



Norwegian University of
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Game Mechanic based E-Learning

A case study

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Master of Science in Computer Science

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This project will focus on making a prototype of an E-Learning system utilizing game mechanics. The goal is to make work with exercises more engaging, motivating and fun. The project will also seek to evaluate the interest among users for such a system. The prototype will be implemented in the web application framework Ruby on Rails. The work will entail both interaction with users, design, programming and evaluation. The major technological delivery of this project will be a dynamic website.

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Supervisor: Arvid Staupe, IDI

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Abstract

This thesis presents a case study of Game Mechanic based E-Learning. This is put forward as a new approach to E-Learning that tries to mimic games to harness some of their motivational properties. A prototype system was developed as a web application, using an Agile and Lean development approach. The system was evaluated with a class at the Norwegian University of Science and Technology. This was done to give an indication of the system's ability to make work with exercises more engaging and fun. To give context in this thesis, the growing trend of Gamification is unveiled and explained in detail.

The major technological delivery posited by this thesis was the prototype, implemented as a web application (dynamic webpage). The major research achievement was evaluating respondents' perception of the system. It was discovered that the chosen Game Mechanic was indeed considered to make work with exercises more engaging, although this effect was marginal. The evaluation was also used to arrive at a general definition for games. This definition can be used to distinguish Game Mechanics based systems from games. It also serves as a much needed guide to designing games and non-game systems that tries to achieve similar motivational benefits as games.

Preface

This is a Master Thesis in the field of Game Technology, as part of my degree in Computer Science at the Norwegian University of Science and Technology (NTNU). My specialization is in the field of ICT and Learning, at the Department of Computer and Information Science (IDI), in the faculty of Information Technology, Mathematics and Electrical Engineering (IME).

In the work with this thesis there have been several people that have assisted me and made my work possible. I would like to direct a special thanks to my supervisor, associate professor Arvid Staupe, for continuous feedback, guidance and discussion.

My work would also not have been made possible if it wasn't for the help of Yuming Jiang, the subject teacher in TTM4100 - Communication Services and Networks at NTNU. He has been very forthcoming and helped in administering the evaluation of the system developed as a part of this thesis. Furthermore, I would like to give a wholehearted thanks to all the students in his subject, who participated in testing the system and gave me feedback underway. Special thanks goes to the subject teaching assistants Olav Nymoen and Anders Nordbø, and student Halfdan Bondevik, for participating in the usability testing, and providing valuable feedback.

Finally, thanks are in order for fellow student Ole Johan Væringstad for invaluable help in integrating necessary frameworks and administering the server. Thanks also goes to NTNU and Gurutjenesten for access to use their facilities for the server.

Trondheim, June 13th, 2011

Magne Matre Gåsland

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Glossary of important terms

Game Mechanic *An element of a game that is made up of a set of rules and feedback loops used to incentivize the player. Common Game Mechanics are Items, Levels, and Points.*

Serious Games *Games that have pedagogy as the primary goal, and fun and entertainment as secondary.*

Web 2.0 Technology *Technology that facilitates production of content, sharing and collaboration through social networks.*

Web Application Framework *A web application framework is a software framework that is designed to support the development of dynamic websites, web applications and web services (from Wikipedia). Examples of types of sites that could be developed with the help of such frameworks are for instance Facebook, Google Docs and Gmail.*

Learning Management System (LMS) *Administrative E-Learning systems that are commonly used in educational institutions.*

Introduction

1.1 Motivation behind the project

For years it has been recommended to support collective and individual learning processes by using E-Learning systems (Ramboell (2010); Norgesuniversitetet (2009)). Today, the existing E-Learning systems are to a large extent focused on course administration and facilitation, and less on the pedagogy (Kolaas et al. (2008); Norgesuniversitetet (2009)). Typical uses today include the teacher publishing messages and documents to the students, and students handing in assignments. The reason for this is that today's E-Learning systems (the Learning Management Systems, LMS) were created in the late 90's with that purpose in mind. Consequently, they lack extensive support for pedagogical tools, personalization and collaboration / user-to-user interaction. This has resulted in users all over the world voicing requests for an E-Learning system with inherent support for pedagogy (Graven and MacKinnon (2006)). As a possible solution, many people have suggested that E-Learning systems should draw more inspiration from social networks, and use Web 2.0 technology to a larger extent than today (Nordkvelle Ramberg, Kirsti Rye, Wilhelmsen, Janne (2009)).

At the same time, we find ourselves in an era where a generation of students have grown up with computer and video games. These games provide highly stimulating experiences, which shape the students expectations of education and learning (Henderson (2005); Prensky (2003)). This represents a great challenge for educational institutions, as students might find it increasingly demotivating with old learning processes.

In light of this, a great body of research have been dedicated to Serious Games; games that are created with learning as the primary goal, and fun or entertainment as secondary. Still, the development and application of Serious Games to real life educational settings have met several challenges (see section 1.5). The most important practical concern is the tangible benefit of the time students invest in playing them. The content in the games are often not all relevant for the exam, making the games more of a side-activity in a course. Since the exam often is written or oral, it might even be more efficient and applicable for students to study in a similar fashion. That leaves many Serious Games impractical to use in a real life educational setting.

But what if one could somehow extract some of the elements of games that make them fun?

1.2 Goal

My preliminary work on this thesis has revealed another approach than Serious Games and traditional E-Learning. It should be possible to use Game Mechanics to create an E-Learning system which gives a new kind of online learning experience. (Gaastrand (2010)).

The objective of this thesis is to create such a system. With some simple Game Mechanics it should be possible to create a more rewarding learning experience *around the existing course content*. The goal is to make traditional work with exercises (in the form of answering questions from the syllabus) slightly more engaging and fun. This will be done by utilizing a common Game Mechanic seen in many games.

The functional aim is to construct the system using Web 2.0 technology, to focus on cooperation and sharing amongst students. In my preliminary work, I evaluated potential Web 2.0 application frameworks. The best suited framework to implement the system at hand was found to be Ruby on Rails. Since I haven't programmed in the Ruby language, or used the Ruby on Rails framework before, the technological work will entail learning both. To demonstrate the basic principle behind Game Mechanics based E-Learning, the major delivery of this thesis will be a dynamic website.

The methodological aim is to develop the system from scratch, using a popular Agile software development methodology, and continuous user testing. The work will entail sketching, designing, and implementing a functional prototype of the system. During this process I will seek to gain user feedback, to ensure that the system will be intuitive for the end user. The work will entail interacting with various end-users.

Finally, the system will be tested in a university subject, to gain data on the practical implementation in a real life education setting. Preliminary talks with Professor Yuming Jiang have indicated that it would be possible to test the system in the TTM4100 - Communication Services and Networks subject at NTNU. The research goal will be to evaluate the students response from both usability tests and a questionnaire.

1.3 Research Questions

The primary focus of this thesis is to implement the proposed system, and highlight it as a case of Game Mechanics based E-Learning. Hopefully, this case can shed some light in the Game Mechanics approach to E-Learning. As a part of the thesis, I will seek to evaluate the system, to gain insights that might be elaborated on in future research. In that respect, there are some research questions which are especially interesting.

Q1: How usable and useful will students find the Game Mechanics based E-Learning system in this thesis?

The first criteria any E-Learning system should have to pass is that it's users find it both useful and usable. To evaluate how engaging or fun a system is, users have to use it, and be able to use it properly. In the first case, it is important that they find it *useful*, otherwise they aren't likely to use it, or will use it less. The second case is a case of *usability*. To gain the most valuable feedback on the fun factor, it is critical that the users are not obstructed by system flaws or software bugs. From talks with fellow researchers, I have also learned that even small visual design flaws might skew user feedback away from what one is trying to measure. In general, I will try to make the system as intuitive and simple as possible, to be able to harness the proper feedback. Feedback on the system's usability and usefulness will enable me to evaluate whether those factors were likely to have influenced the experience of fun.

Q2: How motivating can a simple Game Mechanic be when used as the basis for E-Learning?

There are several types of Game Mechanics available (see section 2.2). It could be tempting to combine several of these to try to create the most engagement possible. But this would likely lead to an inability to precisely measure how motivating each of the mechanics were. Instead, I will try to choose an appropriate and popular mechanic, and then evaluate how motivating that simple mechanic can be when used as the central element in an E-Learning system. The evaluation should be able to be deduced from user feedback. My hypothesis is that visual/on-screen progression feedback motivates students, and I will seek to implement a mechanic that will sufficiently provide that.

Q3: Where lies the difference between applying Game Mechanics to E-Learning and making a Serious Game?

E-Learning is a widely diverse field of different applications (see section 1.5). Serious Games (also called educational games) is one such type of application. Since Serious Games (as other games) contain Game Mechanics, it is natural to ask ourselves what the difference is between a Serious Game and a Game Mechanics based E-Learning system. This is not something that previous research have adressed, according to my preliminary work and knowledge. One could argue that a Serious Game is indeed a Game Mechanics based E-Learning system. However, this thesis tries to explore uses of Game Mechanics outside of games, in accordance with recent trend of Gamification (see section 2.3). But the borderline between the application of Game Mechanics and making an actual game is still considered as rather vague. In this thesis I will therefore try to explore where the borderline actually lies. Hopefully, it will be able to give some indication as to when a Game Mechanics based E-Learning system transitions into being a Serious Game. To shed light on this matter, one has to discuss what an actual game is, and measure what users perceive as a game.

1.4 Limitations

The scope of this thesis is to design, implement and evaluate a Game Mechanics based E-Learning system, and present and discuss the case in this report. Considering the work also include learning a new programming language, and how to program a web application, the scope of this thesis is already extensive. Therefore, there is some limitations to what this thesis will be able to uncover.

First of all, the evaluation and usability testing is done on a tertiary educational level (the NTNU university in Norway). Although it might be argued that students / pupils at lower educational levels are more susceptible and responsive to motivating factors, they are not the target group for this case study.

The deveopment work contained in this project is also performed in the same semester as the the NTNU course which will be used in the evaluation. It follows that the testing of the prototype in the educational setting cannot be done from the very start of the semester, but only after development has reached a functional state. The class will be given some time to test the system, and provide data for the evaluation. Depending on the time it takes to learn Ruby on Rails and develop a functional prototype, the process of evaluating it in the actual educational context might come towards the end of the the

semester. Although it is most desired to evaluate a finished system throughout an entire semester, with ample time to integrate it well into the subject course and to get data on its use, this is not considered feasible within the limits of this thesis.

Secondly, it is not feasible to test all Game Mechanics, or a combination of several of them. In my preliminary work I charted 47 different Game Mechanics, and made a detailed explanation of each of them (Gaesland (2010)). For this thesis I have chosen one of the most popular Game Mechanics, and explored it's use in a learning context.

The system presented in this thesis as the case study will not be representable as a full Game Mechanics based E-Learning system. It is meant to demonstrate some core principles, as a prototype and as a proof of concept. Inherent in this lies the realization that it will not be technically scalable or particularly extensible.

Finally, it would be in any researchers interest to aquire specific data on measurable learning outcome from using such a system. However, this requires a finished system to test, and could pose enough work for a doctoral thesis in itself. This is therefore sadly omitted. Since this thesis presents a case study, it is likely that the results won't be generalizable either.

1.5 The State of the Art

The state of the art of E-Learning was charted as a part of the preliminary work with this thesis (Gaesland, 2010). It is presented here to give a context of where the Game Mechanics based E-Learning system proposed in this thesis might fit in.

E-Learning is an ambiguous term used to describe a range of different solutions. Here I will attempt to give an overview over today's different types of E-Learning solutions:

1.5.1 *Different types of E-Learning*

1. **Lessonware / Computer Based Training (CBT)** - Software for instruction/tutoring.
2. **Learning Management Systems (LMS)** - Systems for administering formal education.
3. **Learning Content Management Systems (LCMS)** - Systems to author, edit and index E-Learning content.

4. **Computer-Supported Collaborative Learning (CSCL)** - Software where students collaborate to create and administer their own E-Learning material.
5. **Technology-Enhanced Learning (TEL)** - Tools to support/enhance learning.
6. **Courseware** - Digital publications of course material.
7. **Serious Games** - Games with a pedagogical purpose.

1.5.2 *Lessonware / Computer Based Training (CBT)*

Lessonware / CBT could best be described as a form of interactive and pedagogical course-solutions (Osin, 1990). They are normally designed as short stepwise courses with a mix of pictures, text, video and exercises presented to the user. Examples of suppliers of such solutions is IndustrialLogic.com¹ and RosettaStone.com².

1.5.3 *Learning Management Systems (LMS)*

LMS's are systems that are administrative support tools at educational institutions all over the world.

They give the teacher the opportunity to distribute files and information in relation to the course, and they also facilitate digital hand-in of assignments. The largest LMS's on the Norwegian market today are It's Learning and Fronter, and is being used by the majority of schools and universities.

1.5.4 *Learning Content Management Systems (LCMS)*

LCMS are systems working as a sort of container for reusable content for an entire enterprise. They allow for authoring, editing, indexing, and powerful search in digital content. LCMS are content-centric and are paramount to LMS's which operates at a lower level to facilitate lessons or courses. LCMS's enable the creation of lessons and large scale reusability of content. Therefore, such systems are often the source for the content or lessons that are mediated in an LMS. Examples of suppliers of LCMS's are OutStart.com and SumTotal.com.

(1) IndustrialLogic.com provides online courses for programmers

(2) RosettaStone.com provides DVD-courses to learn languages

1.5.5 *Computer-Supported Collaborative Learning (CSCL)*

CSCL is a relatively new and growing type of E-Learning that describes solutions aiming to give users tools that let them collaborate and share content. There are few examples of fully integrated CSCL-solutions today, but the solution "Knowledge Practises Environment" is one of them (Ben-Ami, 2009). It uses a so-called "shared space" which is a digital work surface that lets users switch between working together and individually with the same content. Outside of solutions such as this, CSCL mainly contains combinations of different solutions which are experimented with by pioneering teachers. Examples include combinations of Wiki's, Blog's and existing LMS's (Kane, 2010). Some solutions which can partly be considered under the the CSCL umbrella are Online communities and individual SmartBoards. A lot of Online communities ("social network services") have tools that make sharing of content simple. SmartBoards are interactive blackboards which can be used in classrooms. Some of them allow for multiple-user interaction, and can therefore be said to support CSCL.

1.5.6 *Technology Enhanced Learning (TEL)*

TEL is a description of the software that is being used to support/enhance the learning process. It could refer to video-conferencing tools used in remote education (i.e. Marat-ech used at NTNU), IT-technology that teachers use in correlation with teaching (i.e. SmartBoards), or so-called Mindtools. The latter can for instance be software used to make mind maps, or electronic spreadsheets. A challenge with a lot of contemporary TEL-tools is that they are often too complex, and therefore draw time and cognitive capacity away from the content of the education (Vavik et al., 2009). Examples include commercial spreadsheet software.

1.5.7 *Courseware - digital publications of course material*

Courseware can refer to web-based solutions which accompany syllabus books, or course material which is publicized. Solutions accompanying syllabus books are typically tailor-made to the book and therefore limited in extent. One example of such a solution is Pearson CourseCompass for university-level math. Individual universities are normally behind publicized course material, which often include videos and slides from lectures. Examples include MIT OpenCourseware and NTNU OpenCourseware. There are also other online solutions which publicize course material, as for example cooperation between several publishers (i.e. DigLib.no) or national political initiatives (i.e. NDLA.no).

1.5.8 *Serious Games*

Serious Games are games which are not made with entertainment / fun as the primary purpose, but that often has pedagogical purposes. Serious Games ranges broadly, and include amongst others 3D-simulations, game worlds with pedagogical content, and games that illustrate and lets the user create his own games. Serious Games are usually professionally developed by game designers, programmers and 3D-artists. Serious Games re discussed under section 2.1.

Background Theory

2.1 Games

To understand and appreciate Game Mechanics, we first need to explore the medium from which they originated. Here, I will go into some details on what a game is, and why E-Learning in particular should draw inspiration from games. This should also help provide a background to answer my third research question, Q3 (see section 1.3).

What is a game?

