in FFN is built up as a series of different type of assignments that the user has to complete (Figure 4). Some typical examples of tasks are:

- Print out and sign a “Quit Smoking” contract with friends and family
- Different types of practical exercises (one example is the practical exercise about chronic obstructive pulmonary disease COPD ((NIH 2015) where the users has to breathe through a straw for ten minutes)
- Theme days where the user learn more about various topics and must answer questions to prove that they have understood the topic
- Writing about different topics in the forum
- Register and working with their motivational factors (a recurring task throughout the course)
- Competition on knowledge of smoking-related questions (quiz)

4. Design principles for freeFromNicotine

There are different principles and considerations behind the design of FFN and the assignments that are given in the duration of the course, and in this paper we will focus on the gamification aspects, which are based on the following principles:

1. FFN shall be designed as a game where users have the opportunity to compete against themselves or others in completing the course (competition)
2. The course can be tailored to individual users smoking habits and life situation
3. The course program shall be composed of various theoretical and practical tasks (assignments) that the user must perform each day of the course
4. All users should have the possibility to participate in the overall competition on equal terms
5. It shall be possible to earn points (compete) each day of the course
6. It must be easy to add and remove tasks

Requirement 2, 3 and 6 led to a module based framework with a core “skeleton” to which modules are attached. The framework includes the overall behaviour such as which modules each user shall perform on each given day of the course, user data, game points, leader boards, dependencies

between the modules, the progress of the course, the user interface etc. The modules are the individual assignments users have to perform and modules are connected through a common interface. This module based design is illustrated in Figure 4.

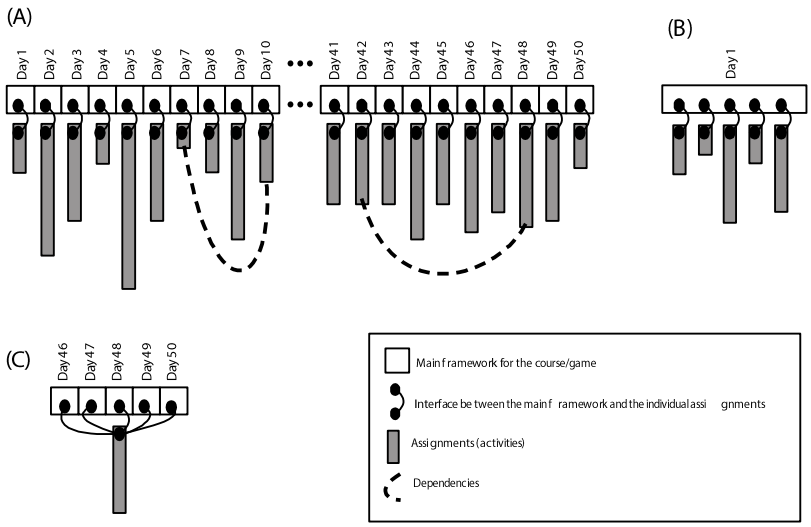

Figure 4 - FFN framework and modules (module based design)

In Figure 4A we see the 50 day long period with assignments for each day of the course. The dotted line illustrates dependencies between assignments for example the assignment given on day 10 is depended on how the user completed the assignment given on day 7. Figure 4B illustrates that there can be many different assignments given on the same day and Figure 4C illustrates that the same assignment can be given on many different days of the course. The different length on the assignments illustrates that some are small and easy to complete and others require more effort. The course program can be tailored to each user (requirement 2) by selecting assignments from a pool when generating personal course programs. Assignments can be chosen according to information each user register about smoking habits and specific life situation. Each tailored course program consists of only a selection of the assignments available in the pool.

To provide the possibility for all users to participate in the overall competition on equal terms (requirement 4) the principle of *core assignments* and *individual assignments* was introduced (see Figure 5). C*ore assignments* have to be performed by all participants and generate game points (requirement 1) when completed. *Individual assignments* do not generate game points. This design enables users to compete on equal terms since all users have the *core assignments* as a part of their course (requirement 4). *Individual assignments* are given to users based on their smoking habits and personal life situation hence it is the *individual assignments* that are used to tailor the course to each users preference (requirement 2). To ensure that the users perform all assignments in their course and not only those that award game points, users are not told until after the assignments were completed how many game points (if any) this assignment generated. Any given day of the course may consist of at least one *core assignments* and zero or more *individual assignments* (req. 5).

