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University of Oslo

The Design of Educational Games: Enki

The Utility of Educational Games for Teachers in the Classroom

Kristian S. Munkvold

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Dedicated to my mother, Kirsten Beate Saksvik, who has inspired, believed in me, and shown me the meaning of resilience, and to my father, Finn Erik Munkvold, who has stressed the importance of hard work, dedication, and education.

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Abstract

It is nearly ten years since digital skills were set as a mandatory part of Norway's curriculum in schools, and in 2014, three quarters of upper primary school students in Norway makes use of computers as a part of their everyday lives. Nearly half of them report playing computer or video games at a daily basis, and although the Norwegian classroom can be considered at the forefront of technological adaptation, how the students are exposed to such technologies vary greatly from teacher to teacher. Few teachers report using ICT at a regular basis in their classrooms , and the report *Digital skills for everyone? Norwegian results from ICILS 2013* concludes that if teachers are to succeed with improving their students learning through using ICT, they have to be able to combine subjects, pedagogy and their own digital competence. This makes the teachers own position, interests, and knowledge levels responsible for their use of ICT in the classroom.

At the time of this study, the Norwegian market for educational technology (edtech) is in full growth, and the hows and whys of using technology for education is debated worldwide. I propose that the making of edtech for the classroom is a "Wicked Problem", and I make the case that edtech such as educational games may be a medium where one can introduce the newest findings within research on learning into the formal educational system. Educational games can be used support teachers through sophisticated learning analytics which make it easier for them to keep a detailed overview of how their students are progressing through a digitally modelled public school curriculum. This is done through investigating the design of the educational game Enki, and redesigning its associated tool for teachers — the Educational Resource Application (ERA).

Enki and ERA are then evaluated in detail through a collective case study with five participating schools: further exploring the UX of Enki and ERA through field studies and interviews, where the main research questions include: Why is Enki and ERA used by teachers in the classroom? How is it experienced by teachers and students? How well does it support the teacher? How may it be redesigned to further support teachers?

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Chapter 1

Introduction

For nearly ten years digital skills has been a mandatory part of Norway's curriculum in schools. The upper primary school students were in 2014 active users of technology, and three quarters of these students have made computers a regular part of their everyday lives: 99 percent of all kids at this level (aged 9-12) has access to a computer at home, where 96 percent has access to the internet and nearly half (48 percent) reports to play computer or video games at a daily basis at home [1].

Norwegian schools have access to technology (e.g. computers and tablets) which should in practice render all students able to participate in the digital arena. Teachers report being positive to using ICT as a part of their teaching, but few report using ICT at a regular basis in their classrooms (Ottestad et al. 2014). The report *Digitale ferdigheter for alle? Norske resultater fra ICILS 2013* concludes that if teachers are to succeed with improving their students learning through using ICT, they have to be able to combine subjects, pedagogy and their own digital competence (ibid.). It seems expected of teachers to find their own way of applying applications to support their students' learning.

1.1 The Use of Computers in the Classroom

The Norwegian classroom is in many cases at the forefront of technological adaptation, but the use of these technologies varies from teacher to teacher. Using technology for else than traditional use (i.e. writing and searching for information) seems therefore to be a result of a teacher's own position, interests, and knowledge level.

This may pose a problem, as a comprehensive study on the American school has found that there are four key criteria for a teacher to use an application in the classroom: it must support them in their most direct needs, give them maximal benefits, must be easy for them to learn, and it must support their current teaching practices. This makes it seem evident that for a teacher to use an application in his or her classroom, it must support them in performing their work as teachers (Zhao and Frank 2003).

[1] MediaNorge Survey, Retrieved from: http://medienorge.uib.no/statistikk/medium/ikt

Norway has a great student-to-computer ratio, but it makes for a challenging situation when these computers are to be used for something besides traditional writing and information seeking, and a study performed by Gasparini and Culén (2012) report that teachers struggle to find applications which are adapted to their practices and curriculum.