Many people have tried to accurately define what a game is. In their seminal book "Rules of Play", [Salen, K. and Zimmerman \(2004\)](#) compared 8 academic definitions, and then defined a game as "*a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome*". Others like [Kim \(2009\)](#) have defined a game as: "*a structured experience with rules and goals that's fun*". These definitions fall short on several accounts. Firstly, [Salen, K. and Zimmerman \(2004\)](#) definition doesn't cover games like The Sims ¹, the worlds best selling PC-game. In games like the Sims and Monkey Island ² there are no conflict and no quantifiable outcome like winning or losing. The informal definition given by [Kim \(2009\)](#) is obviously not entirely correct, since arguably not every game is fun. When we remove that part of the definition, the remaining part could just as well be applied to describe work. And we intuitively know that games are distinct from work. So both of these definitions are unsatisfactory.

A more usable definition is proposed by legendary game designer Sid Meier: "*A game is a series of interesting choices*" [Camargo et al. \(2006\)](#). It remains a too broad definition to use in itself, but it leads us in the right direction. By using this definition, and [Wyeth \(2008\)](#)'s delimitation of the terms game and play, we can derive a suitable definition for this thesis: *A game is a decision space with rules, rewards and loss.*

"Decision space" refers to the fact that the player can choose between various options at several different points in the game. Each choice the player makes, brings him to another point in the decisions space, that has another set of options to choose from. This accounts for the principle in Sid Meier's definition that a game is a series of choices. We

(1) A game similar to a virtual doll house - thesims.com

(2) [MonkeyIslandisapoint-and-clickadventuregame.Seehttp://en.wikipedia.org/wiki/Monkey_Island_\(series\)](http://en.wikipedia.org/wiki/Monkey_Island_(series))

will leave the "interesting" part out of it, since that is highly subjective. We assume that if the player is presented with various disparate options with the potential for reward and loss, it will make the choice interesting. Furthermore, "rewards" and "loss" are meant in the broad sense. "Rewards" mean every reinforcement and benefit given to the player, but also indirect rewards stemming from satisfying curiosity through exploring areas of the game for instance. "Loss" refers to direct punishment, but also more broadly to the indirect punishment of not receiving a reward. An example of the experience of indirect loss could be that the player walked in the wrong direction, and has to walk back. Another case of loss could be where the player has to guide characters in a game and they are showing obvious dissatisfaction with their guidance (example from the Sims). The important part is that "rewards" and "loss" doesn't necessarily refer to a quantifiable outcome, or end state, such as winning or losing the game. This leaves us with a definition that should cover all games. In this thesis, it will later serve as a reference point for discussing the difference between applying game mechanics and making a game (Q3, section 1.3).

Why look to games?

Games have the power to motivate. They motivate and create fun in various ways, already charted in my preliminary work (Gaasland (2010)). Not all games are fun though, but those that are, are undoubtedly tremendous motivators for the players. For this reason, it has long been sought to use games as a source of inspiration in learning contexts. In his book "A Theory of Fun for Game Design", Ralph Koster stated that:

"Fun is just another word for learning - Fun from games arise out of mastery. It arises out of comprehension. It is the act of solving puzzles that make games fun. With games, learning is the drug". Koster and Wright (2004)

So the desire to create fun games seems to correlate well with the desire to create good learning experiences. As Deterding (2010) further stress it: *Fun is learning under optimal conditions*. Games give us these optimal conditions. Given the potential, it is natural to want to utilize that in an educational setting. What if school work could be just as motivating as games?

Educational institutions today are amongst other things struggling with providing personal learning environments (PLE)³. The possibilities are limited by the availability of staff, as well as the functionality provided by today's most common E-Learning systems [Kolaas \(2010\)](#). Games on the other hand, are in their nature centered around providing a personal learning environment for the player. The player gets individual feedback, and progress through the game at his own pace (or gets pushed gently forward). So why not learn from and utilize this property of games in education?

Serious Games

The type of E-Learning called Serious Games tries to address the issue of utilizing the beneficial properties of games for educational purposes (1.5). Serious Games try to mimic normal games, but with educational content. This means that they are often advanced graphical simulations. This is challenging because it requires specialized competence to create the core content for the game. The game developer also has to do this task, and therefore decides the content. Since the games are often made based on general market demand, it follows that the creation of localized content is often limited. It is also hard to find games that cover large parts of the curriculum, resulting in the games being placed as a side-activity in any course. This is even worse in countries like Norway, with a small population (small market), and a curriculum different from the K-12 curriculum in the USA (one of the largest markets). The effect is that teachers and students have little influence over creating or editing the content themselves, and tailor fitting it to their course. The only alternative is to adjust the teaching/course to the game if it should be integrated with success ([WikiBooks, 2010](#)). This is not always an option.

Serious Games have traditionally been distributed as local software, and therefore have to support a wide range of hardware and operating systems. This represents another obstacle to adoption in that it increases the development costs and resulting price. In addition, a number of Serious Games require the computers have a graphics-card or powerful processor to run them. This represents a problem for schools with older hardware and low IT-budgets.

In a course there is significant pressure to "get through the curriculum". When Serious Games only cover a small part of it, and largely represent a side-activity in the course, this becomes an obstacle to any mass adoption into educational settings. Another issue is that the way that students are practising through a Serious Game is very different

(3) Personal Learning Environments are a common term used in the E-Learning field within academia. It refers to systems that individualizes and differentiates the instruction to accommodate for different student needs. For further explanation, see ?.

from traditional written exercises. Though this can be said to be their biggest benefit, it is also a great weakness, since the evaluation formats schools are using haven't changed that much. The exam still comes in the traditional written / oral format. This makes it more relevant for students to study and learn in the traditional manner. And when the time used playing Serious Games is better spent on activities directly relevant to the assesment, the efficiency of playing them decreases drastically.

The final but formemost challenge Serious Games face is the goal of balancing pedagogy with fun/entertainment. This is a difficult task, as game design is already a wicked problem⁴ (Mateas and Stern (2005)). The challenges Serious Games have faced, and the small adoption into classrooms, have led to a general belief that "no one has yet broken the code" of successfully utilizing games in education (Squire et al. (2003)). But what if we could find and use only some of the elements of games that make them motivating? Could we then eliminate or alleviate a lot of the aforementioned problems?

2.2 Game Mechanics

Game Mechanics are elements of games commonly used to improve the experience of playing. The term Game Mechanics is not unambigiously and well defined in the litterature (Lundgren and Bjork (2003); Koster and Wright (2004)). We can however derive that "Rules", Feedback" and "Patterns" are some of the common descriptors used in the various definitions. As a workable definition for this thesis, we can say that: *"Game Mechanics are instruments/patterns in games that are made up of a set of rules and feedback loops"*.

Game Mechanics come in many shapes and forms. In my preliminary work on this thesis I charted and described in detail 47 such mechanics (Gaesland (2010)). This work showed that they have a widely diverse range of applications. This might be why people have struggled with coming up with a very precise definition. To give a better understanding we can highlight examples of some popular and some lesser known Game Mechanics. We will use the enormously popular game World of Warcraft⁵ as the example case:

- **Items** - Items are objects that the player can obtain and use to acheive an advantage. In World of Warcraft the player can find items that will make their character

(4) A wicked problem is a problem with incomplete, contradictory and changing requirements, and solutions which are often difficult to recognise as such because of complex interdependencies. The problem is so unique each time that it can only be fully defined by solving it once.

(5) World of Warcraft is the worlds most popular massive multiplayer online role-playing game with its 11.4 million subscribers."

stronger, or able to perform special moves. Items can be collected, traded, and sometimes also combined with other items to make better items. Needless to say, the acquisition of powerful items can become extremely motivating.

- **Points/progression** - Points are given to the player as an explicit reward for specific actions. The player is given progression feedback through a score counter, or a progression bar. In World of Warcraft the player receives Experience Points (XP) for every monster he defeats, and can see his total XP through both a score counter and an XP bar. Gaining XP is arguably the prime motivator in World of Warcraft.
- **Levels** - Levels are a way to divide the game content into small, separate and surmountable pieces/stages. The game world can be divided into levels to give the player a nearer milestone to reach. World of Warcraft uses levels to divide the acquisition of points (XP) into meaningful stages, where each successive stage requires more effort to reach. Getting to the next level is often a strong motivator for continued effort.
- **Badges / Achievements** - Badges (also called Achievements, Emblems or Ribbons) are given to the player when he has performed a particular set of actions. In World of Warcraft, if you win a certain amount of battles against other players in a gladiator-like arena, you complete the "Brutally Dedicated" achievement and receive a "Tabard of Brute Force". The tabard serves as a badge other players can recognize and admire. Status symbols such as these motivate players to excel.

To give an insight into some of the less common Game Mechanics, we will use various games to illustrate:

- **Variable interval reward schedule** - The player gets rewarded after a somewhat consistent but unknown time period. In Half-Life ⁶ multi-player the player has to wait about 30 minutes between each time a special weapon appears at a given place in the world. The unpredictability of the reward creates fairly high activity from the player, as he often returns to the location for the reward to see if it is there.
- **Appointment** - The player has to return to a specific place or execute a task at a given time to receive a reward or avoid loss. In Farmville ⁷ the flowers the player plants will die if the player doesn't continuously return to water them.
- **Reduced reward** - The player stops receiving rewards for something he was previously rewarded for doing. World of Warcraft uses this mechanic to push the player to defeat stronger monsters. The game gives the player less points for defeating the same monsters over again.

(6) Half-Life is a first-person shooter video game. See [http://en.wikipedia.org/wiki/Half-Life_\(video_game\)](http://en.wikipedia.org/wiki/Half-Life_(video_game)).

(7) Farmville, a game about farming, is the most popular social game on Facebook, with its 62 million active users (from Wikipedia).

- **Viral dependency** - The player is required to cooperate with other players to receive a reward. In Farmville the player can invite friends to become their neighbours in the game, to receive rewards from growing crops together and exchanging supplies.
- **Bonuses** - The player receives an added reward after reaching a milestone, performing special tasks, or a set of actions. In World of Warcraft, when the player is fighting a monster, it is a small chance that he might hit a "critical strike" which deals extra damage.

This is a small selection of Game Mechanics used in games. For an extensive mapping and description of known Game Mechanics, see [Gaesland \(2010\)](#).

From our description of Game Mechanics it should be evident that they have the power to motivate player behaviour. In fact, in their most rudimentary form they can be perceived as incentive structures coupled with feedback mechanisms. In that respect, they are not new in any revolutionary way, except that they are derived from games, and often represent automated systems (at least in computerized games). We can find many examples of Game Mechanics in use in everyday life. Badges are really not much more than a virtual representation of what we know as diplomas or certificates. They both represent some personal achievement, and give others an indication of the owners competency. The appointment mechanic is known from local bars/pubs usage of "Happy Hours", and frequently used to effect behavioural change in customers. Another example of a Game Mechanics in use in everyday life is the use of Points and Bonuses in Frequent-flyer programs promoted by airlines. There they are put in effective use to increase loyalty among customers. We are also all familiar with the level mechanic from ordinary books. Book chapters are actually a rudimentary form of levels, and their behavioural impact is clear: Who hasn't thought "I just have to finish this chapter"? Last but not least we are all too familiar with the Variable interval reward schedule from e-mail and Facebook notifications. Since we never know when we might get an interesting e-mail or notification, we tend to check rather often. From slot machines we also know how addictive other types of variable rewards schedules can be.

Game Mechanics such as reward schedules, appointment and reduced reward mechanics are actually just forms of operant conditioning⁸, known from the experiments of B.J. Skinner (see [Skinner \(1953\)](#)). Skinner was a behavioural psychologist that made experiments on changing the behaviour of pigeons and rats using rewards and punishments. Games can in some sense be compared with a conditioning chamber ("Skinner Box");

(8) Operant conditioning is a form of psychological learning where an individual modifies its own active behavior (operant) due to the association of the behavior with a consequence/stimulus. (see Wikipedia)

the subject utilizes some mechanic to gain a reward or avoid loss. This might explain why some games are really addictive. They are hard-wired to give you reinforcement at the right times and just after the right actions. The appointment mechanic for instance, can be tied to what Behaviorists call "avoidance". In the experiments of Skinner, if a lab rat receives an electric shock after 30 seconds unless it hits a lever, it will learn very fast to continuously hit the lever all the time to avoid the punishment. This can be tied to the previous example of players having to return to water their flowers in Farmville at specific intervals to avoid that their well-cared-for flowers wither and rot. To further illustrate the connection: The reduced reward mechanic exploit the same phenomenon that operant conditioning theory describe as "Extinction". Extinction means that after removing a reinforcement, the associated behavior will decrease and eventually desist. This is used in games to eliminate players old behaviors to incorporate new ones instead, effectively steering the players behaviors throughout the game (most often towards the end goal of the game).

Game Mechanics can in the light of behavioral psychology be viewed as *the systems used to reinforce player behavior*. This reinforcement isn't necessarily a bad thing though, as it contributes towards improving the gameplay experience. One of the strongest reasons why people play games is that they enjoy working towards a goal/challenge, seeing the progress, experiencing the mastery, and feeling the accomplishment of reaching it (Rouse (2000); Wyeth (2008); Malone (1982)). This is all administered and fed back to the player through reinforcing Game Mechanics. Although it should be mentioned that fun in games arise out of many different factors apart from Game Mechanics. These factors are more extensively detailed in my preliminary work (Gaastrand (2010)).

We have established that Game Mechanics are one of the elements of games that make them fun, and enable them to motivate players over sustained periods of time. These are very attractive qualities, and it is only natural to ask how we can apply them elsewhere to achieve the same effect. But deriving heuristics from games to apply in other areas is nothing new. Actually, one such early attempts was made by Malone (1982) within the field of Human-Computer Interaction research already in the 1980s. Malone proposed using game heuristics as a guide to construct more enjoyable user interfaces. Still, the heuristics derived in his work were far from as instrumental as Game Mechanics. What's new today is our understanding of Game Mechanics and our knowledge of existing successful applications of them in fields other than games (see section 2.3). In the context of this thesis, we would like to explore using Game Mechanics as the fundament for fun and engaging E-Learning.

2.2.1 *Game Mechanics in E-Learning*

My preliminary work showed great promise of applying Game Mechanics to E-Learning. In that body of work, I detailedly described how each of the 47 identified Game Mechanics could be applied to E-Learning, and how that could make learning more motivating and fun. Therefore, I will not go into detail here on how the aforementioned examples in this section could be applied in an E-Learning system. The report from my preliminary work already covered that topic to great extent (see [Gaesland \(2010\)](#)).

There are some challenges to the approach of applying Game Mechanics in E-Learning. First of all, Game Mechanics cannot necessarily be combined without limitations. Combining Game Mechanics would increase the complexity of the E-Learning system and particular mechanics could counteract or neutralize each other. They are also not additive in nature, which means that adding a new Game Mechanic may drastically alter the overall experience. The example of speed chess versus normal chess illustrates how adding a simple mechanic can change the nature of the game/system. It is also important to consider the player's/user's ability to rapidly and intuitively understand the system and the mechanics in use.

The potential for fun using only Game Mechanics, instead of constructing an actual game also has its limitations. A game often consists of a world of objects, and a simulation of their interactions. The game world in for instance 3D-games allows for a vast amount of complex and often unknown interactions between objects. This is presumably more than an E-Learning system based on Game Mechanics and traditional exercises (like in this thesis) could hope to achieve. It is not so much a simulation as a pedagogical device.

Another aspect of games it is hard to rival the fact that games offer microscopic levels of decision making and instantaneous and direct feedback. When the player is moving around in the game world, he has to continuously make decisions of where to go next. And he is able to see the perspective of the world change immediately as the character moves. The same principle applies when the player is fighting a hoard of enemies in the game and has to choose who to aim at and how to move. This high level of *interaction* might be why games are so enjoyable to people. In an E-Learning system, providing this high level of interaction and direct feedback would probably require a significant amount of work.

Improvisation is also an element that games capture very well. The game world gives the player a constant availability of options in which the player has the freedom to operate. Rules are often used to limit these options. Game Mechanics are also used in this respect, but first and foremost to guide the player in the right direction, by rewarding the right

actions. Players can even choose to ignore some Game Mechanics without it affecting their play. In some sense, Game Mechanics are instructional, and therefore well suited for pedagogical approaches. They administer pre-defined rewards for good behavior. But it shouldn't be missed that it is the decision space (see section 2.1) created by the game world which allows for the majority of improvisation. The game allows the player to tackle various challenges in different ways, and the interaction sequences vary ever so slightly between each round of playing. The player is never given the *exact* same experience (or set of options to choose from) twice, even if the overall challenges remain the same. This is why games capture improvisation so well. Game Mechanics on their own are not as well suited for creating the decision space which are central to games. It remains to be seen if an E-Learning system could be able to provide the same decision space for its users.