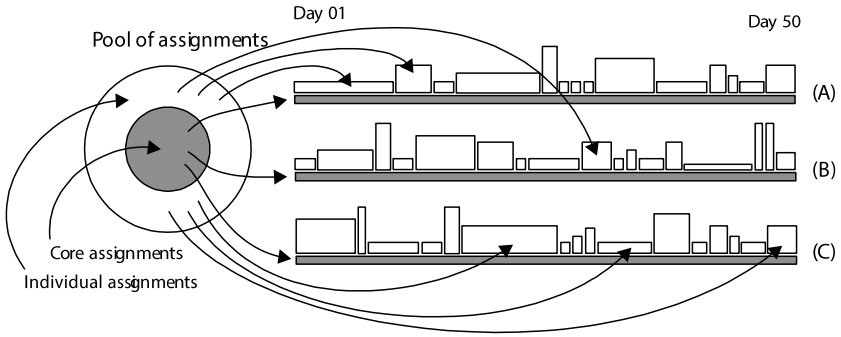

Figure 5 - Pool of assignments and three individually tailored course programs

Figure 5 illustrates how the course program from day 1 to day 50 is tailored to individual users A, B and C by a combination of *core assignments* (the grey areas) and *individual assignments* (the white areas) selected from a *pool.*

The fact that there is a "solid core" of scoring assignments (core assignments) also means that there is a fixed maximum score for each day of the course. This is used as a control mechanism to measure how well the user is conducting the course (Figure 3) as described in section 3. To motivate the user to participate in the course as it is designed, the highest score is given for *core assignments* completed the same day as they are given. A lower score is given for assignments completed a day after and even lower after two days. After more than two days the user will still have the opportunity to complete the task (Figure 2) but without being rewarded.

The diversity of assignments used also means that gamification can be applied to many types of normal everyday activities such as "*The user is from this day not allowed to smoke inside his/hers home and must now go outside to smoke. The task of today is finding an outside spot where the user has to go to smoke and the apartment/house must be properly cleaned to remove all odours of smoke*". This assignment is a part of the *habit breaking phase* and is a game point awarding assignment. However, there is no means to automatically detect that this task is performed and the system relies on the user being honest when these assignment are marked as completed. The completion of other types of assignments such as "*writing in the FFN forum*" or "*writing in the users personal journal*", can be automatically detected and will contribute to the feeling of interaction and feedback.

5. Participants, methods and procedure

A total number of 255 persons registered as users. Out of these 74 had no activity and no user data generated. The final data is collected from the activity of the remaining 181 users (n_{DB} = 181). This includes all types of activity logs from a variety of usage patterns ranging from the ones that only logged in once and performed none or few tasks to users that logged in every day and completed all tasks and assignments they were given. The collected data is gender and age neutral and depersonalized, but all data can be connected to the specific user that generated the data. The following types of data have been analysed:

- The users personal journal (each day each user was given the assignment to write about their thoughts about quitting smoking, difficulties experienced, how they stay motivated, personal issues and whatever is on their mind)
- The discussion forum (the users were in the duration of the course given assignments to write and discuss different topics in the FFN forum, the postings were anonymous).
- General user activity (game points, how many times they have logged in, progress etc.)

Users finishing the course were asked to complete a questionnaire about their experience and suggestions for improvements. 14 users (n_Q = 14) answered this voluntary questionnaire and even though such a small sample does not allow for statistically significant results, the analyses of responses of the open-ended questions may still provide an indication of the users' opinion about the competition aspect and the course in general.

In depth interviews were conducted with the person (n_i = 1) who was in charge of the development and maintenance of the system. The interview mainly dealt with the design of the system, the effect of using gamification and lessons learned while the system was online and running.

6. Results and discussion

The company behind FFN experienced that the course was successful in order to support smoking cessation, but found it very difficult to generate a profit. Different business models were tried in order to make it commercially profitable and the product was advertised on the Internet, national TV and national radio. Licenses were sold to individuals and businesses that wanted their employees to quit smoking, many licenses where given away for free as advertisement and different price and payment models were tested. There are many possible reasons for the lack of commercial success. A main reason could be that people (at this time) expect products on the Internet to be free of charge.

When analysing the data we see that the users can be divided into three groups; *the curious*, *the opportunist* and *the motivated*. *The curious* are the ones that got a free license and logged in once or a few times just to see what it was all about maybe without establishing any dedication to actually follow the course. *This was* the largest user group. The second largest group are the *opportunist*s, who also got a free licence, but registered and showed a higher level of commitment. However, they did not follow the course as intended; did not log in every day, and most of them failed to complete. *The motivated* is the smallest group and includes those that signed up, showed a high level of commitment by logging in every day and completed the tasks and assignments given throughout the whole period of the course. More than 50 percent of the participants in the motivated group managed to quit smoking and when analysing the achieved game score in this group we find that all of the users achieving 80% or more of the total game points managed to quit smoking. Knowing that less than one out of ten manage to quit smoking without help (ACS 2014), this indicates a success in assisting people to quit smoking.