It follows that the successful use of computer-games in the classroom can be a result of pioneer work by a number of technologically inclined teachers. However, it is important to point out that there is a significant difference between using a game which originally was made for entertainment for educational purposes, and using a educational game made for an educational purpose. In this thesis I will focus on the latter, by investigating the use of the educational game Enki — made for the Norwegian classroom, I present the design process and my contribution to its associated teachers tool: the Educational Resource Application (ERA). Together, they are designed to make it easier for teachers to create an engaging and beneficial learning environment for the classroom, where the teachers play an active role [2].

In this thesis I will explore important research questions in this context: How can a educational game such as Enki be adapted to support the Norwegian classroom? How well does it support the teachers and students' different needs in a learning context? How does Enki and ERA facilitate learning?

This is done through a process of *research through design*, which will be introduced in Chapter 2. I propose the design of Information and Communications Technology (ICT) for the classroom as a "Wicked Problem": a problem consisting of multiple stakeholders which have basic conflicts and perspectives. I will then present the educational game Enki, and the design process for the associated tool for teachers: the *Educational Resource Application* (ERA). The end result of the design process will be evaluated through a collective case study, where I will examine how teachers and students experience the use of Enki and ERA in the classroom, how it supports the teacher, and how it can be redesigned to better support the teacher.

1.2 The Motivation

My parents gave me an early exposure to the world of computers and the world of teaching. My mother was a dedicated primary school teacher, and my father was a pioneer in the use of computers. Together, they enabled me to explore both worlds at a young age. As my father was working on his computer which ran a Disk Operating System (DOS), typing commands to navigate and run programs, my mother was preparing lectures and correcting her students assignments. Twenty years later, the combination of these distinct worlds was to become the main subject for my thesis.

[2] Frustrated teacher makes educational game. Retrieved from:http://forskning.no/skole-og-utdanning/2013/11/frustrert-laerer-har-lagd-laeringsspill

My fascination of computer-games started at age four. My father brought home the first – surely not the last – computer-game I was to know. The game was called *King's Quest - Romancing the Throne*, and was the spark that ignited my interest in computers.

This particular game was of a different nature from the ones one ordinarily meets today. In-game actions were only possible through combining arrow navigation on the keyboard and typing commands such as "smell cat", "look at desk", "take apple" at the correct place. The game was in english, and certainly proved a challenge for the four year old whom neither could read or write. The game universe was experienced as so fascinating that it was possible to sit for hours at a time, alternating between me and my brother playing and watching as our father helped us understand what to do and guided us through the gameplay.

Along with many other arenas in my life, these computer games proved to be an important learning arena. The game universe was restricted to the use of the English language, which I was forced to learn if I was to to be able to play it on my own. I remember one of these sessions in particular, playing the game by myself, mastering the game by remembering the possible in-game actions and what they meant, typing "open door" and pressing enter to make the on-screen character open the door of the house of the three bears to let me in.

Through playing this game I learned how, when, and why to use the different words, form meaningful combinations of them, and as a direct consequence of this play it enabled me — a native Norwegian — to do my first writing assignment in school in English. I believe that my experience is not unique, and that even though computer games have changed drastically, the medium has an enormous potential when it comes to facilitating a learning environment and motivating for learning experiences.

Chapter 2

Theoretical Background

In this chapter, I will introduce and explain the foundations behind the research performed in this thesis. I will first introduce the research foundations and then the methodological approaches used in this thesis.

2.1 Human-Computer Interaction

Human-Computer Interaction (HCI) is a research field dedicated to how the design and use of computer technology affect users. Since its beginning HCI has evolved alongside inventions and technological progress, which has in turn made HCI a part of everyday life. This has had a significant effect on where HCI-research takes place. What once was a workplace activity has made its presence known in the everyday life of most people, changing the scene for HCI-research:

> "[...] many of the phenomena that interest researchers are not easy to measure using existing metrics or methods. Many of these phenomena cannot be measured in a laboratory setting using the human factors psychology model". (Lazar, Feng and Hochheiser 2010)

When a design supports multiple user groups and its natural use-context has everyday life, work, and other factors interfering, the laboratory-setting is merely not enough to get a thorough understanding of how the design performs. As more complex designs have become common in both the workplace and everyday life, there has been a need for new approaches and methods to examine how a design performs. What used to be a field where the quantitative tradition dominated has changed into a field where qualitative research has flourished. Both research traditions have strengths and weaknesses, and the discussion of such matters is outside of the scope for this thesis. A beginning definition of the difference between the research traditions is provided by Cooper, Reimann and Cronin:

> "Quantitative research can only answer questions about "how much" or "how many" along a few reductive axes.