The final aspect of games that are increasingly central to many of them, and that Game Mechanics offer no substitute, is narrative. Luckily, an E-Learning system could easily include storytelling without compromising the use of Game Mechanics. As in games, there would be a challenge to weave the narrative into the core content, and not include it as disjoint batches of storytelling. Still, both approaches have been used to success in many games.

In summary, it should be mentioned that there have been limited previous academic research into using Game Mechanics for E-Learning purposes. There have been a lot of research on how to use *games in education*, but not specifically describing Game Mechanics as the basis for an online learning system. Still, academic interest have been shown by others like [Silva \(2010\)](#) who suggested using social Game Mechanics to make learning more like a game. My preliminary work for this thesis also contributed to this research area by specifically looking at potential applications of Game Mechanics in E-Learning (see [Gaasland, 2010](#)). This thesis explores how to use that knowledge to construct an online learning system, evaluating its use in an educational setting. I expect that more research will come in the years to follow, in light of the recent and growing trend of Gamification (section 2.3).

2.3 Gamification

Gamification (also called "funware") is the use of Game Mechanics (see section 2.2) in in areas other than games ([Deterding et al., 2011](#)). It is becoming increasingly popular in particular consumer-oriented applications and services on the web and on mobiles. The purpose is to increase audience engagement, loyalty and fun. The motive is to encourage

desired users behaviors, and give them a greater sense of reward for using the service. In social applications there is also often a motive to drive people to invite their friends and share content with them, to make even more people adopt the service.

Businesses are starting to use Gamification in many ways to drive their business forward. Gamification is being promoted as a way to increase users interaction with websites / services, keep users attention longer, and increase users connection to the businesses brands⁹. As a lot of the businesses on the web center around online communities, they are starting to see gamification as a useful tool. It promises to help them attract customers, build communities and analyze and instantly react to user behavior.

Gamification is a very recent trend, and just started to fully gain traction during the course of 2010. Due to this, there have been very little academic research addressing it and investigating its merits. There is some precedence coming from research into using games and virtual worlds to change the way people work [Reeves and Read \(2009\)](#), giving Gamification a skin of academic respectability. Recently [Antin \(2011\)](#) also performed research into Badges (see section 2.2), one of the most controversial Game Mechanics used in Gamification efforts. [Antin \(2011\)](#) deconstructed Badges and proposed five social psychological functions for how and why they work in social media contexts: goal setting, instruction, reputation, status/affirmation, and group identification. But empirical research into the efficiency of Game Mechanics such as Badges is still lacking. For Badges, evidence suggests that they are not universally accepted, understood or attended to [Antin \(2011\)](#), which further fuels the debate.

In spite of lacking academic empirical investigation, companies are already seeing the effect of Gamification efforts. This is demonstrated by a number of commercial companies rising up to provide Gamification services, technology and platforms¹⁰. The availability of open source platforms such as UserInfuser.com also help to spread Gamification to the masses¹¹. Gamification as a new and growing trend is further illustrated by a strong

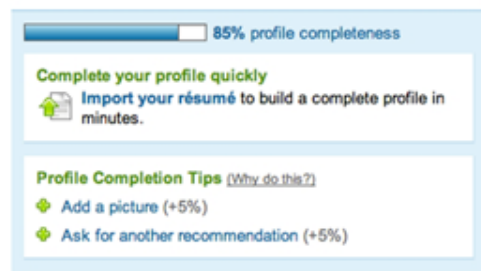


Figure 2.1: LinkedIn's use of the Progression Game Mechanic: Note the inclusion of simple next steps with a tangible reward.

(9) See Bunchball.com, CloudCaptive.com, and Gamify.com

(10) See Bunchball.com, Gamify.com, BigDoor.com, OneTrueFan.com, Badgeville.com and CloudCaptive.com

(11) UserInfuser was not considered suitable for the system created in this thesis.

appearance at seasoned conferences like SXSW2011 Interactive¹². In the spring of 2011, Gamification even got its first dedicated conference with the "Gamification Summit 2011" being held in San Francisco. It should be no surprise that Silicon Valley is the first place in the world to embrace a technology and business trend such as Gamification.

But does Gamification really work, or is it just a hype? Since impartial academic investigation remains, a definite answer is not yet readily available. But reports of success from companies such as LinkedIn¹³ who doesn't have Gamification as their business, is a good indication that there might be something to it. LinkedIn was able to greatly increase the number of people filling out their profiles by adding a simple "Progression" Game Mechanic (see section 2.2 for an explanation of the Progression mechanic). The progress bar has also become very popular to use in surveys and online questionnaires to give respondents a feeling of an "end in sight".

Other companies and organizations are using Game Mechanics to "gamify"¹⁴ their own services:

- **Foursquare** - Foursquare is a mobile application where users can *compete against each other* to visit real life locations, and collect *Badges*.
- **Twitter** - Twitter is a social messaging application on the web. They managed to engage users to translate their service to several languages by "gamifying" the translation work with personal *Progress bars, Levels* and a *Competition*.
- **DevHub** - DevHub is a web portal that helps people create websites and make money from the content on them. The company increased the number of user actions on their web portal by 9 times after "gamifying" the site with *Badges* and other Game Mechanics [Nuval \(2010\)](#).
- **EpicWin** - is a todo-list application for the iPhone where users can gain *Levels* and win virtual *Items* by adding and accomplishing their daily tasks.
- **Keas** - is a website that aims to keep people healthy through using Game Mechanics such as *Viral dependency, Points and Progression, and Levels*. They have experienced success in activating and continuously engaging unhealthy employees [NutritionDietNews \(2011\)](#).
- **DARPA** - The DARPA Network Challenge used *Viral dependency and Group challenge* to collect weather data from red weather balloons all over USA. Individuals all over the country had to form teams and exchange information to win.

(12) South by Southwest (SXSW) Interactiv is an annual festival and conference (held in Austin, Texas, USA) focusing on emerging technologies. It is one of the biggest of it's kind in the world.)

(13) LinkedIn.com is the worlds largest business-related social networking site.

(14) "Gamifying" is the act of utilizing Gamification

(Other attempts at Gamification includes the effort to make filling out surveys more compelling.) See section 2.2 for an explanation of a selection of the emphasized Game Mechanics mentioned above.

In general, Gamification efforts today are largely focused around a few core Game Mechanics: Points, Badges, Levels, and Competitions in the form of Leaderboards (also called Highscore rankings). This might be attributable to the fact that the trend is yet fairly new, and that some mechanics are simpler to implement than others (and possibly more intuitive for the user).

It is clear that Gamification is recognized as having some potential to turn work, health and even education more engaging. In light of this thesis it is most interesting to look at education. Could we "gamify" learning to make it more engaging? According to the research of [Lee and Hammer \(2011\)](#) into Gamification and the potential use in education, the answer is yes. It could be a solution to the major challenges with student motivation that schools today are facing. Gamification could both be applied to change traditional low-tech educational practises, but also to make E-Learning more engaging. Only the latter is within the scope of this thesis.

The future of Gamification in general seems to be a good one. Some industry analysts predict that it will become a multi-billion dollar business already by 2015 [MacMillan \(2011\)](#). Gartner ¹⁵ also predict that by 2015, more than 50 percent of organizations that manage innovation processes will "gamify" those processes [Gartner \(2011\)](#). This is predicted to also become a major influence within education. The New Media Consortiums recent Horizon Report 2011 K-12 Edition ¹⁶, predict that game based learning will be adopted in educational institutions within 2-3 years [Johnson et al. \(2011\)](#). This is supported by more near-term predictions by experts on instructional practises such as Karl Kapp ¹⁷. One of his predictions for training technologies in 2011 were:

"Dramatic increase in gamification of learning and instruction. More game elements—time, accuracy and point systems integrated into all types of training programs encouraging employees to achieve desired goals." - Karl Kapp

The Horizon report further describes Personal Learning Environments (PLEs) (as mentioned in section 2.1) as a technology likely to be adopted in 4-5 years. This bodes well

(15) Gartner is a world recognized information technology research and advisory firm.

(16) "The NMC Horizon Project identifies and describes emerging technologies likely to have a large impact on teaching, learning, research, or creative expression within education around the globe."

(17) Karl Kapp is the Professor of Instructional Technology at Bloomsburg University, and advisory board member for eLearn Magazine

for Game Mechanics based E-Learning systems like the prototype presented in this thesis. Such systems have the potential of becoming true Personal Learning Environments.



General description of the system

3.0.1 *The overall approach of Game Mechanic based E-Learning*

From the state of the art (section 1.5) we know that the field of E-Learning is very diverse. Some types of E-Learning have focused on institutional needs, such as the LMS's and the LCMS's solutions. Serious Games have focused on imitating normal games in design and shape, but with a touch of pedagogy and educational content. The pedagogical E-Learning systems CBT, CSCL and TEL have often exclusively focused on one particular learning style in their implementation (Kolaas, 2005).

Therefore, in this thesis, I will explore the opportunity for a new approach to E-Learning, namely *Game Mechanics based E-Learning*. This approach is unique for a number of reasons. First of all, it represents a mix of CSCL and CBT. The aspects it shares with CSCL is sharing and collaboration. In line with CBT, the approach should also facilitate individualized assessment, and give the user options of various sequential/stepwise dialogs.

The approach is also inspired by Gamification (section 2.3). The goal of the approach is first and foremost to make learning more *fun* and *engaging*. Keeping students engaged, competing for their attention with other stimulating experiences such as games and TV, is seen as one of the major challenges facing educational institutions in our time. It is the authors point of view that learning is and should be fun and self-driven. This philosophy is in line with Gamification, which seek to increase user engagement and own initiative. The approach of trying to make education more fun and entertaining is one that should be further explored by academic efforts such as the one in this thesis. The only really similar approach to E-Learning that the author has been able to find is Khan Academy¹ which is an example of Game Mechanics used within E-Learning.

Serious Games have faced several challenges (explained in subsection 2.1). The approach taken in this thesis alleviates or eliminates several of these problems. Since the system implemented here is a web application, it *circumvents normal hardware/software problems* that educational institutions are faced with. The system presented here would be equally able to run on older computers, as well as new ones, since the computation is performed server-side, and the only requirement is a browser and an internet connection. The

(1) Khan Academy is a website popularly known for supplying a free online collection of more than 2,300 video lectures. But more importantly, it also has *automated MCQ-exercises with continuous assessment using Game Mechanics like Badges and Points*.

system proposed also *opens up for content that can be easily localized, edited and/or replaced at will*. This is something Serious Games and Courseware traditionally haven't been able to offer. In opposition to many LMS's and LCMS's the content is also presented online, and not just made available for download.

What is also unique is that the content is collaboratively created by the students themselves, drawing inspiration from the CSCL approach and a socio-constructivist² philosophy of learning. The free-form text-based answers (see section 3.0.2) also allow for a greater deal of knowledge and memory validation than just multiple-choice questions (MCQ). Retrieving knowledge from memory is arguably harder than just recognizing the correct answer. Research by [Karpicke and Roediger \(2008\)](#) also conclude that retrieving/recalling knowledge is a superior learning method to simply rereading the information. It consolidates learning and tests students "production capability" instead of just "consumption capability". This approach is therefore considered superior to traditional ways of studying, and has been made the central mediating tool within the system presented in this thesis. This is unique, since other online E-Learning approaches have traditionally relied on MCQ to test knowledge.

The approach furthermore presents a *student-centered* approach to learning. While LMS's and LCMS's have been tools for the teacher or the institution, this system is unique in that it focuses on the student primarily. It is the authors point of view that good learning is only achieved when *focusing on the student's needs and abilities*.

The approach takes heed to popular suggestions of using Web 2.0 technology and inspiration from social networks to construct E-Learning systems and experiences (highlighted by [Nordkvelle Ramberg, Kirsti Rye, Wilhelmsen, Janne \(2009\)](#)). The system is implemented in Ruby on Rails which is arguably the fastest growing Web application framework used to construct Web 2.0 services, and represents in many ways the technology front in web application development today. This choice was however carefully considered and made after a proper evaluation in the preliminary work on this thesis ([Gaastrand, 2010](#)).

The system developed in this thesis also take into account the popular demand that E-Learning systems should be personalized to the user ([Kolaas, 2010](#)). While other E-Learning systems in the past have focused on delivering a one-size-fits all solution to education, often directed towards an entire course or class, this approach is *inherently personalized*. The approach here presented has the potential to represent the beginning

(2) Social constructivism is a sociological theory of knowledge (largely attributed to Lev Vygotsky) that asserts that "groups construct knowledge for one another, collaboratively creating a small culture of shared artifacts with shared meanings." (Wikipedia).

of true Personalized Learning Environments (PLE) that are actually able to *motivate and engage the student* in a way similar to games (see section 2.1).

Since the learning takes place in the E-Learning system, the Game Mechanics can be used to give continuous feedback to the student. The meta-data generated from student working in the system could also be used to give better statistics and classroom data to teachers. There are large opportunities with integrating the learning process itself into a digital manner. The prototype presented in this thesis represents a vague beginning of "Gamified Learning", and more precisely: Game Mechanic based E-Learning.

3.0.2 *StudyAid - a prototype of a Game Mechanic based E-Learning system*

The work with this thesis contained developing a prototype of a Game Mechanic based E-Learning system. The system was named StudyAid, to indicate the student-centric approach, and to give associations to a tool that would help students in their studies.

The prototype allows the student to submit questions to a collaboratively created question database (called the question feed). Then, the student may choose to answer his own questions, to verify his/her own knowledge and ability to reproduce the answer. The benefits for the students was that this could help them gain confidence in their own knowledge to the exam. It also represented an alternative and way to study/remember with potential benefits (see section 3.0.1). The student could also answer other students' questions.

The Game Mechanic chosen was the Progression/points Game Mechanic (explained in section 2.2 and further exemplified in section 2.3). This choice was based on the studies of Gamification that indicated that it was one of the most popular and successful Game Mechanics utilized in other efforts. The potential for use in E-Learning for this particular mechanic was of research interest. Previous quantitative data on the use of various Game Mechanics in E-Learning sadly wasn't available to influence the choice. Perhaps due to few previous academic attempts using the approach posited by this thesis. To properly answer research question Q2 (see 1.3) no other Game Mechanic was added to the system. The progression/points mechanic was implemented using a score counter and a progress bar. The counter and the progress bar measured Experience Points (XP) which are a known idiom from popular games. (Usability testing revealed that the students at large were familiar with this term.) Student's individual XP and progression were shown to them. This represented one aspect of personalization in the system.

The questions were presented in a question feed on the home screen (after logged in). Personalization in the system was also achieved through the colors in the question feed. Questions were colored as either red, green or grey, depending on whether the student had answered wrong, correct or not marked the answer yet.

The benefits for the student included the ability to see other students' correct answers, which could give a new perspective. It was also an example of how the system accommodated for a high degree of localization. Seeing something explained by someone in your exact same situation is arguably almost optimal localization. Another benefit for the students were that they could collaboratively edit each others questions and the solutions to those questions. This allowed them to continuously and collaboratively improve the knowledge base that the question feed represented. For the university, it could also represent a resource in knowledge transfer between classes from year to year. If the system were to be used in the following semester, the questions from the previous semester would remain.

Finally, the system made use of the students themselves to correct their own answers. This could help to alleviate work on the teacher or teaching assistants part. The approach relied on students honestly evaluating their own answer. To prevent cheating and dishonesty, no competitive scoreboards or other measures were implemented. Also, and maybe more importantly, all answers marked as correct would be show to everyone else, with the student's name next to it. This gave the desired effect, in that only the positive and contributing answers were shown, and people were disincentivized from cheating.

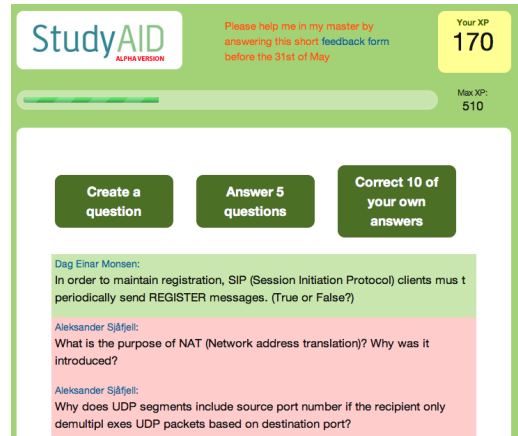


Figure 3.1: The home screen: The home screen shows the XP score counter, the XP progress bar, and the question feed.