The quotes in Table 1 are taken from the users' personal journals by analysing a total of 1242 diary entries from 181 users. The quotes are a representative sample of the quotes that expresses an opinion on the competition element of FFN.

Table 1: Quotes from the course participants personal journals on the topic of the competition element in FFN (the users are marked A – G for referral purposes only)

A	*I shall win the internal competition at my workplace; I have a competitive instinct that no one can match.*
B	*I performed poorly in the competition today and I feel that that was a bit demotivating. I must work harder to stay on top in the competition.* *I become so angry when I answer wrongly on the quiz. I want to be on top!* *All of the answers were correct in today's quiz, hurray!* *Hooray, I didn't smoke and I got all of the points today.*
C	*I am getting more motivated when using FFN. I am a competitive person and I think this group pressure is helping me.*
D	*Amazing how competitive I am. I was actually disappointed when I answered wrong on two of the questions today, I did not like the thought that I wasn't on first place in the competition.*
E	*My wife is catching up with me. I want to win.* *I forgot to mark the tasks as completed yesterday! Lost a lot of points. Not good.*

F	*I am going to a party tomorrow and I must keep from smoking so I will get the extra points for not smoking.*
G	*I hate this assignment. If it was not for the game points I would not have done it.*

The quotes in Table 2 are taken from the answers to the open-ended questions in the questionnaire that the users where given on day 50 of FFN (answering the questionnaire were voluntary). The quotes are a representative sample of the quotes that expresses an opinion on the competition element of FFN.

Table 2: Quotes from the questionnaire (Day 50) on the topic of the competition element in FFN (the users are marked H – N for referral purposes only)

H	*.. I think that the assignments and the competition are motivating.*
I	*... I was surprised on how motivated I became by the questions, the daily tasks and the competition.*
J	*... It was fun to be able to get points; it immediately becomes fun to quit smoking.*
K	*... I think the assignments with the quiz where you had to search the Internet to find the answers where quite difficult and I was often unable to find the answer which was a bit demotivating for me. Otherwise I am very happy with the course.*
L	*... I liked the theme days and the competition. It was very motivating to be able to get as many points as possible.*
M	*I was very "triggered" by the competition to get the most points possible. Then you certainly could not smoke because you lost too many points. Obviously it was my own smoking cessation that was most important, but it became important for me to do well in the competition.*
N	*For me, the competition has been a huge motivational factor. I have worked diligently to be on top of the high score list. But at the same time, I was also demotivated the times that I was not able to stay on top of the list.*

The quotes in Table 1 and 2 clearly illustrates that the competition was a high motivational factor. All of the quotes indicates that the competition/gaming element of FFN where perceived as important by the users and that they were motivated by the competition. Just as important as the positive quotes in Table 1 and Table 2 is the fact that we were unable to find any negative comment about the competition element in FFN in any of the data from the 181 users we analysed. The negative comments (user B, K and N) are not related to the use of gamification in FFN but that the competition element is so important for these users that they feel a bit demotivated when they are not doing as well in the competition as they would like.

One motivation for applying gamification in FFN was also to motivate the users to complete all of the assignments – even the assignments they don't like. The quote from User G in Table 1 clearly illustrates that the gamification element of FFN motivated users to perform the assignments that they would otherwise not have done. Getting the most game points possible by completing the assignments the same day as they were given also seemed important to the users. This is illustrated by the quote from User E in Table 1 that is upset because he forgot to mark an assignment as completed the same day as it was performed and thereby lost a lot of game points.

The nature of the assignments in FFN where some assignments are automatically detected as completed and some assignments must be marked manually by the users as completed, is a design choice that provides possibilities for cheating. However, the analysis of the user data from the database does not indicate any sign of users trying to cheat. For example, the users are awarded with game points when they write in their personal journal, but FFN does not check whether the user has written a meaningful text. FFN just counts the number of characters and assign game point to the user when a specified number of characters are written. Hence users have the opportunity to cheat by entering a meaningless text phrase such as "asdfasdfasdf" to gain game points. However, the analysis

of the personal journal notes in the database shows that all of the 1242 entries consist of meaningful texts. The same applies to the texts that the users where assigned to write in the FFN forum. From this we conclude that it does not appear that the users have applied cheating as a strategy to gain game points and we assume that the same honesty prevails when it comes to marking an assignment as completed and that very few (if any) will mark an assignment as completed if the task is not done.