Qualitative research can tell you about what, how , and why in rich detail that is reflective of the actual complexities of real human situations." (Cooper, Reimann and Cronin 2007, p.50)

Cooper, Reimann and Cronin may favour qualitative research as they make the case that understanding how a design performs is a more complex process than measuring the time it takes to perform an activity, or how many clicks it takes an user to perform a task. The need for qualitative research is apparent, as the old computing was about what computers could do, the new computing is mainly about what people can do with them. (Schneiderman (2002) (as cited in Lazar, Feng and Hochheiser 2010))

This does not entail that there is no place for quantitative research within HCI, it is just that qualitative research is used to gain an understanding of other facets of a design then what quantitative research allows. Where the laboratory can be used for usability-testing and quality-assuring the design of a product (which is often done through quantitative research), a case-study is often used to uncover how a certain design performs in its natural context on actual users (which is often done through qualitative research). Together, the research traditions can be used in unison to uncover multiple facets of a design.

Where the HCI-field uncovers how interactive design affects users, a related discipline named *interaction design* focuses on the hows and whys related to creating such designs.

2.2 Interaction Design

Behind the term *interaction design* (IxD) is the discipline with the purpose of "designing interactive products to support the way people communicate and interact in their everyday and working lives." (Preece, Rogers and Sharp 2007, p.8)

An interactive product is any product, system, or service which enables the user to interact (e.g. a computer, website, web-application, ticket-machine, smartphone, alarm clock). A product's IxD affect what has become one of the central concepts within IxD: the user-experience (UX).

How to design for a positive UX is a complicated question. A product consists of many more layers than the interaction itself, among others, the information architecture (regarding how the information is structured), graphical design (the aesthetics and layout of the design), and the technical implementation (how the design implemented and works for the user). Therefore, in IxD it is suggested that when designing, there are two separate concepts that play together: usability, and UX (ibid., p.20).

Usability is defined by Iso (2010) as:

> "[The] extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ibid.)

UX is defined in Iso (ibid.) as:

> "A person's perceptions and responses that result from the use or anticipated use of a product, system or service" (ibid.)

Usability and UX address different goals within a design, where usability goals deals with how well a product performs in terms of effectiveness, efficiency, safety, utility, learnability and memorability. The UX goals deals with the more subjective aspects of a design, and how it makes the user feel is at the centre. Seeing these two concepts in unison makes design for a UX possible. (Preece, Rogers and Sharp 2007, p.21-25)

2.2.1 The Process of IxD

To design for a positive UX, there are four basic activities which will be used as a foundation of the work performed in this thesis:

1. "Identifying needs and establishing requirements for the user experience
2. Developing alternative designs that meet those requirements
3. Building interactive versions of the designs
4. Evaluating what is being built throughout the process and the user experience it offers" (ibid., p.17)

These four basic activities are expressed in Figure 2.1 as an adaptation of the simple lifecycle model provided by Preece, Rogers and Sharp (ibid., p.448). Together they make an iterative process, meaning that the designer continuously repeats these steps, building and establishing new knowledge which again informs the design.