Methods & Implementation

4.1 Summary of general approach

I chose several methods to guide my work in constructing the system proposed by this thesis. First of all, I chose to use an Agile software development methodology, to stay flexible and able to adapt to new requirements from users. I started out using a TDD approach, but decided to forfeit it later on because it didn't prove to be practical. As my main tool to maintain and track the development effort I used KANBAN. Going into this project, I didn't know the Ruby programming language, or the Ruby on Rails web application framework, so a considerable amount of time was spent on learning both.

For designing, I used a process recommended by the very successful and acknowledged web application company 37signals.com. It consisted of brainstorming, drawing paper sketches, creating mockups ¹. in HTML, and then coding the underlying functionality. This was repeated as necessary according to user feedback.

I had made arrangements with Yuming Jiang, the subject teacher of TTM4100 ² at NTNU to allow the students of his class to test the prototype in the study for their exam. I maintained contact with him and we cooperated to inform the students on its progression. To guide the development, I performed 9 in-person usability test with various subjects, some from the class and some not. In addition, I enlisted 25 students from the class for feedback on the working prototype before it was released to the entire class (as a pilot test). After releasing the Alpha version to the entire class, I performed a survey amongst them in the form of an online questionnaire. This gave me the data I needed to evaluate the general reception of the "Game Mechanics based E-Learning system" prototype made in this thesis. It also gave me the insights needed to answer my research questions.

The development plan and process could be explained in the following stages throughout the semester: January to about the middle of March consisted mainly of learning Ruby on Rails, developing ideas, designing and doing some development. The succeeding period leading up to the beginning of May was the time where most of the usability tests were performed, and development iterated around that. The rest of May was used to pilot test system, release it to the class of TTM4100, and perform the evaluation. Simultaneously,

(1) In software development mockups are user interfaces that shows what the software will look like without having to build the software or the underlying functionality. It is used amongst others for design evaluation.

(2) TTM4100 - Communication Services and Networks, NTNU, Spring class of 2011

the most of the work on this report was made, and that work continued into June.

To gain further insights into the field of E-Learning and its future in Norway, I attended the NKUL11³ conference at NTNU in the beginning of May.

4.2 Design Process

The design process used when designing the system was the one recommended by the reknowned web application company 37signals.com in their book "Getting Real" about building web applications⁴. First, I brainstormed the minimum set of features I thought the application would need, according to my knowledge of the students needs uncovered through the focus group and observation report in my preliminary work (Gausland (2010)). The brainstorming was guided by the principle of creating a Minimum Viable Product⁵ which would gain maximum feedback from users the fastest way possible. As a part of the brainstorming, I also created a simple UML diagram of the database model classes.

The paper sketches were purposefully drawn with a black felt tip marker, to avoid attention to unnecessary detail. The sketches (as seen in appendix A.1) represent rough interface designs with the features considered most important at the time. Some features were later removed during the design process, adhering to the Lean (see section 4.3) principle of eliminating everything not stricly necessary (as that represent waste).

The next stage was to implement the design sketches as mockups using only HTML and CSS. After evaluating this tatic design in the web-browser, the coding on the back-end and server/database setup began. Slowly but surely the back-end was developed, and connected to the mockups (representing the front-end of the application), resulting in a dynamic web site. User feedback gained from testing later resulted in redesigning the front-end to give a more intuitive user interface. This represented a milestone in the continuous design process which followed from the development methodology chosen for this thesis.

(3) NKUL11 - Translated: "National conference on use of ICT in education and learning 2011."

(4) http://gettingreal.37signals.com/ch06_From_Idea_to_Implementation.php

(5) In product development, the Minimum Viable Product or MVP is a strategy used for fast and quantitative market testing of a product or product feature, popularized by Eric Ries for web applications. A Minimum Viable Product has just those features that allow the product to be deployed, and no more.

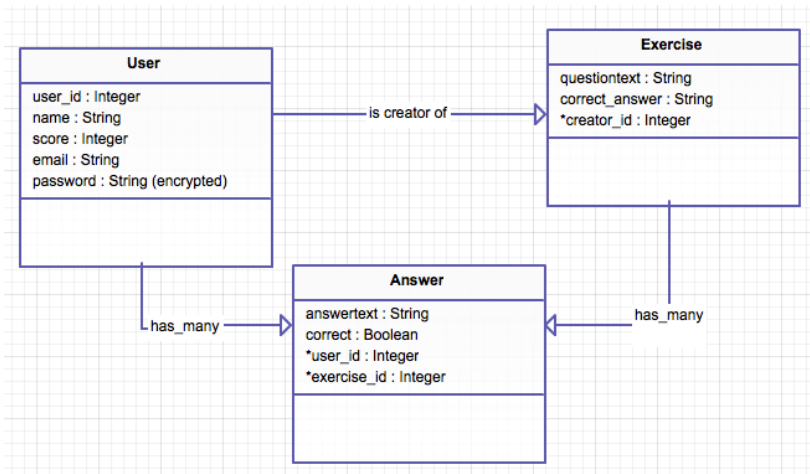


Figure 4.1: The UML diagram of the final database model: Note that "Exercise" here and "Question" (on the design sketches) is used interchangeably; they are just different names for the same entity.

4.3 Development methodology

The choice of the Agile software development methodology was influenced by several factors. Most importantly, it would help me adapt to new requirements from users, and react to feedback I got from the usability tests I had planned throughout the process (see section 4.4). It allowed me to stay flexible instead of writing a detailed specification up front, and then relying on my specification to be precisely correct. Another benefit from the agile approach was that it enabled me to make better decisions (on the importance of various features) later in the process, when I had the most information available. It also allowed me to deviate from previous decisions, and incrementally improve the system, instead of following a strict Waterfall approach.

Since I was a single developer, the more elaborate Agile software development methodologies for teams (like SCRUM) didn't apply very well. Instead I chose a Lean software development approach ⁶. This approach let me focus on eliminating everything identified as not creating value for the end user (the student, chosen in this case). This was beneficial in ensuring that the system was developed according to students needs and was intuitive to use. It also helped to rapidly eliminate unwanted and unnecessary features.

(6) Lean software development is a set of principles and practises translated from the Toyota Production Systems use of Lean manufacturing. Lean focuses on creating value for the customer through, amongst others, eliminating waste in the production process. It starting to become more commonplace to use Lean practises within the IT-consultant industry.

The disadvantage with the Agile methodology was that the end outcome couldn't be determined up-front, and neither could the development time to any large degree. A possible disadvantage with the Lean approach was that the resulting system developed likely wouldn't be very feature-rich. For demonstration purposes, feature richness might be what you want. However, in this thesis, the design decision were to rather have a small set of features that map well to user feedback, than to implement a wide range of functionality people might not use, and that might be confusing.

I chose KANBAN⁷ as the main tool to control the development process. The KANBAN chart (see table 4.1) allowed me to visualize the workflow and prioritize my efforts. I modified the chart to include an "Inbox" where I could put all new "Work Items" (like requests for features or discovered bugs) as soon as they were discovered. The Inbox served as a sort of note collection / braindump area. I made a "Maybe" column as well, where I could list Work Items accepted from the Inbox. Work Items not feasible for this project could be deleted from the Inbox after evaluation, before reaching and cluttering the Maybe column. The Pending column represented the work that was determined to be implemented (similar to a loosely prioritized todo-list). When beginning development, I would pick Work Items from the Pending column, and then move them to the Work in Progress column which could have 1 or 2 Work Items maximum at any given time. This is the part of KANBAN that ensures that the developer focus on finishing Work Items instead of taking on too many many things at once. All in all, KANBAN helped me focus my development efforts, prioritize tasks and stay productive.

My preliminary work uncovered Ruby on Rails to be the most suited web application framework for constructing the system in this thesis. Since I didn't know the Ruby programming language, or the Rails framework beforehand, I had to learn it as a part of my development effort. My approach to getting the necessary knowledge was to read and work through the "Ruby on Rails Tutorial: Learn Rails by Example" book by Michael Hartl⁸, and used various other resources on the web. Learning Ruby and Ruby on Rails was one of the challenges presented by the work in this thesis.

I began the programming by using a Test-Driven Development (TDD) approach⁹, with the knowledge that it could help focus my efforts, and help to discover possible bugs introduced at a later stage. After using it for a while, I soon realised that it wasn't practical for my purposes. It introduced too much overhead in producing usable features fast, which somewhat conflicted with the Lean approach I had chosen to follow. The main

(7) KANBAN is a visual process management system centered on pulling work from a queue and optimizing flow.

(8) The book is available online at <http://ruby.railstutorial.org/>. I highly recommend it.

(9) Test-driven development requires developers to create automated unit tests that define code requirements (immediately) before writing the code itself.

benefit of TDD is arguably that it helps you create a robust system. Since the focus of this thesis was to implement a small prototype to evaluate a concept, long term robustness wasn't of priority. Arguably, it isn't worth putting a lot of effort into creating really robust code if you are likely to throw it away at a later stage. Removing functionality could happen as a result of user feedback, for instance. The design decision were that the prototype should focus on being just sufficient to gain data to answer the research questions, and not purposefully built to be extensible/scalable. But the latter should be kept in mind if building a real-life full scale implementation.

4.4 Evaluation Methods

My preliminary work with this thesis included several research methods to uncover students and staff needs towards an E-Learning system (Gausland (2010)). I performed a formal interview of one subject teacher at NTNU, where I got the perspective of the teacher, and uncovered surrounding organizational issues that influences the use of any E-Learning system. In addition I performed an formal observation of students working together in a study group, and got insights and uncovered students needs through conducting a focus group. I will not go into detail of any of these efforts here, but they form the background for the choice of evaluation methods in this thesis.

For this thesis, to properly evaluate the developed system in a real-life educational setting, I made arrangements to test it in an appropriate subject at NTNU. I made arrangements with Yuming Jiang, the subject teacher of "TTM4100 - Communication Services and Networks" to allow the students of his spring class of 2011 to test the system in the study to their exam. I maintained contact with him throughout the process, and we cooperated to inform the students of the systems progression and availability.

The methods used to evaluate the system have been threefold. Firstly, I have sought to uncover usability issues and direct feedback from test subjects by performing 9 in-person usability tests. Secondly, I performed a pilot test of the system with 25 selected students from TTM4100 to get feedback on features and general usability, as well as to discover bugs. Lastly, after releasing it to the entire class, I performed a survey in the form of a questionnaire to get enough data to answer my research questions.

4.4.1 Usability Testing & Interviewing Process

The primary way of receiving feedback during the development process, I used in-person usability tests with following informal interviews. The goal was primarily to receive feedback on the usability, but some of the interviews also served towards receiving an indication of students general sentiment towards the system (research question Q1, see section 1.3)

As a background for the usability tests, I knew from [Nielsen and Landauer \(1993\)](#) work that about 5 subjects were enough to uncover the majority of usability issues at a given point in time (see fig 4.4.1). [Nielsen and Landauer \(1993\)](#) also suggest it is better to distribute the testing over many small tests instead of using a lot of resources on a single elaborate study. Taking this into consideration, and the time and resources available, I performed in-person usability tests with 9 subjects over the entire course of development. This allowed me to uncover issues at every iteration of the development process.

The subjects for the usability tests were chosen based on varying age, technological competence and availability. Their age varied from 20-59 years, and none had previous experience with the system. Most of the subjects were students, but not all. It was considered more important that the subjects came from a different background, and had varying previous experience with web applications such as the proposed system.

Some subjects were specifically chosen because they were tied to the TTM4100 class, and could give specific feedback on its application in that context. Two of the subjects were teaching assistants in TTM4100, and one was a student in the class. This student was introduced at a late stage in the development cycle, to thoroughly test and give in-person feedback on the finished prototype. He was required to perform a scenario test in addition to the normal test plan. The scenario test included objectives that were tied to studying for the TTM4100 exam. They were used as a measure to evaluate the practicality and usefulness of using the system to study for the exam.

The method used to perform the usability test was the one recommended by [Svanaes](#)

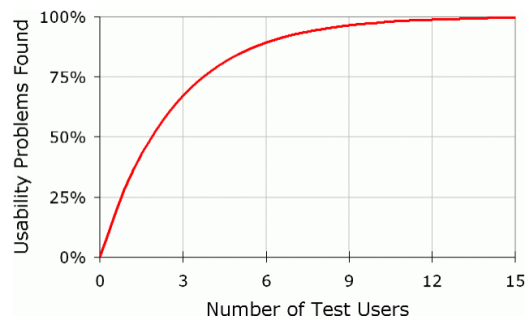


Figure 4.2: Number of test users needed to uncover usability problems: A mathematical model discovered by [Nielsen and Landauer \(1993\)](#).

(2007). A test plan was initially constructed, and the subjects were formally informed of the procedure before beginning the test. As Svanaes (2007) suggests, the following procedure were followed as a part of the formal introduction:

- Introducing myself and explaining the purpose of the test. This served as reassurance, and giving an understanding of our mutual expectations and needs.
- Explain that it is the system being tested and not the subject himself/herself. Emphasize that the subject could withdraw from the test at any time, without further explanation. This served to give the subject confidence, and feeling of control.
- Explaining that the subject should try to "think aloud", to state his every thought and impression during the test. Then demonstrating an example of this to the subject. Explain that the purpose were to get an insight into the subject's strategies, experienced difficulties, and mental model.
- Explain that no help can be offered throughout the test, since we want the users unbiased attempt. (But also explain that I could intervene if a system error or bug prevent continuing with the test).
- Explain the task: learning what the system is, how it can be used, and exploring its various functionality. (The usability tests were "qualitative exploratory tests" as described in Svanaes (2007)).
- Ask if the subject has any questions or needs clarification before the test begins. Also explain that all questions asked under way would be answered in the informal interview after the test.

During the test, I was sitting next to the subject, looking at the same screen, and taking detailed notes. After the test, the subject was informally interviewed. This helped clarify issues encountered during the test, but also helped me understand their general sentiment towards the system. Since four of the test subjects were students this gave valuable insights towards answering my research questions (Q1 and Q2, see section 1.3). In the interview, the subjects could reveal their subjective opinion and also suggest proposals for redesign, or desired functionality.

The usability tests represented *continuous formative evaluations* throughout the various stages of prototype development. This was fed back into the development process through *work prioritization criteria*. The criteria used for prioritizing work in the KANBAN system (see section 4.3 consisted of feedback from users own words, my own notes during the in-person usability tests, and the number of users having the same issue. The usability testing also served as quality assurance. For further quality assurance and rapid

feedback, continuous input were received from various people asked to test the system by themselves online.

4.4.2 Pilot test

A pilot test was conducted before releasing the prototype to the entire class of TTM4100. The pilot was a pre-alpha test, since the version released to the class was the Alpha version of the system. Voluntary test subjects were enlisted from the class to give feedback during the pilot test period. This was considered to be the best way of receiving a good amount of early contextual feedback on the use of the system in the actual educational environment. The 25 students that signed up for the pilot test gave valuable feedback on the usability and the available features in the system at the time. They also discovered bugs and made suggestions for future functionality in the system. These suggestions were coupled with popular suggestions from the usability tests, and used as a basis for designing parts of the survey later conducted on the entire class.

4.4.3 Survey

To answer my research questions, and to properly evaluate the system proposed as a part of this thesis, a survey was conducted. The survey was performed on the class of TTM4100 in the form of a online questionnaire. This was distributed to the class after they had been able to use the system in studying to their exam. Before releasing it, it was dry-tested on 4 subjects from the class, to uncover and resolve any difficulties with it. The survey was in english, but the participants were allowed to answer in Norwegian if they wanted.

The survey sought to uncover several facts:

1. How students respond to a Game Mechanics based E-Learning system such as the one one in this thesis (research question Q1, see section 1.3).
2. The usability of the system.
3. The system's general usefulness.
4. The system's usefulness in the context of the TTM4100 subject. To highlight the practical aspects of use in a real-life educational setting.
5. The most desired functionality for future implementations of the system.

6. The manner in which the system was used in a real-life educational setting.
7. How motivating the system was considered to be (research question Q2, see section 1.3).
8. Whether or not the inclusion of the chosen Game Mechanic made it to be perceived as a game (research question Q3, see section 1.3).

The system was presented in English to an audience of native speaking Norwegians. This wasn't considered to be a problem, since it was at a university level course with an English syllabus and English speaking course teacher. Still, the survey also sought to uncover if the students would have preferred if the system was in Norwegian.