The design choice of *core assignments* and *individual assignments* where it was only possible to gain game points by conducting the *core assignments* (to enable competition on equal terms and using the users total game score as a control mechanism), seems to be successful. As described in section 4, for most of the assignments the users don't know if they will receive game points or not until after the assignment is completed. None of the users have made any comments about not receiving game points when they have performed an *individual assignment* hence it seems like the principles of *core assignments* and *individual assignments* was accepted by the users.

7. Conclusion and future work

The main contribution presented in this paper is a gamified smoking cessation course based on a highly reusable design *core* and *individual assignments* design approach which enables both tailored courses for each individual user and competition on equal terms between the users.

The *freeFromNicotine* course demonstrates that a gamification approach where everyday activities are included in the game as assignments is a promising approach for including everyday type of activities in a game. Analyses of user data indicate that users are honest when they mark assignments as completed and that cheating is not applied as a strategy to gain game points. The possibility to rely on users registering correct information makes it easier to include everyday tasks in learning games.

Being a pervasive game that lasted for 50 days FFN could have provided facilities for supporting "in-game-awareness" which has proven to be an important property in order to increase player participation in pervasive games (Pløhn, Louchart et al. 2014). Furthermore, FFN was conducted without a game story. Research has shown that the use of a game story may help to increase both player participation and player motivation (Pløhn and Aalberg 2014, Pløhn, Louchart et al. 2014) and designing and applying a suitable game story to FFN may have helped to motivate the users.

The design principles used in FFN and presented here can easily be adapted and implemented in other types of learning games where there is a need to provide individually tailored courses while using gamification and competition as a motivational element.

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Paper VI

A Dynamic Bonus System to Increase Player Participation in Pervasive Learning Games

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Abstract: A pervasive game blends gaming with the real world and makes the experience pervasive according to the players' everyday life. Pervasive games typically last for days or weeks and have successfully been used within advertising and social relationship building. A pervasive learning game intentionally removes the walls of the classroom and makes learning something that happens everywhere at all times. However, lessons learned in previous research on long-lasting pervasive learning games have shown that not all players/students participate enough in the game to achieve the desired learning outcome. The-Last-Shall-Be-The-First (TLSBTF) is a method to overcome this problem by rewarding players that activate passive players. Activated players also receive special bonus that – given that they from this point on actively participate in the game – gives them the opportunity to get ahead and even win the game. The method has shown promising results in experimental long-lasting pervasive learning games. In this paper, the method is refined and presented as mathematical formulas. Formulas make it easier to integrate the method into similar types of games. Another important contribution is the clarification of the elements of the model behind the method that makes it easier to conduct research on the effect of the individual parameters in relation to increased player participation in long lasting pervasive learning games. Furthermore, the mathematical formulas presented in this paper, provide a good platform for further development of the TLSBTF method. The main contribution of this paper is the presentation and description of the mathematical model that make up the dynamic TLSBTF bonus system method.

Keywords: Pervasive games, Education, Serious games, Player Participation, Dynamic Bonus System

1. Introduction

The game Pervasive Clue from 2001 is probably the first to be labelled as pervasive (Nieuwdorp, 2007, Schneider and Kortuem, 2001). According to (Montola et al., 2009), the name "pervasive game" was coined in the same year – to categorize alternate reality games such as The Beast (Beast, 2020). For some years this has been described as a new and emerging genre and many different games, activities and experiences have been labelled and defined as pervasive. Even though the terms pervasive game and pervasive gaming are widely used, there is no unifying definition. Different researchers approach pervasive games from different perspectives, defining the term based on the technology that enables the game to be played, or the game itself (Nieuwdorp, 2007). The work presented in this paper uses the following definition of a pervasive game:

A pervasive game is a game that is pervasive according to the player's everyday life.

This definition removes the technological aspect and links the definition to the player and the player's daily life. This means that pervasive gaming is not limited to the contractual space of the traditional magic circle of gameplay, the technology used or the physical location where the game is conducted, but deduces that participating in a pervasive game influences the player's ordinary life directly (Montola, 2005). It can be argued that this is an incomplete definition since the term *pervasive* is used recursively, however, for a game to become pervasive it has to be pervasive according to something.