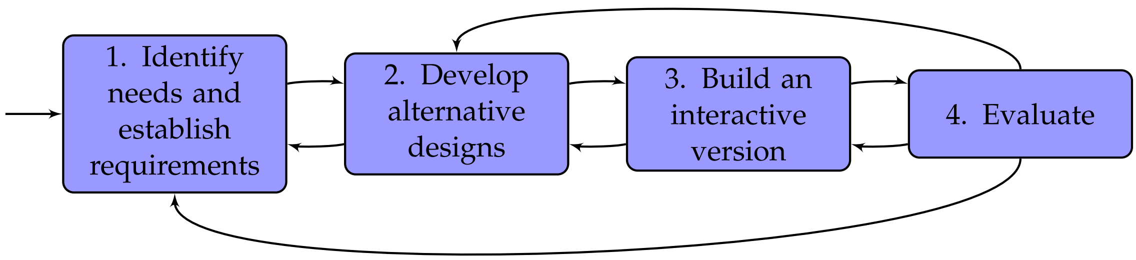


Figure 2.1: The IxD Process: overview

How these activities are used to support the design in this thesis will be thoroughly explained in Chapter 6. The activities are the backbone for the design and development-process in this thesis.

2.2.2 The IxD Researcher's Position

The IxD researcher's underlying perspective is an important aspect of how a research project is designed and conducted. The underlying philosophical inclination affects the researchers position, be it subconsciously or consciously. The author is no exception to this rule.

Klein and Myers (1999) identifies three different research philosophies. These research philosophies are termed as *research paradigms* by Myers (1997). They classify three paradigms within qualitative research:

- Positivist
- Critical
- Interpretive

These paradigms affect how researchers position their work, and is recognised by their own distinct characteristics. It influences the researcher's position, and when conducting research it underpins the research design of a project. This author is no exception, and can be classified within the interpretive research paradigm.

Interpretive studies can be characterised by the researchers attempt to get an understanding of a phenomena by examining the meanings that people assign to them (ibid.). Methods for performing interpretive studies are usually "[...] aimed at producing an understanding of the context of the [design], and the process whereby the [design] influences and is influenced by the context" (Walsham (1993) as cited by Myers (1997)).

2.2.3 Methods for IxD Research

A research method affects the underpinning design of how a researcher structures, collects, analyses and gathers data. For this thesis, there are two distinct methods which will be used:

- Research Through Design
- Case Study

There are many different methods which help researchers to structure the approach and research process. These methods have unique strengths, weaknesses, and different uses. They are often referred to as methodological approaches, but I will use Myers (ibid.) term *research method* in this thesis:

> "A research method is a strategy of inquiry which moves from the underlying philosophical assumptions to research design and data collection. The choice of research method influences the way in which the researcher collects data." (ibid.)

The main research method applied in this thesis is the relatively new *research through design* as proposed by Zimmerman, Forlizzi and Evenson. The method is used in combination with a *case study* to provide a summative evaluation of the design. The foundation for these two methods will now be explained in depth.

2.3 Research Through Design

Research through design enables the design researcher to take on what is termed as a "Wicked Problem", apply a design process, and conduct research with the intent of integrating *real*, *how* and *true* knowledge to create a possible design solution (Zimmerman, Forlizzi and Evenson 2007). In *Understanding Computers and Cognition: A New Foundation for Design*, Winograd and Flores (1986) state:

> "All new technologies develop within the background of a tacit understanding of human nature and human work. The use of technology in turn leads to fundamental changes in what we do, and ultimately in what it is to be human. We encounter the deep questions of design when we recognise that in designing tools we are designing a way of being. By confronting these questions directly, we can develop a new background for understanding computer technology — one that can lead to important advances in the design and use of computer systems." (ibid.)

It is the design, making and evaluation of the *right thing* which is the focus of the research method proposed by Zimmerman, Forlizzi and Evenson (2007): *Research through design*. The making of a right thing is considered the epitome of a designers work, but what exactly is the right thing and how do you get there? I will document the process of trying to get there; proposing a possible right thing for digital classroom educational games.

The method is intended to bridge the gap between practitioners and researchers in HCI, enabling designers to do what they do best:

> "[...] [Design] researchers focus on making the right thing; artefacts intended to transform the world from the current state to a preferred state." (ibid.)