To properly measure the usability of the system, a formal usability measurement scale was used. The System Usability Scale (SUS) proposed by [Brooke \(1996\)](#) provided a quick and generic way of measuring usability. It is also commonly used as a questionnaire in a variety of research projects ([Brooke, 1996](#)). The SUS questionnaire consists of 10 questions, giving a global view of subjective assessments of usability. Each question has a scale position from 1-5, which indicates a corresponding agreement from "strongly disagree" to "strongly agree".

The SUS score is calculated as [Wang et al. \(2008\)](#) explains: For the odd numbered questions 1,3,5,7 and 9, the score contribution is given by subtracting 1 from the scale position. For the even numbered questions 2,4,6,8 and 10 the contribution is 5 minus the scale position. This implies that each question has a SUS contribution of 0-4 points. The reasoning behind this this scoring is simple: The odd numbered questions are positive responses, so their values are just rescaled to begin at zero. The even numbered questions are negative responses, so their values are converted to represent a positive score contribution. The totals for each question is then added up, and divided by the number of respondents, to get the score contribution average. Finally, the sum of the score contribution averages for all questions are multiplied with 2.5, to obtain the SUS score. (The reason behind this last multiplication is to convert the range of scores from 0-40 to 0-100.)

In summary, SUS yields a single number between 0 and 100 which represents a composite measure of the overall usability of the system being studied. The average responses for the system in this thesis and the resulting SUS Score can be seen in table 5.2.



The KANBAN chart

| <i>INBOX</i> | <i>MAYBE</i> | <i>PENDING</i> | <i>WORK IN PROGRESS</i> | <i>FINISHED = DEPLOYED TO SERVER</i> |
|-------------------------------|---|---|---|---|
| New un-prioritised Work Item. | Feature: Flag other people's answers you think are incorrect. | GUI: Show previous question. | Feature: Make questions answering random. | Feature: Option in answer screen to answer questions you've already answered correctly. |
| | | Feature: Button for stop marking answers. | | GUI: Rename button "Mark answer" to "Correct answer". |

Table 4.1: Example of the KANBAN chart used in the development: Note that the "Inbox" and "Maybe" columns are personal modifications.

Results from evaluation

5.1 Usability Tests & Interviews

The usability tests were the primary feedback mechanism used to guide the development process towards a more usable and useful system (formative evaluation). The feedback from the 9 different subjects was noted during the test, and later fed into the KANBAN chart. In the KANBAN chart the feedback was coupled with the name of the subject who made me aware of the issue, and displayed in a "Suggested by" column. For this report, their anonymity is maintained by referring to them as subject #1-#9. Some important results from the 9 in-person usability tests that led to a design change are summarized in table 5.1.

Highlights of user feedback and resulting actions taken to redesign system

| <i>User feedback</i> | <i>Action taken</i> |
|--|---|
| #4 was afraid that his/her questions were stupid. #9 didn't want his/her question to worsen the quality of questions in the system. | Information was given to user when creating a question: questions can be deleted later at will. |
| #1 was missing more feedback to guide him/her through the system. | Notifications were added that informed the user of the next step. |
| #6 desired a manual explaining the meaning of the colors. #5 wanted info on how the points were calculated. | A "How it works" page was created, to instruct the user. |
| #6 and #7 tried to log in without registering first | Redesigned the front page to put the registration form first, and be emphasized in grey color. |
| #7 falsely assumed that the system might correct questions automatically. #9 suggested moving the review of a question right after answering it, when it is still fresh in the users memory. | #9's suggestion was implemented. |
| #5 asked "what is the maximum amount of acheivable XP" | The max amount of achievable XP was included next to the progress bar. |

Table 5.1: Feedback from usability tests led to actions taken at different stages throughout the development cycle.

In addition to the feedback mentioned in table 5.1 a number of usability issues of lesser or higher degree were discovered and fixed. Fixing these was important, so that later usability tests and the responses from the survey would provide high quality feedback (as mentioned in Q1, in section 1.3).

In the interviews after the usability tests, some very important discoveries were made. In one of the first usability tests, subject #2 noted that the system gave the feeling of an "admin GUI" (see examples in appendix A.4 and A.5). This was an entirely correct description, as the system overall had a lot of information and options presented to the user. This information was used to completely redesign the entire GUI (now centering around the home screen (as seen in appendix A.6).

Later interviews revealed various impressions of the system: "A Q&A site", "A quiz", "A test", and "a rote rehearsal tool" was some of the different mental models users had. This was useful information which would be hard to obtain without the interviews. They were all correct mental models to some extent, but future work on the system should focus on engraining users with one clear mental model right from the start.

The interviews also led to an early indication of some positive sentiment towards the system:

"reviewing answers is actually a good way to repetition" -subject #6

"testing yourself like this is a good way to learn" -subject #9

"it was fun to get XP" -subject #5

On the other hand, some concerns about the usefulness of the system were raised. Subjects #3 and #4 openly admitted an "egoistical attitude". Further explaining that they preferred to answer other peoples questions and not create questions themselves. This supports the notion that the system is best used in collaboration with others, and not primarily as an individual tool for rote rehearsal. That insight was used in the creation of the questionnaire to probe for the utility of using the system entirely by oneself. The data from the survey later confirmed that most people carried this egoistical sentiment (see subsection 5.2.2).

The feedback from the usability testing also led to a redesign of the website page structure. The number of individual pages were reduced from 16 to 10, and interactions were significantly reduced as well. This led to a more usable interface and a better flow for the user. All in all, the usability testing provided a very fruitful (albeit time-consuming) approach to improve the usability of the system.

5.2 Survey findings

The survey was conducted on the class of TTM4100 in the form of a questionnaire. The questionnaire got 44 respondents, 38 males and 6 females. Their age ranged from 21-25 years. Generally, the respondents were asked to answer various questions by choosing a value on a scale from 1-5. The scale represented various statements from "not very", "less", "somewhat", to "quite" and "very", for 1-5 respectively. The results will be presented in this section and discussed where appropriate.

Overall discussion of the findings will be done in chapter 6. The usability and usefulness findings relate to research question Q1, and the evaluation of fun relate to research question Q2. The findings on whether or not the respondents experienced the system as a game relate to research question Q3.

5.2.1 Usability

The general usability of the system was measured with the SUS tool (see subsection 4.4.3). Responses on the 10 SUS questions indicated that the system was experienced as very usable (see table 5.2). The total SUS score of the system was 77.3 out of 100. This is a very good score, but it is important to note that SUS scores are not percentages. The average SUS score has been found to be 68, after studies of 500 evaluations (Sauro, 2011). A SUS score of 77.3 is above average, and can be interpreted as a *B+ grade* (Sauro, 2011).

As predicted, the impact of presenting an English system to an audience of Norwegian students was marginal. The questionnaire revealed that the plurality¹ of students strongly disagreed that they would have preferred that the system was in Norwegian instead of English. As much as 59% of students disagreed with this statement, and only 19% agreed to some extent. This sentiment was further supported by the responses to the question of whether the students wanted the system in multiple languages (like Norwegian): only 14% of students indicated they wanted it "much" or "very much" in total. Taking into consideration that the course was a university level course taught in English, the fact that the system was presented English was therefore not considered to have a significant effect on the usability.

The general good usability of the system was supported by statements made in the questionnaire to the question "what worked best in the system":

(1) Plurality means the larger/greater part. In the context of voting it doesn't need to be above half of the votes.

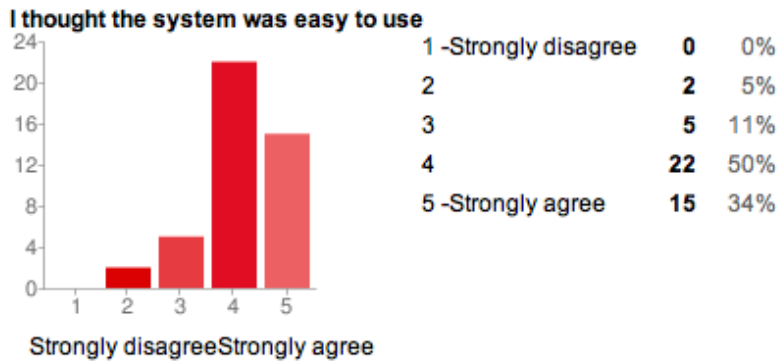


Figure 5.1: Easy to use: The system was considered easy to use by most of the respondents.

"Simple, easy to use.",

"Easy to use.",

"Easy to navigate. Very intuitive." (translated)

The aspects affecting the usability, and probably limiting it from obtaining a max SUS score was revealed in some of the answers to "what worked the worst in the system":

"Great system, but bugs drags down the total impression.",

"Correcting your own answers, those buttons were not intuitive enough, (creating the need to explain them)."

And when asked about the one thing in the system they would choose to improve, some answered:

"The navigation between menus were a little bit confusing from time to time.",

"Make it more streamlined, i.e. more links between relevant pages (e.g. you couldn't go directly from correcting your answer to seeing other people's answers ..."

Overall, the usability of the system was considered to be very good. Perhaps it is best illustrated from the responses to the statement "I thought the system was easy to use", as shown in figure 5.1.

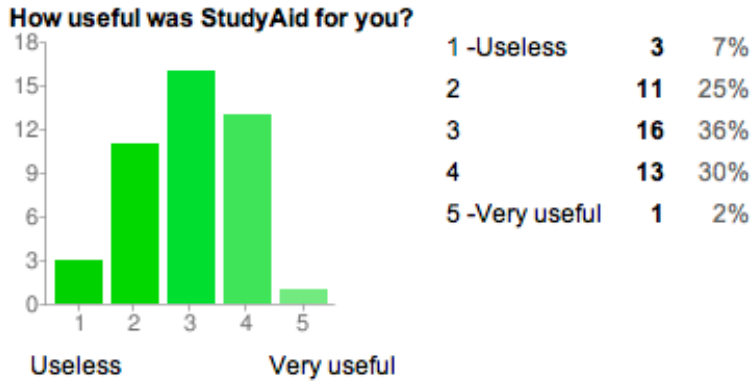


Figure 5.2: Usefulness: How useful the the various students considered the system to be for them.

5.2.2 Usefulness

The questionnaire included questions to indicate whether or not the students found the system useful. Responses to various questions regarding the usefulness indicated that there was a difference in preference amongst students, but the plurality found it to be "somewhat useful".

The perceived usefulness was likely highly influenced by the social aspect, and the fact that some students contributed questions for everyone to answer. To illustrate: When respondents were asked if they would use the system solely to test themselves (given no questions from others in the system), it didn't appeal to a lot of students. Only 25 % of students would use it for that purpose "often" to "very often". This is further illustrated by the fact that there was a small amount of question contributors amongst all of the users. But they in return contributed a lot, similar to the effect seen in other online collaborative communities like Wikipedia (Ortega, 2009).

Another perspective on the usefulness of the system was revealed through respondents answers to a question probing for independent use. As much as 70% of students would use the system from "somewhat" to "very often" on their own, in a different subject, even if it wasn't required or promoted by the teacher. This might indicate that they found the system useful on it's own.

When asked directly if they found it useful for themselves, the most people replied it was "somewhat useful", but difference in preference led to a normal distribution of the



Figure 5.3: Usefulness: How much the system helped different students in their learning.

responses. The system was clearly more useful for some than others.

An important aspect of the usefulness of an E-Learning system is tied to the actual learning benefit. The responses on "whether it helped in their own learning" were similar to the responses of usefulness (as seen from figure 5.3). Even though the desire is to get everyone to get a great learning benefit from using such a system, it might not be realistic. People have different learning styles, which might be attributable to multiple intelligences according to the theory of Gardner (1985). In respect, E-Learning systems should accommodate for various learning styles according to Kolaas (2010). It might be a requirement for truly personalized learning, but unfortunately it wasn't considered feasible within the scope of this thesis. The fact that 63 % of students found the system "somewhat" to "very helpful" in their learning is considered as satisfactory within the constraints. Often, it is just as important to give extra help to the students struggling with a subject, as it is to make a solution that fits all to an equal degree.

The system was in majority used by the students when studying to their exam. This could have affected their perception of its usefulness. The period leading up to their exams are typically characterized by intense studying and harsh prioritization. If they only considered using the system as an "added benefit", it might have been perceived as less useful in efficiently delivering the most important required knowledge. This interpretation is supported by statements from some of the respondents:

"If the questions were made by the teacher or they were somehow know to be relevant

to the exam I would use it more, but when students make the questions I don't trust the usefulness of the questions, compared to previous exams.",
"I did not use StudyAid that much and found that doing the previous exams was more conducive to my learning.",
"I were rather late and didn't spend much time in doing the questions on StudyAid. I focused on reading the book and looking at old exams. If I were more prepared I'd probably be able to use it more."

From these statements we can also infer that the perception of usefulness was likely influenced by the *content* (questions and answers) in the system. Even though the majority of students found the content in the system to be relevant, it was clearly not the case for everyone. A minority of 11 % of students found the questions "less relevant" or "not very relevant". This is likely to have influenced their perception of the system's overall usefulness, and can attribute for some of the negative responses to the questions regarding usefulness.

On the positive side, some of the responses referring to usefulness were:

Response to "what worked the best": "People used it, got different questions and viewpoints, by being able to read other peoples answers.",
"I would love to have it in every subject where there is facts to remember."

The usefulness would probably be perceived to be higher if implemented as a complete system in a subject from the very start of the semester. That way, students could use it over a longer period to build a larger set of questions, which they could get cross-checked by the teacher. This is supported by the overall response to the first SUS question: whether they would like to use this system frequently. As many as 43 % of students agreed, versus the 20 % that disagreed (to some extent) to this statement. So it is conceivable that a good deal of students would have liked to use it more often, if they had more time and less pressure than in the exam period.

5.2.3 *Motivation, engagement and fun*

The survey also sought to uncover the systems ability to motivate and engage the students. This was done to evaluate if the Game Mechanic based E-Learning approach has a practical purpose for students on a university level.

The responses from the students indicate that the plurality didn't perceive the system to be more than "somewhat" motivating in itself. Similar to the responses to usefulness, this is likely to have been influenced by the fact that the students used the system primarily while studying for their exam. The significance of this influence was discovered in the interview after the last in-person usability test. The student explained that in the exam period he considered himself to study for the exam "like a machine", fueled only by self-discipline. To him, fun had no place in this process, and he didn't care about the progression Game Mechanic at all for that reason. He just wanted to get through all questions in the system as fast as possible. It is conceivable that other students felt the same. The survey response from another student also documented this:

"Still exam preparations, so "fun" is rarely the correct word."

A related factor that could have had importance for the experience of fun is how the system was framed. The framing, in terms of the wording on the front page, as well as on the system help page, could have given an impression of "work" more so than "fun". This was discovered in the last in-person usability test where the subject stated that his first impression of the system was that it was a tool for rote rehearsal. While that was also one of the benefits of the system, the mindset with which subjects entered it might have been changed. This could have *primed*² them to be less likely to think "fun" of and describe the system as such.

Another influencing factor on the experienced motivational / fun aspect of the system is the content of the course subject (TTM4100) itself. Some respondents indicated that their own perception of the system as "fun" was influenced by the course content to a degree. One respondent from the survey explained:

"Well, a lot of subjects never gets fun even though you introduce remedies like this."

The fact that the respondents feeling of "fun" was influenced by course content could attribute for some of the negative replies to questions on motivation, fun and engagement. But the case that some students also actually liked the subject, and found the system more fun because of the content there, shouldn't be dismissed either.

Despite the context and surrounding influencers, the system managed to motivate a number of its users. A total of 66 % of users responded that the system was "somewhat"

(2) Priming is an implicit memory effect known from psychology. It describes the effect where exposure to a stimulus influences response to a later stimulus.