Lessons learned when using pervasive games within the field of game based learning has shown that in games that last for a long time, for several days such as HiNTHunt (Pløhn and Aalberg, 2013) or several months such as Nuclear Mayhem (Pløhn, 2013), some players are less motivated and therefore participate less. This is of course problematic as it influences the learning outcome. There may be many reasons why some players are less motivated or for other reasons choose to not participate actively in the game. One reason that was identified during the two runs of the experimental pervasive game HiNTHunT, a game designed to be used the first week of the academic year to prepare new students for their new life as students, was that some players lost their motivation because they were late to start the game and then discovered that other players already

were far ahead. The following quotes from the questionnaire that players had to fill in after completing HiNTHunt, identify that several players lost motivation because they had a bad or delayed start and consequently fell behind other players in the competition (quotes are translated from Norwegian):

- *"I found the game a bit messy at first, and once I understood the game, the others were far ahead. So, I decided not to play."*
- *"The reason why I did not play the game as much as I was supposed to was that I got off to a bad start."*
- *"I got off to a bad start since I had some problems with the Internet on the phone. The others eventually came so far ahead that I lost interest in the game."*
- *"Started at school later than the rest and was therefore too late to participate properly in the game."*
- *"If I had played it from the very start, I would probably have played it more."*
- *"For me to participate more in the game I would have needed a better start."*

As a means to engage passive but initially motivated players, we designed "The-Last-Shall-Be-The-First" bonus system (TLSBTF). This is an approach to give passive players a chance to advance from the bottom to the top of the result list given that they become engaged in the game afterwards. TLSBTF is designed primarily as a means to increase player participation in pervasive learning games but may also be useful in other games with similar characteristics.

Our paper is organized as follows. In section 2 we provide an overview of related work. In section 3 we introduce how TLSBTF was implemented using a static model in the game HiNTHunt and present some experiment results. In section 4 we present a dynamic model of TLSBTF using variables from the game and the overall state of the game. Finally, we conclude and suggest further work.

2. Related Work

Two terms that correlate directly to the level of player participation in games are *player engagement* and *player enjoyment*. If a game is perceived as a fun game to play, players are more likely to spend time on the game. A systematic review examining how engagement has been measured and defined is presented by Hookham and Nesbitt (Hookham and Nesbitt, 2019). They describe engagement as a multi-dimensional construct and define a three-part framework looking at the cognitive, behavioural and affective dimensions. Three primary uses of engagement are identified: engagement referring to use (the player is engaging in or with an activity or game), engagement referring to a player state (the player is engaged), and engagement referring to the property of a game or object as engaging.

Enjoyment in games is often discussed in the context of The GameFlow model (Sweetser and Wyeth, 2005) which is a model that maps elements of gaming to (Csikszentmihalyi, 1990) elements of flow. Work done on evaluating the GameFlow model in relation to pervasive games as a means to understand player enjoyment in pervasive gaming (Jegers, 2007), concludes that the GameFlow model is appropriate for gaining understanding of player enjoyment in pervasive games. This led to the outline of a model – the Pervasive GameFlow model – that can be used as both heuristic guidelines for designers and as evaluation criteria in user-centred evaluation of pervasive games (Jegers, 2009).

The use of virtual characters in serious games has shown to have a significant positive effect on player engagement (Gamage and Ennis, 2018), however this is not a design strategy for pervasive learning games where much of the game play takes place in the real world and the players play as themselves.

Several approaches have been used to try to increase player participation in pervasive games such as storytelling (Pløhn et al., 2014), awareness reinforcement (Pløhn et al., 2014, Pløhn and Aalberg, 2014), group competition (social pressure) (Pløhn and Aalberg, 2014). The Pervasive GameFlow model consists of eight core elements and HiNTHunt – the game where we have implemented The-Last-Shall-Be-The-First-Bonus-System (TLSBTF) – is designed according to these elements (Pløhn and Aalberg, 2014).

3. The-Last-Shall-Be-The-First Bonus System

The main purpose of The-Last-Shall-Be-The-First-Bonus-System (TLSBTF) is to target the group of passive players that would have been motivated to participate actively in the game if they had got off to a better start.

The main hypothesis is that if a passive player gets a bonus that outweighs or cancels the negative effect of a bad start, he will assert himself in the competition as much as players that got a good start. Players that participate actively in the game from the moment they have been targeted by the TLSBTF system, will be transformed from unmotivated to motivated players resulting in overall increased participation in the game. The main strategy behind TLSBTF is to use motivated players to engage those who are less motivated, by providing a game mechanics to engage passive players to perform actions in the game. Hence, a prerequisite for the model is that some of the players in the game must be what we define as “eager players”, that is, highly motivated players who assert themselves in the individual competition and are willing to perform actions that award them game points. If this is the case, we can use “eager players” to trigger TLSBTF and target the passive players.