Zimmerman, Forlizzi and Evenson (ibid.) states that *research through design* is a needed method for interaction designers as there has been no established method for research contributions besides the "[...] development and evaluation of new design methods" (ibid.).

2.3.1 A Wicked Problem

The objective of research through design is to design the right thing, and the goal is to solve a "*Wicked Problem*". A "Wicked Problem" is defined as (ibid.):

> "[...] a problem that because of the conflicting perspectives of the stakeholders cannot be accurately modelled and cannot be addressed using the reductionist approaches of science and engineering." (ibid.)

Finding the design — the right thing — to solve a "Wicked Problem" is a complicated process, as the proposed solutions and suggestions from stakeholders can be conflicting, and reflect completely different interests. The definition of a stakeholder makes it more apparent why it is hard to find a solution to such problems:

> "[People] or organizations who will be affected by the system and who have a direct or indirect influence on the system requirements" (Kotonya and Sommerville, 1998 Preece, Rogers and Sharp (as cited in 2007, p.430)).

The requirements of a system can be seen as the same as the requirements of a design, and therefore it follows that stakeholders with conflicting perspectives make it hard to specify what the requirements of a design should be. The right thing becomes difficult to discover when one must figure out which perspectives one is meant to support, and the problem becomes evident when these stakeholders are decision-makers, as described by Preece, Rogers and Sharp (ibid.):

> "It will frequently be the case that the formal ´client´ who orders the system falls very low on the list of those affected. Be very wary of changes which take power, influence or control from some stakeholders without returning something tangible in its place." (ibid., p.430)

This issue is central in a "Wicked Problem", and it follows from Preece, Rogers and Sharp that it is in direct conflict with the user-centred principles of IxD. It creates a distance between the actual problem-situation, where the conflicting perspectives of stakeholders which are not even real users take their toll on the design. Understanding the difference between users, user-types, and stakeholders is of importance in any design situation, and becomes even more clear here. These can be broken up into three user groups: primary, secondary and tertiary (ibid.):

> "Primary users are those likely to be frequent hands-on users of the system; secondary users are occasional users or those who use the system through an intermediary; and tertiary users are those affected by the introduction of the system or who will influence its purchase. (ibid., p.430)

2.3.2 Conflicting Perspectives

A "Wicked Problem" brings complexity into the design as the conflicting perspectives of the stakeholders make it difficult to identify what exactly is the problem to be solved. Recognising each perspective is important, but it can be impossible to satisfy every stakeholder. This use of perspective has long been regarded as an important part of design, in 'The Perspective Concept in Informatics', Nygaard and Sørgaard state:

> "Information systems are, however, typically introduced and operated for economical reasons, designed and implemented using insights from informatics, and result in a changed environment for people. Modifications of the informatical properties of the organisation may have desirable economic, but undesirable social consequences. The ability to apply several perspectives to the phenomena studied or the situations occurring in system development is therefore crucial to obtain a sufficiently general and refined understanding. It is the opinion of the authors that the capability of multi-perspective reflection is essential for every computer professional." (Nygaard and Sørgaard 1985)

Following Nygaard and Sørgaard (ibid.), it is this multi-perspective reflection that enables a "Wicked Problem" to be solved. Finding the solution is a design process where conflict between stakeholders is a part of the process. According to Nygaard and Sørgaard (ibid.), addressing these issues must be a conscious choice. If one does not take a position on this matter Nygaard and Sørgaard (ibid.) state that a *harmony perspective* will be employed. Here the relations between groups and individuals as "[...] characterized by harmony and the absence of basic conflicts" (ibid.).

It is only through conscious choice that a designer employs a *conflict perspective*. The designer accepts that it can exist unresolvable conflicts of basic interests between the groups. These can be "[...] handled by confrontation, negotiation, and compromise, resulting in the postponement of the next confrontation" (ibid.).

It follows that the conflicting perspectives must be taken into account, and the designer must be able to identify them for what they are; seeing the duck for a duck, the rabbit for a rabbit, the rabbit as a duck, and the duck as a rabbit. See Figure 2.2[1] for an illustration.