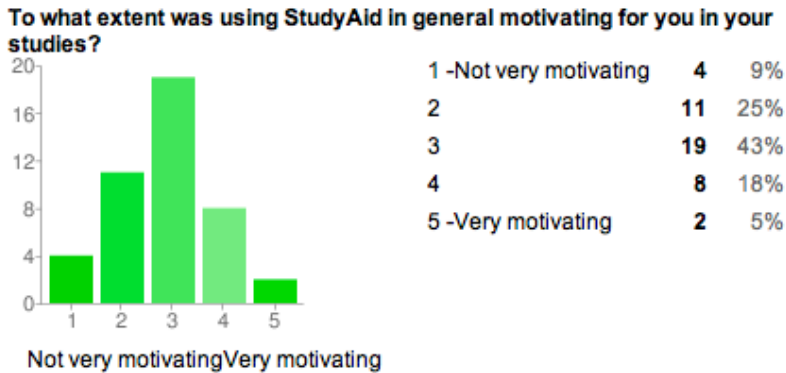


Figure 5.4: *Motivating: The system was considered in general to be only "somewhat" motivating. The motivating factors were likely marginalized by the fact that it was used in an intense period of exam study.*

to "very motivating". But what was the reasoning behind this? A look into some of their statements shed some light on the matter:

*"Quick active feedback on whether one performs well or not." (translated),
"Variation."*

(The stated reasons for motivation overlap with the ones for engagement, so the respondents positive and negative statements continue into the next paragraph)

When respondents were asked if they found that the system made exercises / questions more engaging, the plurality reported that they did. As much as 75 % reported that they thought the system made this type of content "somewhat" to "very much" more engaging. The reasons stated were:

*"It is way more motivating and engaging than just reading the books. To get to test yourself in an efficient and fun way would be very valuable to me.",
"I can score points! (wohoo)",
"Fun to see what others feel confident about, and if one is in the same boat as the rest of the class. Is there a lot I don't know, that I should know?" (translated)*

The reasons people didn't find it making exercises more engaging were amongst others:

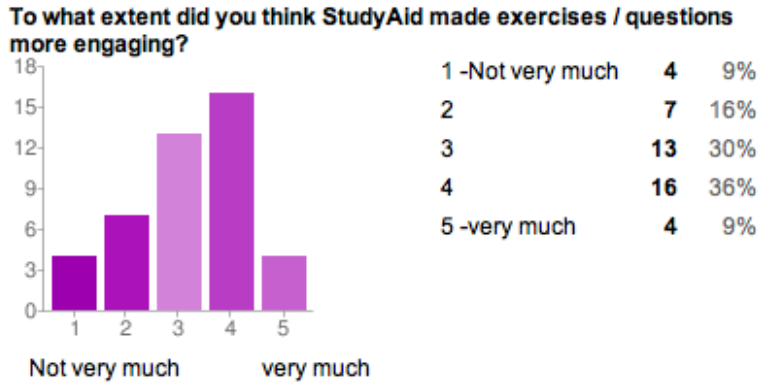


Figure 5.5: Engaging: The plurality of students found the system to make work with exercises/questions quite engaging.



Figure 5.6: Experience of Fun:

*"There was no clear tie for me between Studyaid and motivation.",
 "I could have just answered the questions in the textbook if I wanted to answer questions."*

Both motivation and engagement can be considered factors related to the experience of fun. But to get the respondents direct opinion of fun, they were also asked directly. A total of 77 % of respondents indicated that the system was "somewhat fun" to "fun". The reasons behind the experience of fun were various, and some have already been stated above. Some reasons given, that were not as expected, were:

*"Fun in a way that I could make my own question.",
"More fun to answer questions at the computer than on paper."*

Yet, no respondents would say that the system was "very fun". One of the most interesting reasons why one of the respondents didn't consider the system fun was:

"The whole game/xp aspect doesn't really do much for me without some tangible prize. Good questions make it more worthwhile for me."

This indicated that the XP part wasn't conceived (for him at least) to be the what made the system fun. Although other people mentioned that the XP/points part was the part that made using the system engaging (stated above), there is clearly a difference in sentiment towards this Game Mechanic.

The people that responded well to the Game Mechanic based approach felt that it could be even better in the future, with some improvements:

"When I first started, there wasn't that many questions, so I didn't care that much. When I tried it once more, there were some more questions and I had fun gaining experience. I think that a new experience system could make StudyAid a bit more fun. Maybe have levels as well as just the experience."

"It was sort of fun but with some improvements it could really work and be good."

"I think it would be motivative to have such an approach to studying instead of just reading the books. Especially the competition to come up with great questions and get the best score would motivate me."

5.2.4 Was the system perceived as a game?

The system used a "Progression/points" Game Mechanic with a goal of reaching 500 XP points, and visualising the progress through a progress bar. It also had a list of rules, tied to the XP and to the general use of the system. Since the definitions of a game according to both [Salen, K. and Zimmerman \(2004\)](#) and [Kim \(2009\)](#) cite "rules" and "a goal / quantifiable outcome" as central to what a game is, it is natural to discuss whether or not the system actually is a game. (This is also central to research question Q3.) To aid in this discussion, users own perception of the system was considered useful.

Did you perceive StudyAid as a game?

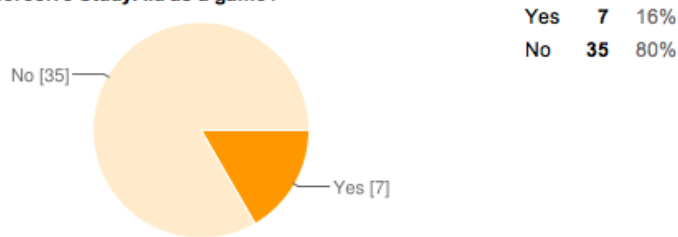


Figure 5.7: Perception of StudyAid: The vast majority of users did NOT consider StudyAid as a game in itself.

The vast majority of students didn't consider StudyAid as a game in itself. They stated a number of different and interesting reasons:

1. *"Does not resemble a game."*. Another said: *"Progress bar wasn't enough :P"*
2. *"I did it only to learn."*
3. *"For me it doesn't feel like a game. I either need an entertainment part or a very strong competition part to make it feel like a game."* Another said: *"[No] But I could have done that if it was multiple-choice questions for different topics, with (high)scores that I could have tried to improve."*
4. *"I got more the "quiz"-feeling really, and I didn't immediately think of it as a game. The difference between a quiz and a game (like Trivial Pursuit) is probably that the prize by answering correctly is more than just a number."*
5. *"No main character, levels or options "along the road", more like "answer these questions until you get them all correct"."*

These reasons will be discussed in detail in chapter 6, and seen in the light of research question Q3.

An interesting note, to the aforementioned *priming effect* were some reasons stated why people didn't consider it to be a game. The very name, StudyAid could have primed people to not think about it as as a game (or even as something "fun", as mentioned in subsection 5.2.3). The statements made were:

"I didn't actually see it as a game, more like the name - a study aid.",
"[I am] More likely to view it as a help-application to study and learn something new." (translated)

Among the people that did perceive StudyAid to be a game, the only indicative response was:

"The XP did the trick."

These findings will be discussed in detail in section 6.1 and seen in the light of the research question Q3. All findings presented in this chapter will be elaborately discussed and contextualized in chapter 6.



StudyAid Total SUS Score = 77.3

| # | QUESTION | AVG. | SCORE CONTRIB. AVG. |
|----|--|------|---------------------------|
| 1 | I think that I would like to use this system frequently. | 3.27 | 2.27 |
| 2 | I found the system unnecessarily complex. | 1.66 | 3.34 |
| 3 | I thought the system was easy to use. | 4.14 | 3.14 |
| 4 | I think that I would need the support of a technical person to be able to use this system. | 1.20 | 3.80 |
| 5 | I found the various functions in this system were well integrated. | 3.50 | 2.50 |
| 6 | I thought there was too much inconsistency in this system. | 1.86 | 3.14 |
| 7 | I would imagine that most people would learn to use this system very quickly. | 4.34 | 3.34 |
| 8 | I found the system very cumbersome to use. | 1.86 | 3.14 |
| 9 | I felt very confident using the system. | 3.80 | 2.80 |
| 10 | I needed to learn a lot of things before I could get going with this system. | 1.52 | 3.48 |

Table 5.2: StudyAid SUS Score: The final SUS Score of 77.3 is the sum of the "SCORE CONTRIB. AVG." column multiplied by 2.5 (to convert the range of scores from 0-40 to 0-100). The "AVG." column represent the average rating users gave on a scale from 1 ("strongly disagree") to 5 ("strongly agree").

Discussion & Conclusion

6.1 Research questions

The results for the evaluation gives some measures to discuss and answer the research questions put forward by this thesis. Each question will be appropriately adressed here, and viewed in the light of the most important findings.

6.1.1 *Q1: How usable and useful will students find the Game Mechanics based E-Learning system in this thesis?*

This research question sought to give an indication of whether or not the factors of usability and usefulness had influenced the experience of fun, motivation and engagement derived from the system. As mentioned in the introduction, usability could influence negatively through hindering the proper use of the system. Furthermore, the perception of usefulness could prevent people from using the system at all, or less often. If the system was used less often, the effect of its engaging elements could be marginalized. Here we will look into both factors, and make the case for whether or not they had a significant influence.

The feedback from the survey showed that the system was indeed considered to be very usable. The calculated SUS score of 77.3 confirmed and supported the positive statements various users made about the system's ease of use. It is natural to ask whether the SUS score can be considered to be reliable and valid. Actually, it is safe to say that it is both valid and reliable (even on very small sample sizes). SUS has been shown to effectively distinguish between unusable and usable systems, and correlates highly with other questionnaire-based measurements of usability (concurrent validity) (Sauro, 2011). The usability of the system wasn't considered to have a significant negative impact on the experience of fun, motivation or engagement. It is unlikely that a significant amount of users had a deteriorating experience of fun because of usability problems.

Usefulness was not such a clear-cut case. The survey data showed that the system was considered to be "somewhat" useful by most students (normally distributed). Roughly the same normal distribution was put forth to the question of how helpful it was in the respondents' learning. Although it wasn't considered as useful as hoped, the response isn't necessarily a bad one. As previously mentioned, any system pertaining to helping

students in their study is affected by various study habits and preferences of study techniques (for example testing yourself vs just rereading). It might also not be realistic to expect that a simple prototype system can accommodate for all kinds of learning styles. The fact that it was useful for and helped *some* students *quite much* in their learning should be considered as satisfactory for this thesis.

The most of the students considered the questions to be "quite relevant" for the exam. This didn't come as a surprise since the students contributed most of the questions themselves. The content in this case wasn't seen as a negative influence on the usefulness of the system. But one part that might have influenced the usefulness was the fact that the majority of content was created during the period the system was used. Therefore, the usefulness might have increased over time (as one respondent stated, in subsection 5.2.3).

So, did the usefulness of the system influence the experience of motivation, fun and engagement? The results indicate that it did, negatively, to some extent. Perhaps the largest influencing factor was that the students didn't use the system very often. To get the full motivational effect of the Progression/points Game Mechanic which was used, it is important that the users are somewhat *engaged* with it over time. Progression is, after all, best viewed and appreciated over time.

As much as 68% of the users reported that they used the system "not very often" to "less often". This can be attributed to several causes. First of all, it is likely that they didn't consider the system to be very useful. This however, is contradicted by the direct responses to the question of whether it was useful/helpful or not (which gave the normal distribution mentioned above). Another and perhaps more likely explanation is that *the users had too little time to use the system*, and used it in a period with intense studying to exams in a lot of different subjects. Some students stated that they didn't get around to using the system until right before before the exam (see section 5.2.2). Information gained through the interviews with the usability testers from the TTM4100 class leads me to believe that this was very likely the case for the majority.

In spite of its low usage, the students considered the general usefulness of the system to be high. A total of 79 % of students considered it to be from "quite useful" to "very useful". The discrepancy between this high perception of usefulness and their actual low usage might come from the aforementioned contextual influencers. But an alternative explanation that shouldn't be disregarded is the fact that respondents might not act in accordance with how they say they will act (Oates, 2006). Nothing should be taken for granted, so this should be looked into in future research. What we can say for now, is that *the general interest for a system such as the one as proposed in this thesis was quite*

high. Feedback also indicated that prototype in this thesis still has a lot of unrealized potential.

6.1.2 Q2: *How motivating can a simple Game Mechanic be when used as the basis for E-Learning?*

The initial hypothesis for this research question was that progression feedback motivates students. To evaluate this, the chosen approach was to construct an E-Learning system using the Progression/points Game Mechanic and then evaluate the motivation/fun/engagement derived from the system as a whole. This was done with the assumption in mind that "fun", "motivating" and "engaging" are different perspectives of the same underlying experience. Collective responses to questions regarding each of these perspectives were further assumed to give a better insight than just responses to one of them. Another assumption was that "fun" is a holistic and emergent experience, hard to pull away from the complex interdependencies and details of any system providing it. To reduce this complexity and factors influencing fun other than the central Game Mechanic itself, the system was made as Lean (with a small feature set) as possible.

The Game Mechanic in question also had to be implemented with a practical purpose, giving feedback on a certain type of user actions. In that respect it was indicative of a certain type of skill. For any other system or implementation, the same Game Mechanic can have a different effect, depending on what "meaning" is attached to the feedback it gives. The meaning attached to it for the system in this thesis, could be stated as: "how well the user is able to correctly answer questions", and "how many questions (considered relevant for the exam) the user has answered". This could give an indication of "how prepared the user is for the exam" as the overarching meaning.

So, how motivating, fun or engaging was the Progression/points Game Mechanic really? There is no simple answer, as fun is a perpetually hard concept to measure. However, the results from the evaluation enable us to shed some light on the matter.

A total of 34 % of students considered the system to be "quite fun" and 43 % "somewhat fun", as seen from figure 5.6. The factors influencing fun have already been discussed in subsection 5.2.3. The negative factor considered most influential, the limited time people used to test it, was highlighted in the previous research question above. As also hinted, the experience of "fun" is likely to have been marginalized by the circumstances of the system's use. Fun likely wasn't the primary reason for why people used the system, but more so the relevant content. Like in a game, the player / user can choose to play

or not. And the circumstances surround the use of the system unfortunately dictated that a lot of the students didn't choose to fully engage. This might have been because the chosen Game Mechanic simply wasn't "*fun enough*", but in a period so intense as the exam preparations period (at university level), it would be hard to compete in any case. It was concedingly more important for many to get through the curriculum fast, than see how many points they could score. In addition, subject preference were also likely to have had an influence of fun (5.2.3). Sadly, these circumstantial factors weren't predicted to be of such a large influence before the beginning of this research. Time of development would in any case have made it hard to have made the evaluation performed at an earlier stage.

Perhaps a better indication of how motivating the Progression/points Game Mechanic were, was the question of "to what extent the system made exercises / questions more engaging". *The greater part of students stated that it made exercises "quite" "more engaging". This was considered as a positive response, since the goal of the development work put into this thesis was to make work with exercises / questions more engaging and fun.* In light of this, and the quotes from the survey (seen in section 5.2.3), we can confirm the initial hypothesis that visual/on-screen progression feedback likely motivated the students in this case study. As the current thesis present a case study, this statement is not immediately generalizable, but other successes from Gamification (see section 2.3) indicate that it likely is.

In summary, the Game Mechanic based E-Learning system was on average considered to be "somewhat motivating", "somewhat fun", and made the work therein "quite engaging". This could likely have been higher, given more uncontested time for the evaluation period, and more time to refine the Game Mechanic implementation through iterating based on user feedback. Further work could also be done in quantifying the "fun factor" even more. Lastly, it can't be dismissed that the effect of the "fun factor" might have less of an impact and practical purpose for students at a university level, than at other levels of education. Students at a university level are arguably more self-disciplined than high school students for instance. That might mean they have less of a need for an E-Learning system which is based on Game Mechanics for motivation. In any case, the case study presented in this thesis isn't enough on its own to confirm or rule it out entirely.

If one thing was learned through this case study, it was that the main importance to applying Game Mechanics based E-Learning is that the intrinsic motivations of students needs to be supported. Students need to get value for their time spent, and be efficiently driven towards getting better grades. A simple Game Mechanic isn't as motivating in

itself as if it aligns with the overall goal of the student.

6.1.3 Q3: *Where lies the difference between applying Game Mechanics to E-Learning and making a Serious Game?*

To answer the third research question, it is interesting to evaluate how the users themselves perceived the system. Was it experienced as a game, or just an online exercise system? To my knowledge, the point of transition between utilizing Game Mechanics and making an actual game hasn't been made before. In the context of this thesis, it is interesting to discuss where Game Mechanics based E-Learning systems and Serious Games differ in the central defining way.

From knowledge of other Gamification efforts, it was predicted beforehand that the inclusion of Game Mechanics can make a system actually be perceived as a game. The results from the evaluation of the system in this thesis also told us that as much as 16 % of users perceived it as such. The response, in one respondents own words, confirmed that it was in fact the Game Mechanic that made this perception materialize:

"The XP did the trick".