TLSBTF was implemented in the second run of the experimental pervasive learning game HiNTHunt to test if the above hypothesis and prerequisite were valid assumptions. In this experiment, TLSBTF was implemented as a static system where all game points awarded were constants hard coded in the implementation. All passive players received the same amount of bonus points if they were targeted successfully by TLSBTF, not considering their individual situation in the game competition. This value was based on an estimate of how many game points that would be “enough” for the passive player to advance significantly on the result listing. The eager player was also awarded with game points if they targeted a passive player successfully, but received significantly less points than the passive player. Ideally, the reward for an eager player should be as low as possible and just enough to motivate them to target a passive player. In this experimental run, the value was set to the same value as ordinary game related activities. Which players were considered as passive players was decided by the high score list at any given time. A list of the 10 least engaged players at the given time (passive players), was generated by picking the 10 players at the bottom of the high score list. They were presented as “bonus players” that could be targeted by other players to gain bonus points. Hence, the size of the group of bonus players was also a constant value and not adjusted for the overall number of participants or any other variables in the game. In the game, there was both an individual competition and a group competition between two school classes and the bonus list was generated without regard to group competition. The bonus list consisted of the ten bottom players in the individual competition regardless of which group they belonged to.

How to generate the group of bonus players, the size of the group, which players should be part of the group, and how it should be organized to not have an unwanted or negative effect on other parts of the game or the competition, requires more work and more research. However, in terms of testing whether TLSBTF would have an impact on player participation, this way of generating the bonus list was an adequate solution.

TLSBTF was implemented in quite a simple way in HiNTHunt. The game client showed a list of “bonus players” that active players could attempt to engage by performing a game related activity. This activity consisted of getting the passive player to register a unique code that was generated by clicking the passive player’s name in the bonus list. When the action was completed successfully, both players received game points, but the passive player received significantly more bonus points than the active player. The process is illustrated in Figure 1.

Figure 1 - (A) The dynamic bonus list shown in the game client (the names have been redacted due to privacy rules). (B) The active player has clicked on one of the passive players listed and revealed a five-digit unique code that the passive player has to register in his/her game client. (C) The passive player is registering the code in his/her game client after being told the code by the active player.

In the first run of HiNTHunt (without TLSBTF), 49 students registered as players and in the following year, when TLSBTF had been implemented, 45 students registered as players. All players had to fill in a quantitative questionnaire and data was also gathered by analysis of system logs of player activities and by observations. In the duration of HiNTHunt, TLSBTF was successfully used 111 times. Analyses of data from the questionnaire and log files suggest that passive players that were successfully targeted by the bonus method, became more motivated to participate in the game.
Analyses of log files showed that they became more engaged in the ordinary game play (collecting diamonds) compared to the previous year. Replies in the questionnaire also suggested that they became more motivated to participate in the game. 63,3% stated that being targeted by bonus system made them more motivated to play the game. So, even the simple and static implementation of TLSBTF in HiNTHunt, shows that it is a promising method to increase player participation and to transform passive into active players. However, there were some unintended effects and problems that need to be addressed.

For new students who did not yet know each other by name, TLSBTF use was less than optimal because it was difficult to identify players on the bonus list (which only displayed names of the players). This problem can easily be addressed, for example, by requesting players to upload a picture of themselves in the game and display this picture along with the name when a player is targeted.

A more fundamental challenge is that the bonus system influenced the intended normal game play in a negative way. Regularly collecting diamonds became less important as a game play strategy and some actively chose not to participate in the game in order to be targeted by TLSBTF as much as possible. Then towards the end of the game, they would collect all remaining ordinary game points. The player that came in second in the individual competition, and several others, followed this strategy. To avoid this, the amount of bonus that passive players receive must be adapted to the overall situation in the game. Active participation in the ordinary game play from start to finish, should always be the most rewarding strategy. To achieve this, the bonus must be dynamically adjusted based, for example, on the passive players' situation, the other players' situation, the status of the game in relation to how many game points have been awarded and how many possible game points remain in the game.

Another challenge we faced was that the group competition in HiNTHunt had an unintended effect on the bonus system and caused it to be activated less than optimal. As described above, the bonus list was generated without considering the group competition. The 10 bottom players from the high score list were presented as "bonus players" that could be targeted by other players. However, because the group competition was perceived as important, active players were reluctant to target "bonus players" in the other group to avoid giving extra points to others. Possible strategies to solve the problem of group competition having a negative effect include ignoring bonus points awarded in the group competition. Unfortunately, activating players in the opponent group will still be unfavourable because the activated player will start collecting regular points.