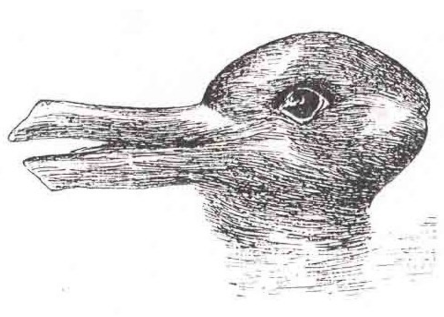


Figure 2.2: The duck and rabbit illusion illustrates how a problem can be viewed from different perspectives

[1]The Duck-Rabbit Illusion by American Psychologist Joseph Jastrow. Also discussed by Wittgeinstein in Philosophische Untersuchungen, 1953. Retrieved from: http://ist-socrates.berkeley.edu/~kihlstrm/JastrowDuck.htm

2.3.3 The Proposed Method

Research through design as a method integrates what Zimmerman, Forlizzi and Evenson (2007) term as the *true* knowledge (models and theories from behavioural scientists), with the *how* knowledge (how this may technologically be solved). The design researcher will then explore based on *real* knowledge, produced by design researchers and anthropologists while they perform upfront research for a design project (ibid.).

This is done in combination with a design process, where the design researcher continually reframe the problem as one is trying to create the *right* thing (ibid.). This reframing is supported by Winograd and Flores (1986), which argue that the design process itself is the key to uncover design possibilities:

> "Through the emergence of new tools, we come to a changing awareness of human nature and human action, which in turn leads to new technological development. The designing process is part of this "dance" in which our structure of possibilities is generated." (ibid., p.163)

It follows that a proposed design-solution helps to uncover complexities and possible solutions to the different stakeholders' conflicting perspectives.

The final output of research through design should be a definite problem framing and an articulation of the preferred state accompanied by a series of prototypes and the documentation of the design process (Zimmerman, Forlizzi and Evenson 2007).

2.3.4 Evaluating Research Through Design

To help the formalisation of this research method, Zimmerman, Forlizzi and Evenson (ibid.) suggest a set of criteria to be used when evaluating the quality of such research. There are four criteria to quality assure the *research through design* approach:

- Process
- Invention
- Relevance
- Extensibility

The first criteria – the *process* – relates to how well the process is documented. The research contribution should provide a thorough rationale for the employed methods and enough information that it is possible to replicate the process.

The second criteria suggest that the given research should be a significant *invention* within HCI. Demonstrating that this is, in fact, an innovative integration of "[...] various subject matters to address a specific situation" (ibid.).

The *relevance* of the given research is an important criteria. Why is the research important? What is the design attempting to solve? The researcher must highlight the relevance of the project by framing it within the real world, and explain why this is of importance. The researcher is to "[...] articulate the preferred state their design attempts to achieve and provide support for why the community should consider this state to be preferred" (ibid.).

The last criteria is *extensibility*, meaning that the given research should be performed and documented in such a way that it creates value for the community (ibid.).

2.4 Case Study

In combination with the research through design method, a summative evaluation of the design will be performed as a case study. This is a well-known method in HCI research used to explore or evaluate technology in a specific real-life context. Allowing the researcher to do in-depth investigations through a wide variety of data sources on a small number of cases. This illuminates other aspects than what is available through lab-based usability studies (Lazar, Feng and Hochheiser 2010).

According to Baxter and Jack (2008), a case study is defined as a method which:

> "[...] facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the issue is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood." (ibid.)

Case studies may further be categorised into three different types. The *intrinsic* case study which is performed to create insight into a particular case of interest. The *instrumental* case study which is to provide insight into an issue or to make a generalisation, where the case itself is of secondary interest to facilitate an understanding of something else. The last type is called a *collective* case study, where the case itself is not of a particular interest and the researcher explores a number of cases to illuminate the given phenomena (Stake 2005) .