Was this perception just a confusion, or could the system in right terms be defined as a game? To examine this, we should first look at some of the reasons respondents *didn't* perceive the system to be a game. They were decidedly very different from each other (see subsection 5.2.4), which raises the question:

What makes a game? Is it:

1. The visual resemblance
2. The choice play
3. Entertainment or Competition
4. The rewards given
5. The content or the Game Mechanics

These aspects correspond to the reasoning made by various respondents in the survey, which are listed in 5.2.4.

The first reason stated, the visual resemblance asserts that if it looks like a game, it is a game. This might be an easy way of relating to games in everyday life, as we often have a very intuitive understanding of what a game actually is, or can easily recognize when someone is "playing". But it isn't a term that is very descriptive, or enable us to effectively and objectively categorize systems in to games and non-games. Therefore, it won't suffice.

What about the second reason: "A game is a game if the participant chooses to play". This might seem like an absurd definition at first, but it actually has some meaning to it. The concept of the "Magic Circle"¹ as a boundary of being "inside" or "outside" of a game is actually well known within literature on games and play (Moss (2008)). The participant can step into the magic circle to start the game and play, or step out of it, choosing not to play. And if the Magic Circle delimits the boundary of a game, isn't what's inside the actual game? The issue with this definition is of course that it is entirely subjective, and related to a choice and not an inherent substance. A workable definition for a game should explain what it is objectively, without relying on the choice of a user. Besides, what if the game has several players, and one chooses to play and another chooses not to. Does the game/system then change its nature? Arguably not. So this definition won't suffice either.

The third reason can be divided into two parts. The first part, "Entertainment", is arguably not a good descriptor for a game. Apart from being subjective, it broadly describes all types of media from magazines, to tv, to games. It simply isn't precise enough. The second part, "Competition" is interesting, as it can be related to the part of Salen, K. and Zimmerman (2004) definition of a game which pertains to games having an "artificial conflict". As argued in section 2.1, not all games have an artificial conflict (or a competition for that matter). Quite a few games have competitions, but there are quite a few competitions which aren't games as well. Therefore, "competition" is not a good defining characteristic of games either.

The fourth reason asserts that games are represented by the rewards given. This is actually a definition that leads us closer to being able to distinguish Game Mechanics from Games. What is a central element to games is that rewards give an actual benefit *within the game*. They aren't just empty representations, but have an inherent meaning to the player. A reward is only an effective reward if the player feels he is being rewarded. We will come back to the meaning of rewards later. For now, we can say that rewards are

(1) The term Magic Circle refers to the membrane that encloses virtual worlds such as online social environments, and online games such as World of Warcraft. It can be viewed as the boundary that separates the fantasy world that is the game from the outside world. Every game exists within a such a frame, a specially demarcated time and space. See Wikipedia or Huizinga (1955) for elaboration on the concept.

too narrow a term to be used to describe the complex nature of games on its own.

The fifth reason given stated content (like "a main character") as a necessity for a game. Are games only the physical content they contain? The immense variety of games, and their arguably vastly differing content, makes this hard to accept as a defining characteristic. Besides, a game such as chess, or even poker, has no "main character", but are still unequivocally considered games. The second statement also suggested that "levels" should be a part of a game. This is of particular interest, since "levels" are one of the most popular Game Mechanics (listed in section 2.2). The system already had the Progression/points Game Mechanic, so suggesting that the inclusion of yet another Game Mechanic could make it into a game is interesting. Are games just compositions / collections of several Game Mechanics? Under the umbrella of Gamification (2.3), a lot of actors have already combined several Game Mechanics into the same systems. But neither the creators of the systems or the users are calling them games (the most popular denomination might be "online communities"). If we put some weight into a definition of games being both descriptive, classifiable and resonating with our intuition, it is hard to accept that everything that is a combination of Game Mechanics is in fact a game. That would describe all "gamified" systems as games, and they are decidedly not commonly perceived as such.

What remains then? What possible quality of a game puts it apart from being just a system with Game Mechanics? How can we tell when we are constructing a game, from when we are applying Game Mechanics? In designing Game Mechanics based E-Learning systems, this is important to know. How would we otherwise be able to discern Game Mechanics based E-Learning systems from Serious Games, or guide us in constructing the one or the other? From Gamification efforts we know that they are not one and the same. And the results from the evaluation of the system in this thesis indicate that they are indeed not the same. The Game Mechanics based E-Learning herein proposed was in fact not considered to be a game by 80 % of respondents.

The distinction is not very easy to make without going back and exploring the definition of a Game we made in the introduction: *"A game is a decision-space with rules, rewards and loss"*.

From this definition it stands clear: The decision-space is the central element of games. This is what separates the Game Mechanics based systems from actual games. Furthermore, this is what separates Game Mechanics based E-Learning from Serious Gaming. A discovery made in this thesis, is that the system made wasn't a game, because it didn't provide the user with a new set of meaningful / interesting choices for each action the user took. The linear sequence of actions the system presented the user with (answer

this question, answer the next) isn't actually representative for a decision space. The only choice given to the user was to continue stepping through a sequence of questions ("answer 5 questions"), or choose a question at will from the question feed. But there were no reward coupled to either action, or consequences the user would experience. The decisions stopped with choosing a question, or starting answering a sequence of them. There were no alternative routes or actions from within a sequence. Therefore, the decisions the user had to make were strictly linear, and no space / room / game world were presented to the user.

What is characteristic of a decision-space is that one decision affects the next available decisions. The player/user navigates the decision space and shapes its extent along the way. E-Learning systems like the one in this thesis, are on the other hand characterized by having a predefined static set of actions and decisions the user can make. After all, *E-Learning seeks to simplify the acquisition of knowledge, while Games seek to make interesting / complex decision spaces*. In this regard, it might represent a conflict of purpose. For the system in this thesis, the respondent with the fifth statement (5.2.4) actually got it right:

The system wasn't a game because it had no "... options "along the road", [it was] more like "answer these questions until you get them all correct".

And the respondent with the fourth statement (regarding the meaning of rewards), actually touched on the answer as well.

"The difference between a quiz and a game (like Trivial Pursuit) is probably that the prize by answering correctly is more than just a number".

The "more than just a number" indicates it has some "meaning". The meaning imparted by rewards with real (and often exaggerated) consequences are what makes it rewarding to navigate the decision space in games. This correlates well with Sid Meier's definition of a game as "a series of interesting choices". As we stated in the theory section on games (2.1): *"if the player is presented with various disparate options with the potential for reward and loss, it will make the choice interesting"*. We can add that choices are often interesting because they are meaningful, making those descriptions two sides of the same story. The point missed when explaining rewards introductory, was the fact that *rewards in the game should relate to, and shape, the decision space* in the game for them to be truly meaningful and rewarding. The same goes for the rules and the experience of loss. (The rules are actually what defines the extent of the possible decision space, which is arguably what makes every game unique.)

If we look at games, there is one thing that is known from game design theory to make games lose their meaning and become boring to the player. This happens if the player is able to discover an *optimal strategy*². In terms of our definition for games, this discovery leads to a collapse of the perceived decision-space down to a one-dimensional sequence of actions. The player picks the one action he/she knows is sure to win, then picks the next such action, and so on. In other words, (given that the player wants to succeed) the number of *viable alternatives/options* are reduced to only one at each step, namely the action that leads to guaranteed success (in line with the optimal strategy). This represents no real challenge to the player, and the game loses meaning and becomes boring. In many ways, the pedagogical approach of leading the student through a predefined sequence of steps, could be compared with giving an optimal strategy, or even worse, removing all alternatives whatsoever. This should be a note of warning to creators of future Game Mechanics based E-Learning systems such as the one in this thesis.

It is conceivable that the system proposed in this thesis would have been considered more fun if it had actually had a decision space, with coupled rewards and loss. It could then have been considered a Serious Game according to the definition proposed here. *The difference between applying Game Mechanics to E-Learning and making a Serious Game is simply considered to be that a Serious Game inherently has a decision space within which the user/player can navigate.* An E-Learning system can present the users with various decisions at various stages, but pedagogical concerns often lead them to present linear decision sequences containing *no* various disparate options with the potential for reward or loss. Therefore making choices less interesting, resulting in less motivational impact. The potential for making a Game Mechanics based E-Learning system even more fun could be done by giving it a decision-space within which the user can *interact* and *experience consequences*. This would effectively make it into a Serious Game. That such a game has the likelihood of being perceived as *even more fun*, than an E-Learning system with some Game Mechanics, is supported by the following quote from [Camargo et al. \(2006\)](#):

*"What makes games fun is the **interactive** element."*

(2) An optimal strategy is a strategy that is guaranteed to lead to success.

6.2 Contributions & Implications

This thesis has contributed to the field of E-Learning research in several different ways. It has:

- Presented a case study for Game Mechanics based E-Learning which others can draw inspiration from.
- Charted the field of E-Learning.
- Explained the challenges faced by Serious Games.
- Introduced and charted the growing trend of Gamification. Gamification is predicted to have huge societal impacts, so it should be the interest of fellow researchers.
- Introduced the potential of using Game Mechanics in E-Learning - as an alternative approach to Serious Games which would exclude a lot of the problems.
- Evaluated the use of the Progression/points Game Mechanic within E-Learning.
- Defined and discussed some of the central elements to games, and how they differ from Game Mechanics. This could be used for designing better games, and in designing games for education.

The system presented in this thesis has some implications for its use. Some are of ethical concern. The most notable feature of the system is that the names of the users can be seen by other users. This is however only possible if creating a question or if the user marks an answer of his/her own to be correct. The answers marked as correct for each question will be shown in a list. This has a preventative effect against cheating, since everyone else in the system would see that you marked your wrong answer as correct. However, one flaw with the system in its current state is that it doesn't allow you to remove or edit an answer you mistakenly marked as correct. In that case, it might look to others as if you tried to cheat. This could be corrected in a future version by allowing to undo submitting an answer (which would also remove the points the user gained in the first place).

Another issue that could be of ethical concern, is that it allows everyone to edit submitted questions with their solutions. This was done to inspire openness and collaboration, and delay decisions (in accordance with the Lean principle) that would impose constraints possibly limiting the utility of the system. Currently though, the original creator name will still always be connected and show next to the question. This could open for misuse by pranksters by changing other users' questions texts to something self-inflicting or derogatory. Yet, this was not considered a concern for the prototype test in this thesis. It

was alleviated by the fact that only students from the TTM4100 were using the system. The fact that students went in the same physical class together, and that the system was promoted by the teacher, made it less likely that someone would exploit this feature. In the future, this ethical concern might be larger. It could be alleviated by showing a log of who edited other users questions, and notifying the originator of a question when other people edit it.

Another implication by the system pertains to its practical implementation in an educational setting. The role of the teacher in the system has not yet been clarified. It is presumed that the teacher could go into the system at regular intervals to verify the solutions to various contended questions. The teacher could even answer some difficult questions posed, or create own questions which test specifically relevant knowledge. By using the system as is today, the teacher would be able to see the questions from students, and their correct answers (just like anyone else can). From this, the teacher can deduce which students are well-performing and also those who are contributing to the class as a whole. This is positive, as it could be included in the formal assessment, benefiting students who help others.

6.3 Limitations

There are some limitations to the approach taken in this thesis. Limitations are related to the technical aspect of the system, as well as to the evaluation research performed. Finally, some limitations to the Game Mechanics based approach will be clarified.

First of all, on the technical side of things, there are some limitations which shouldn't go unmentioned. The prototype system built in this project has not been built to scale. *Accessing the web application is also currently quite slow*, due to the large database of questions and users added, and the brute approach taken to database access. The latter was a development decision made, to focus on delivering the necessary functionality before optimising (in accordance with the Lean philosophy). The database back-end solution SQLite is also a solution which decidedly isn't built to handle a lot of users simultaneously accessing it. For this project, it has been satisfactory, but in efforts to scale the application, or a similar application, MySQL or a similar DB back-end is recommended. In addition, a larger system should also implement more security measures, to prevent unrestricted access, and prevent harmful actions and possibilities for "cheating".

Secondly, the evaluation research and theoretical discussion done in the work with this

thesis is all done in the context of the case study which is the developed system. This means that results from the evaluation, as well as the theoretical discussion on which it is based is not immediately generalizable. There needs to be more quantitative and general research into the applications of Game Mechanics and Game Mechanic based E-Learning. When it comes to the use of the evaluation results for the system developed here, it also isn't without consideration to the fact that there might have been a bias in the selection of respondents. The respondents might have been particularly proficient in the use of technology and computers, which again might have skewed them towards both testing the online system and answering the questionnaire. The usability tests with older subject outside of the TTM4100 class indicated that they were far from as proficient as the students themselves, indicating a gap between generations. This should be taken into consideration in any future effort that tries to actively include the teachers to a larger degree.

Another question to ask is whether their age group is particularly susceptible to systems such as the one proposed in my work. In that case, the sentiment from a larger population might not be as favorable. In any case, the respondent group from TTM4100 is considered to be fairly representable for the population of students studying Mathematics and Information Sciences at NTNU.

The most important limitations with the Game Mechanic based approach to E-Learning is the fact that it can't as easily provide all elements of Serious Games, for instance. Games are very good at giving the player constant microscopic decisions to make, at every turn in the game. The approach taken in this thesis can't provide the same level of feedback because it is concerned with knowledge generation (typing in the answers) more than reacting to a visual stimuli on the screen. Games are also constantly giving better and more stimulating feedback than the Game Mechanics based E-Learning approach (in line with other Gamification efforts) currently could hope to achieve, without a considerable amount of work. The fact that Gamified applications don't provide the same wide decision space given by games make it harder to offer the same level of decision making and constant interaction (subsection 2.2.1). This might lessen the motivational impact of Game Mechanic based E-Learning systems compared to the potential of Serious Games.

6.4 Future Research

In future research there are several aspects about Game Mechanic based E-Learning that could be interesting to examine. For the system presented in this thesis, it would be very interesting to test the system over an entire semester, from beginning to start. This could

give better data as to how fun the Progression/points Game Mechanic really is, when not marginalized by other factors. An different option would be to choose an entirely different Game Mechanic, and evaluate its potential to create fun and engagement. Even several mechanics could be tested and compared, to discern what combinations have a larger impact on motivation. This could however lead to difficulties with complexity from interdependencies and discerning the actual factors affecting fun (as previously explained in subsection 2.2.1). Maybe a better approach would be to evaluate each Game Mechanic on its own, and create a comparative overview of their individual motivational effect.

Any researcher interested in ICT and Learning would also presumably be interested to learn what the quantitative learning outcome the approach in this thesis can give. This would be left to other research, and is perhaps best performed in a strictly controlled environment unlike a real-life educational setting.

Finally, it was previously suggested that perhaps fun and engagement factors have a larger influence on people of lesser age than students at university level. It might be a more fruitful approach to test various Game Mechanics ability to motivate children for instance. It should also be taken care that the setting of the test doesn't include outside distractors like the exam period in this thesis. That way, maximum motivational effect could be even more accurately measured.

6.5 Conclusion

This thesis have presented a case study of Game Mechanic based E-Learning. In the light of the prototype developed, both its usability and usefulness have been evaluated, to substantiate whether those factors had any influence on the experience of fun and engagement (Q1). It was concluded that the usability of the system didn't have an impact, due to careful iteration on user feedback. However, it was also concluded that the usefulness of the system did in fact negatively influence the experience of fun to a certain degree. This was likely due to circumstantial factors in the evaluation of the system, namely that the students were in a different state of mind in their exam period.

Furthermore, it was explored how motivating the Progression/points Game Mechanic could be considered to be when used as the basis for E-Learning (Q2). It was found that the system on average was considered to be "somewhat motivating", "somewhat fun", but also that it made work with exercises "quite engaging", according to the 44 respondents.

The difference between applying Game Mechanics to E-Learning and making a Serious Game was also explored (Q3). From evaluating the respondents' perception of the developed system as a game or not, several aspects of games were uncovered. In the light of this work, a general definition for games was presented, and used to derive and argue for where the borderline between a system with Game Mechanics and a game (in general) actually lies. It was found that the defining characteristic of games, which also indicates the separating factor between any Game Mechanic based systems and games, lies in the "decision space" that games offer. The concept of a decision space, and the reasoning for it being the central element of games was further elaborated and justified.