Another strategy might be to generate bonus lists for each group containing only players from the same group. This, however, removes the group competition reasons for activating passive players. Size of the groups is another issue that needs consideration. Two groups of different sizes should maybe have different number of bonus players presented on their group bonus list or perhaps a more just solution would be for the bonus list to show a percentage of bonus players according to the size of the given group.

It is obvious from our experience that the proposed TLSBTF bonus systems need to be carefully designed and adapted to make up a fair system that contributes to the overall purpose of the game, which is to motivate and engage all students. The bonus system should not dominate as a game play strategy and thus have a negative influence on the main game play, and the bonus system needs to function well together with other game elements such as group competition. Which solution that is optimal is not known, and is a topic that needs further research.

4. The-Last-Shall-Be-The-First Dynamic Bonus System

To develop TLSBTF further and make it suitable for different pervasive games, it must be changed from a static model designed for use in one specific game, into a dynamic model that uses commonly found variables to adjust and calibrate itself according to the changing state in the game. A dynamic TLSBTF model will also provide better opportunities to conduct research on the effect it has on player participation as well as allow for further systematic development of the method. The refinement from a static model to a dynamic model that can be implemented in other pervasive games is presented in this chapter.

In order to design a dynamic TLSBTF model, we must first identify variables that commonly will be present in such games. Then we need to investigate if these can be used to construct a model that makes the bonus system dynamic in relation to the game situation at any given time. At the same time we need to be able to use the variables to optimize for ordinary game play combined with effective use of the bonus system to activate passive players.

We have analysed the long-lasting pervasive games HiNTHunt and Nuclear Mayhem and identified the following variables that commonly will be present in long-lasting pervasive games. A selection of the most significant variables is shown in Table 1.

N_a	Number of active players
N_u	Number of passive players
N_{tot}	Total number of players
NP_g	Total number of players in a given group g when there is a group competition
P_M	The score of a motivated player at a given time t
P_U	The score of an unmotivated (passive) player at a given time t
HS	Highest score in the high score list at any given time t
HS_{min}	Lowest score in the high score list at any given time t
HSG	Highest score in group g in the high score list at a given time t
HSG_{min}	Lowest score in group g in the high score list at a given time t
MAX_{end}	Maximum number of points possible in the game from start to finish if one gets all the points
MAX	Maximum number of points possible in the game from start to a given point t
REST	Available remaining points for a specific player
BG	The number of P_u to be included in the bonus group
BG_g	The number of P_u to include in the bonus group from a given group g if the bonus list shall be group orientated (it's not certain that all groups should have the same size)
t	A given time t in the game
t_{total}	Total duration of the game from start to finish (if the game has a defined end time)
t_{rest}	The remaining time from t to t_{total}
BG_g	Number of players in BG (bonus group) for group g
BG_{gmax}	Highest score of the players included in the bonus group
BG_{gmin}	Lowest score of the players included in the bonus group
MP_{limit}	When a P_u receives a bonus boost, he/she must not get higher up on the high score list than MP_{limit}

Table 1 – Identified variables present in all types of long-lasting pervasive games

The game HiNTHunt2013 used a set of *constant bonuses* for the players involved in a successful TLSBTF interaction. The aim of the current paper is to extend this to a *dynamic bonus system* by introducing a mathematical ratio model. The model is based on elected variables from Table 1 and the overall game situation illustrated in Figure 2.

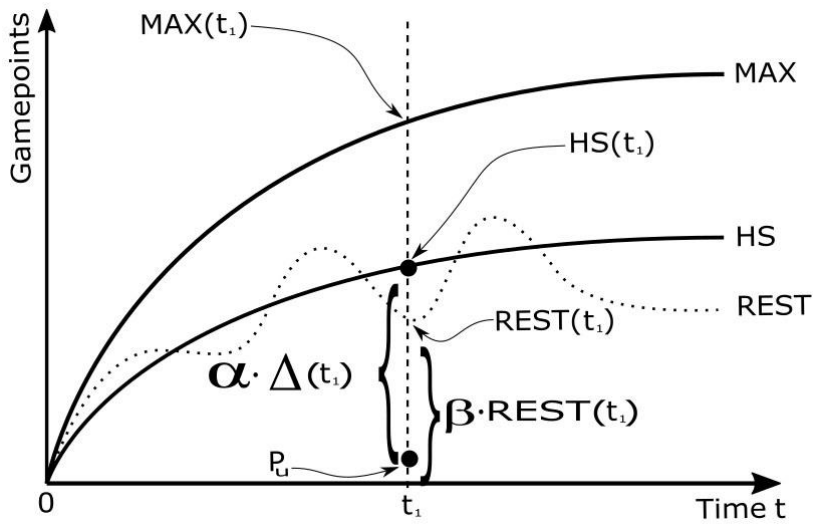

Figure 2 - Illustration of the relevant variables at a certain game state at the point where the unmotivated player receives a bonus based on these variables.