In case studies the combination of multiple data sources is done to provide a holistic view of the phenomenon in question. When performing the analysis on the data collected from the various sources, they are converged instead of treated individually. This increases the researchers understanding of the phenomenon and strengthens the findings as the "[...] various strands of data are braided together to promote a greater understanding of the case" (Baxter and Jack 2008).

2.5 Methods for Data Gathering

In this section, I will describe the foundation of the data gathering methods (i.e. interviews, observations) which are used in this thesis, and the concepts of validity and reliability which must be taken into account when gathering data. How the interviews and observations are performed will be discussed in detail alongside the research design in Chapter 6.

2.5.1 Interviews

When planning to conduct interviews, there are four different types which can be considered (Preece, Rogers and Sharp 2007, p.288-303):

- Open-ended or unstructured
- Structured
- Semi-Structured
- Group Interviews or Focus Groups

These different types of interviews impact what kind and how much information one is able to contract from the interviewees. The open-ended or unstructured interview may resemble a normal conversation revolving around a predefined theme. This form enables both the interviewers and interviewees to steer the interview (ibid., p.298). The structured interview is defined by the rigid script from which questions will be presented in a well-defined order (Lazar, Feng and Hochheiser 2010, p.189). This type of interview is in direct contrast to the unstructured interview, as it leaves no room to explore comments made by the subject.

Between the two extremes, lies the semi-structured interview. A semi-structured interview is performed with a script, usually consisting of both closed and open-ended questions. This enables the interviewer to explore comments by asking follow-up questions, while making sure that the same topics are covered with all interviewees (Preece, Rogers and Sharp 2007, p.299).

2.5.2 Observation

Observing users engaging with a design allows a researcher to uncover aspects which are hard or impossible to discover otherwise. It can be performed at any part of the product development, in a controlled setting, or in the field (ibid., p.321).

Observation comes in two contrasting forms: the insider, and the outsider. The insider is a participant observer, joining in and taking part in the activity; the outsider is a passive observer, which shadows the activity without interfering (ibid., p.326). Both forms of observations have positive and negative implications, the insider can become immersed in the activity and therefore unable to take objective notes, where the outsider can disturb the results through stressing the participants (being watched is seldom a positive feeling) or misinterpret what is happening.

However, these observations forms are extremes. The researcher may position themselves in the centre between an insider and an outsider. Leaving room to ask questions during observations, and be a part of the activity when necessary.

2.5.3 Validity

Validity describes if the methods, measurements and the execution of research measures what it is supposed to measure (ibid., p.640). As qualitative data is not objective, the concept has an unique definition within this type of research:

> "[...] *validity* means that we use well-established and well-documented procedures to increase the accuracy of findings." (Creswell, 2009 as cited in Lazar, Feng and Hochheiser (2010, p.295))

To ensure validity in qualitative research, the methods should be firmly documented and measurements performed on multiple data sources. Collecting from multiple data-sources is what is termed as *triangulation*. It strengthens the validity of the data as it offers multiple perspectives; making replication of findings from multiple data-sources possible (Preece, Rogers and Sharp 2007, p.293). A finding with multiple evidences spanning across different participants and sources increases the confidence that it in fact is a valid interpretation. (Lazar, Feng and Hochheiser 2010, p.295) In addition, if the raw data is well-organised, it enables the findings to be traced back to their origin. This enables the researcher to show that the interpretations of the data are firmly grounded in the raw-data (ibid., p.295).

2.5.4 Reliability

Reliability and validity are two concepts that should be seen in unison; where validity ensures that the research methods and measurements employed measure what they are supposed to measure, the concept of reliability ensures that multiple researchers would be able to reproduce these results:

> "The reliability or consistency of a method is how well it produces the same results on separate occasions under the same circumstances." (Preece, Rogers and Sharp 2007, p.640)

Reliability is closely related to the methods used and how the data is collected, making it hard to ensure high reliability in many of the research methods in qualitative research. This due to that it may not be possible to reproduce an unstructured interview or observation. Therefore, these methods have low reliability (ibid., p.640). This makes it of importance to have transparency, meaning that the researcher should keep the raw-data well-organised, and make it easier for findings to be traced easily.