The approach of Game Mechanic based E-Learning needs further verification and case studies to be adequately assessed. Especially its potential to motivate and engage students needs further quantification to be generalizable. Still, it is the authors' conception that it remains an approach with great potential for creating true Personal Learning Environments with individualized measurement, feedback and potential to motivate students. It could very well prove to be one of the measures educational institutions need to keep students engaged in the future.

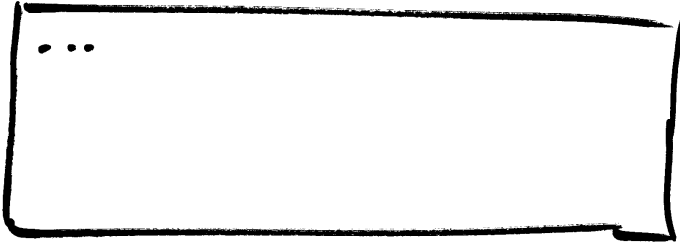
— A —

Implementation

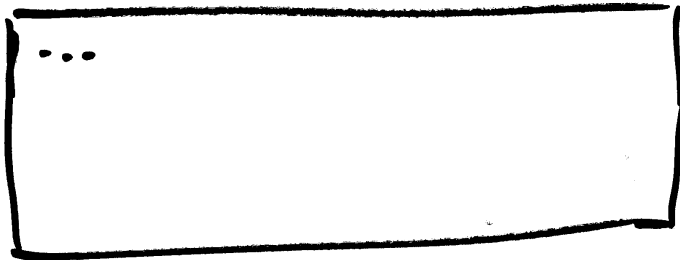
A.1 Design sketches

CREATE QUESTION

QUESTION:



CORRECT ANSWER:



ADD

Figure A.1: "Create Question" design sketch. The design sketches were purposefully drawn with a black felt tip pen to force attention to the major features (and limit attention to detail).

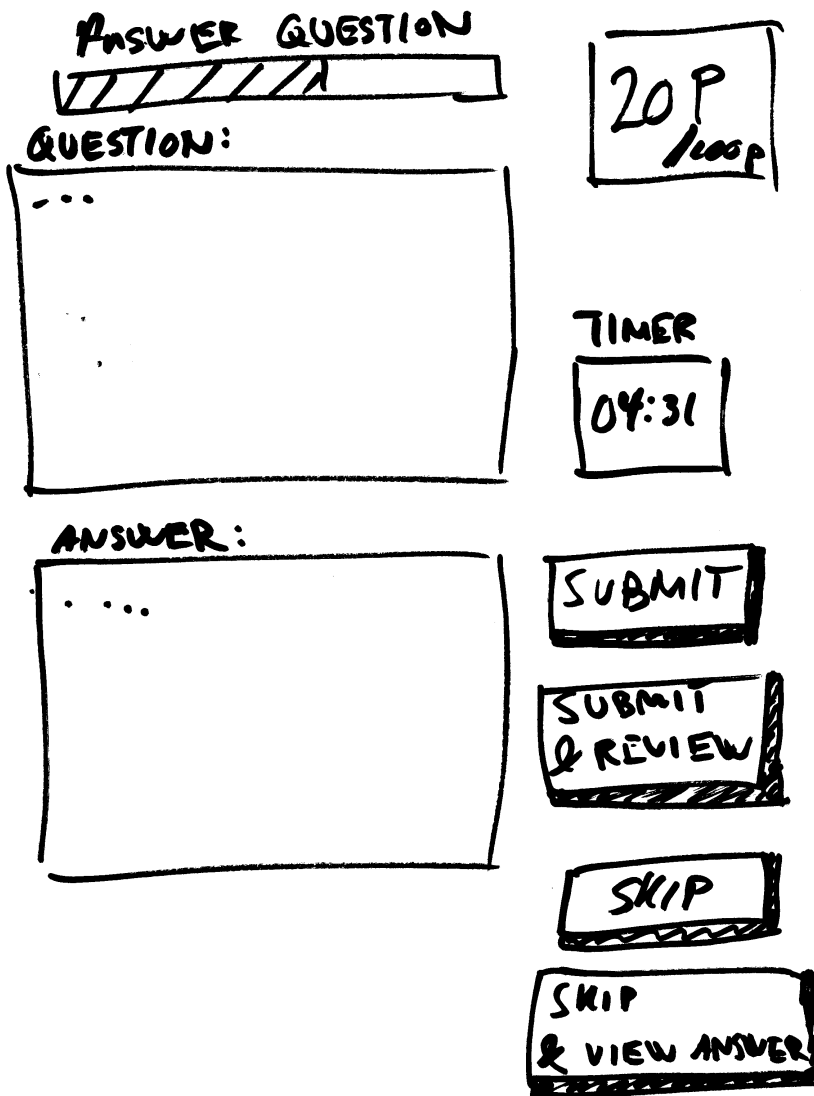


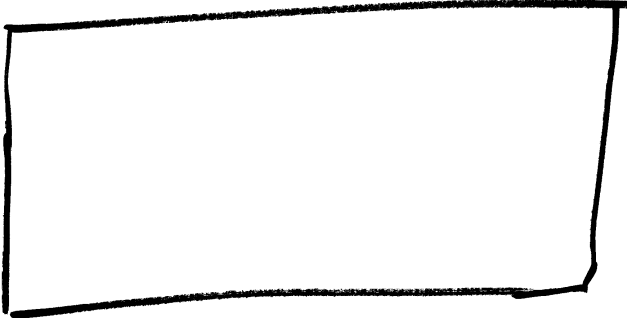
Figure A.2: "Answer Question" design sketch.

REVIEW QUESTION



20P

QUESTION:



CORRECT ANSWER



YOUR ANSWER



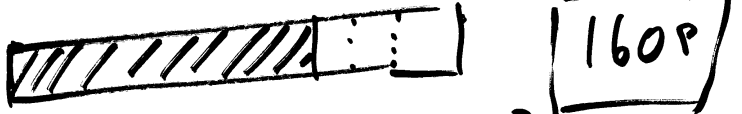
Figure A.3: "Review Question" design sketch.

LIST QUESTIONS (ALL) (OVERVIEW)

| CREATE Q | DO Q | 20 P | TIMER | <input checked="" type="checkbox"/> |
|------------------------------|------|------|-------|-------------------------------------|
| Q1. What is Communication? | | | 04:31 | 3 |
| Q2. What are the 5 layers... | | | | |
| Q3. _____ | | | 02:15 | 1 |
| Q4. _____ | | | 00:10 | 5 |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |
| . _____ | | | . | . |

Figure A.4: "List Questions" design sketch. This page was reshaped into the "Question Feed" design.

LIST BATCH FOR REVIEW



Q1. What is Communication?

Q2. What are the 5 layers in...? 10P

Q3

Q4

.

.

.

~~Q5. What are the 5 layers in...? 20P~~

.

.

.

Q20

10P

Figure A.5: "List questions for review" design sketch. This page was dropped after user feedback and a redesign effort.

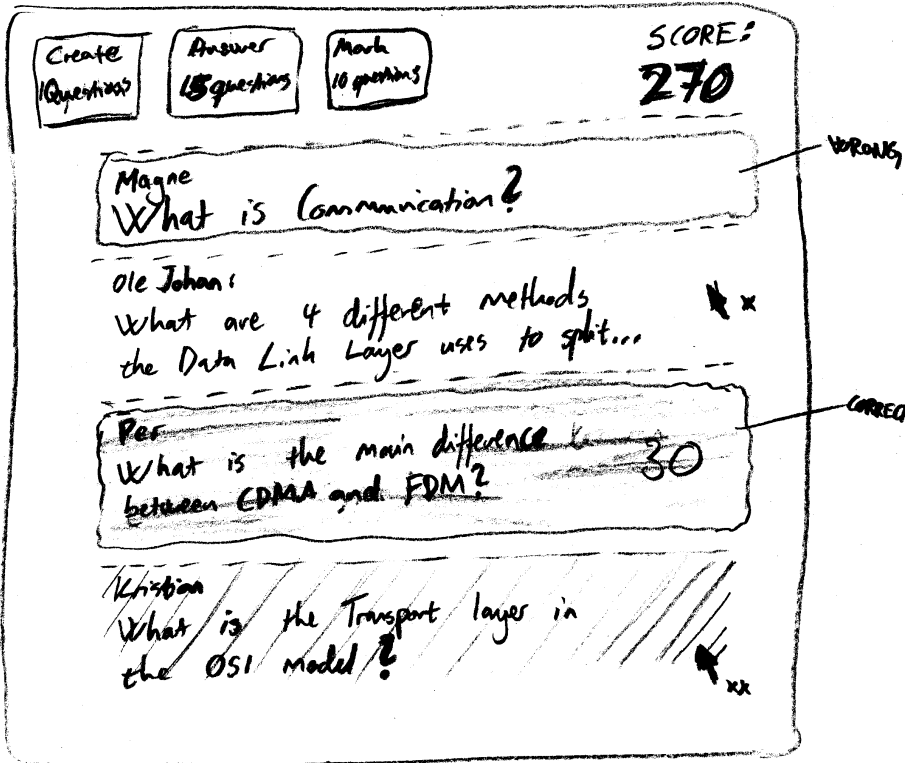


Figure A.6: "Question feed" design sketch. This was the result after redesigning the "List Questions" design.

Resources

B.1 Web page - The live StudyAid system

The live StudyAid system can be accessed at the following URL:

<http://yin.idi.ntnu.no/studyaid>

Disclaimer: It currently takes a while to access, and is quite slow in use. This is due to the number of questions and users in the database, and the brute approach to data retrieval (which was most Lean at the time).

B.2 Source Code, KANBAN chart and Questionnaire data

The source code is included in the attached USB-stick. The USB stick also includes a README-file on which files to specifically access.

The KANBAN chart can be found in its entirety on the attached USB-stick.

The entire data-set from the Questionnaire can also be found on the USB-stick.

B.3 Technical description of the system

The system was implemented using Ruby on Rails, since my preliminary work showed it to be the best framework for the work (Gaastrand, 2010).

The additional tools used were:

- Git - Distributed version control system used to keep track of changes to the codebase.
- SQLite database - Database included with Ruby on Rails. Sufficient for prototypes like the one developed in this thesis.
- Rspec rails gem - Used for the TDD tests written (which were later abandoned)
- Devise rails gem - Used to handle user accounts and registrations to StudyAid.

- Blueprint CSS framework - Used to provide a basis for the visual design. Included with Rails.
- Various other rails gems - Webrat, Passenger, Spork, Autotest, FactoryGirl.
- CSS3 Progress Bar - <http://css-tricks.com/css3-progress-bars/>

The database was backed up to a local machine regularly to prevent data-loss. The webserver was an Apache webserver.

References

- Antin, J. (2011). Badges in Social Media : A Social Psychological Perspective. *Human Factors*, pages 1–4.
- Ben-Ami, Z. (2009). Knowledge Practises Environment (KPE).
- Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry*, pages 189–194.
- Camargo, C., Approach, K., and Service, S. (2006). Interesting Complexity : Sid Meier and the Secrets of Game Design. *Civilization*.
- Deterding, S. (2010). Just add points? What UX can (and cannot) learn from games.
- Deterding, S., Sicart, M., Nacke, L., O’Hara, K., and Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. *CHI EA ’11 Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems*, pages 5–8.
- Gaasland, M. M. (2010). Anvendelse av spillmekanikker i e-Læring. Technical report, NTNU.
- Gardner, H. (1985). Frames of mind: The theory of multiple intelligences. *Basic books*.
- Gartner (2011). Gartner Says By 2015, More Than 50 Percent of Organizations That Manage Innovation Processes Will Gamify Those Processes.
- Graven, O. H. and MacKinnon, L. (2006). Exploitation of games and virtual environments for e-learning.
- Henderson, L. (2005). Video games: A significant cognitive artifact of contemporary youth culture. Citeseer.
- Huizinga, J. (1955). *Homo ludens: A study of the play-element in culture*.
- Johnson, L., Adams, S., and Haywood, K. (2011). The NMC Horizon Report: 2011 K-12 Edition. Technical report, New Media Consortium, Austin, Texas, USA.
- Kane, G. C. (2010). Correspondance; Associate Professor in information systems, Boston University.
- Karpicke, J. and Roediger, H. (2008). The critical importance of retrieval for learning. *Science*, 319(5865):966.
- Kim, A. J. (2009). Putting the Fun in Functional: Applying Game Mechanics to Functional Software.
- Kolaas, L. (2005). Variation and Reusability in E-Learning: Not Compatible?
- Kolaas, L. (2010). Implementation of pedagogical principles into the software design process of e-learning applications.

- Kolaas, L., Høimyr Edvardsen, L. F., and Martin, H. (2008). Bruk av It's learning ved NTNU - en kvantitativ og kvalitativ studie.
- Koster, R. and Wright, W. (2004). *A theory of fun for game design*. Paraglyph press.
- Lee, J. and Hammer, J. (2011). Gamification in Education: What, How, Why Bother? *Academic Exchange Quarterly*, 15(2):2.
- Lundgren, S. and Bjork, S. (2003). Game mechanics: Describing computer-augmented games in terms of interaction. pages 24–26. Citeseer.
- MacMillan, D. (2011). 'Gamification': A Growing Business to Invigorate Stale Websites.
- Malone, T. W. (1982). Heuristics for designing enjoyable user interfaces: Lessons from computer games. pages 63–68. ACM.
- Mateas, M. and Stern, A. (2005). Build It to Understand It : Ludology Meets Narratology in Game Design Space. *Proceedings of DiGRA 2005 Conference: Changing Views – Worlds in Play.*, 2.
- Moss, J. (2008). Fundamentals of Game Design Lecture 3.
- Nielsen, J. and Landauer, T. (1993). A Mathematical Model of the Finding of Usability Problems. In *Proceedings of the INTERACT'93 and CHI'93 conference on Human factors in computing systems*, pages 206–213. ACM.
- Nordkvelle Ramberg, Kirsti Rye, Wilhelmsen, Janne, Y. (2009). Kunsten å ile langsomt...
- Norgesuniversitetet (2009). Digitale utfordringer i høyere utdanning.
- NutritionDietNews (2011). Keas Introduces the Power of Perform in a New Online Health and Wellness Social Video game that Delivers Unprecedented Employee Health Engagement Costs.
- Nuval, G. (2010). Why Gamify DebHub?
- Oates, B. (2006). *Researching information systems and computing*. Sage Publications Ltd.
- Ortega, F. (2009). Wikipedia: A quantitative analysis. *doctoral dissertation. University Rey Juan Carlos.*
- Osin, L. (1990). Integrating courseware with lessonware. pages 657–659. IEEE Computer Society Press.
- Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment (CIE)*, 1(1):21.
- Ramboell (2010). Evalueringsrapport - Bruk av It's Learning ved NTNU.
- Reeves, B. and Read, J. L. (2009). *Total engagement: using games and virtual worlds to change the way people work and businesses compete*. Harvard Business School Press.

- Rouse, R. (2000). *Game design theory and practice*. Wordware Publishing Inc. Plano, TX, USA.
- Salen, K. and Zimmerman, E. (2004). Rules of play: Game design fundamentals. *The MIT Press*.
- Sauro, J. (2011). Measuring Usability with the System Usability Scale (SUS).
- Silva, E. (2010). *Gamifying Learning with Social Gaming Mechanics*. The MASIE Center & The Learning CONSORTIUM.
- Skinner, B. (1953). *Science and human behavior*. Free Press.
- Squire, K., Jenkins, H., Holland, W., Miller, H., Tan, K. P., and Todd, K. (2003). Design Principles of Next-Generation Digital Gaming for Education. *Educational Technology*, 43(5):17–23.
- Svanaes, D. (2007). Prototyping and usability testing (Lecture in TDT4180 - HCI, NTNU).
- Vavik, L., Arnesen, T. E., Arnesen, T., Espeland, M., Flatøy, I., Grønndal, I., Fadnes, P., Sømoe, K., Tuset, G. A., and Andersland, S. (2009). Skolefagsundersøkelsen. Technical report, Stord, Norge.
- Wang, A. I., Øfsdahl, T., and Mørch Storstein, O. K. (2008). An Evaluation of a Mobile Game Concept for Lectures. *2008 21st Conference on Software Engineering Education and Training*, pages 197–204.
- WikiBooks (2010). *K-12 School Networking: An Online Resource for the Technical Coordinator*.
- Wyeth, P. (2008). ITN016 - Fundamentals of Game Design - Lecture 2, QUT.