The game starts at t=0 at the left side of the figure and evolves from left to right as t increases. MAX illustrates the maximum point a player can get if he/she plays the game perfectly and collects all possible game points. HS is the high score in the game at any given time. REST illustrates the available remaining game point at any time for a specific player. REST fluctuates because some game related activities are available for only a limited time in the game and when the activity is no longer available, the associated game points will become inaccessible. While MAX and HS are general for all players in the game, REST is specific for the unmotivated player. The unmotivated player receives a bonus at time t1.

While the bonus system of the earlier versions of TLSBTF was based on constant bonus values at the time of interaction (t1), we now want to describe the mathematical model that takes account of the relevant variables in the game described above. Data from real time playing in specific games is needed to set the values for the parameters α and β described in our model.

In our model we use the variables REST and HS (as illustrated in Figure 2) because they are natural limit values for any bonus system at any time and their values can be used to calculate a bonus at any particular time. The calculation of the bonus is based on calculation of two different values, one for each of the limit functions $\alpha\Delta(t_1)$ and $\beta REST(t_1)$ as shown in Figure 2 above. To prevent TLSBTF from becoming a preferred strategy over ordinary game play for winning the game, the awarded bonus to the passive/unmotivated player P_u will be the minimum value of these candidates (bonus1, bonus2).

At time t1 when TLSBTF is activated, the unmotivated player P_u receives a bonus. An alternative to a constant bonus system is to take into account the actual scores in the game at that time. To do this we use a ratio model based on the score of the unmotivated player constrained by the two different limit values of these variables at time t1.

First, we consider the high score variable HS. At the time of interaction between the two players, the score of the unmotivated player is $P_U(t1)$ and the high score at this time is HS(t1). The bonus must then be a percentage

of the distance, Δ, between these values but not higher. If the bonus is higher, the unmotivated player will move to the top of the high score list, which will demotivate the other players. To prevent this situation, the first candidate for the bonus, bonus1, should be a fractional part of this distance decided by α, hence bonus1 will be:

$$\Delta = HS(t1) - P_U(t1)$$

bonus1 = α (Δ), where α is a positive number less than 1.

HS(t1) is used as a limit value in our calculation of the bonus, where the scale line $P_U(t1)$ to HS(t1) is the relevant quantity for the calculation of the bonus.

Next we need to consider the other limit function; the rest score function bonus2. This function gives information about the available game points for the unmotivated player, REST (see Figure 2), in the game at any time. The reason we consider this value is to prevent that TLSBTF becomes a winning strategy above ordinary game play. The logic for this function is similar to the one for the high score function. At time t1, the passive player has score $P_U(t1)$ and the rest score available in game for this player is REST(t1). If the player is awarded a bonus higher than this, TLSBTF would be a winning strategy before ordinary game play, which is an unwanted result. Instead the bonus2 for this limit value is calculated as follow:

bonus2 = β REST(t1), where β is a positive number less than 1.

To ensure that the bonus received by the unmotivated player is lower than both of the limit values, the final value used is the minimal value of the two values we have calculated above. That is, the bonus awarded to P_u is given by:

Bonus = MIN(bonus1, bonus2)

Bonus = MIN(α (Δ), β REST(t1))

The new score of the unmotivated player after the interaction is then:

$$P_U(t1) = P_U(t1) + MIN(\alpha (\Delta), \beta\ REST(t1))$$

The values of α and β must be decided for each specific game where this dynamic bonus system is implemented.

5. Conclusion and future work

The main contribution of this paper is the refinement of The-Last-Shall-Be-The-First method from a static model, initially implemented for one specific game, into a dynamic model that can be implemented and used in most, if not all types of long-lasting pervasive games. This paper has described the model, the challenges, and how to use variables common in all long-lasting pervasive games to construct mathematical formulas for calculating TLSBTF scores in run-time. As a result, we have a dynamic model that can be explored in further research and development of the TLSBTF method, as well as research on the effect of the individual parameters on player participation. Scoring functions based on this model are easy to implement and can be developed further in other long-lasting pervasive games.

We have identified some problems when using group competition and TLSBTF simultaneously in a long lasting pervasive game to increase player participation and have suggested some solutions, but this area needs further work, especially on how to implement TLSBTF and generate the bonus list without causing the group competition to have negative effect on TLSBTF or the opposite. These problems need to be addressed in future research and development of the TLSBTF method.

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