Reliability within qualitative research is therefore strongly related to the ability of researchers finding the same results within the same raw-data (Lazar, Feng and Hochheiser 2010, p.296).

Chapter 3

Framing the Problem

When performing *research through design*, a “Wicked Problem” is the subject of the study. In this chapter, I will make the case that the making of well-designed educational technology (edtech) is a “Wicked Problem” and begin the first step in the IxD process: identifying needs and requirements, as illustrated in Figure 3.1.

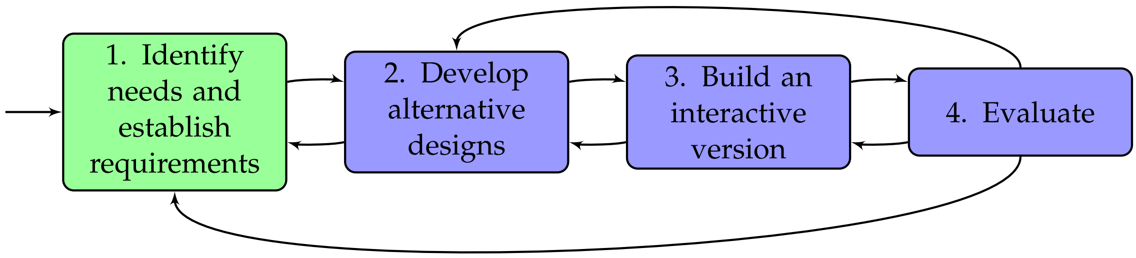


Figure 3.1: The IxD process, step 1: identify needs and establish requirements

To provide an understanding of the domain (i.e. educational games and technology to support the educational system), I will elaborate on the historical background and design of the formal educational system. I provide a basic introduction to the structure of the Norwegian public school system, and the concept of *Mastery Learning*, which is an important concept for educational games. I will then introduce the field of the *learning sciences*, where I present research findings which may be be central for the students’ learning in the school of the future, and that edtech may play an important role in making these findings a part of the formal educational system. I will then introduce a common use-case of edtech in Norwegian schools, followed by an example of the use of well-designed edtech in USA. I finish the chapter by introducing two central findings for educational games: adaptive learning and learning analytics.

3.1 The "Wicked Problem"

A "Wicked Problem" is defined as a problem where the conflicting perspectives of the stakeholders make it impossible to accurately model and address it by using the reductionist approaches of science and engineering. I will now address how the making of edtech may in fact be such a problem.

The educational system has a high number of stakeholders with conflicting perspectives; it is a complex government run institution with a long and intricate history. I will elaborate on the historical factors which are affecting the design of educational tools, and present the model which such tools are to fit in in this chapter. In addition, schools are complex systems consisting of many user-groups with different needs. By following Preece, Rogers and Sharp's definition of user groups, edtech for schools can be modelled as the following:

- Primary users:
  - Teacher
  - Student
- Secondary users:
  - ICT-Responsible
  - Substitute
- Tertiary users:
  - Principal
  - Inspector

There are clear differences in the needs of these user-groups, with conflicting perspectives at play at every user-group. In addition, there are stakeholders at many levels with conflicting interests and perspectives. There is a clear separation between who buys the software, who creates it, and who use it.

The supplier develops and sells the software. The government enforces rules and regulations which affect the ICT-use in schools. The municipalities regulate in many cases the ICT-practices for their schools. A tertiary user — principal or inspector — is in charge of buying the software. A secondary user — ICT-responsible — may be in charge of distributing equipment, installing software, and supporting the users of it. However, the primary user-group — teachers and students — have completely different basic needs when it comes to the use.

3.2 The Formal Educational System

The introductory chapter of *The Cambridge Handbook of The Learning Sciences* states that "[by] the twentieth century, all major industrialised countries offered formal schooling to all of their children. When these schools took shape in the nineteenth and twentieth centuries, scientists didn't know very much about how people learn" (Sawyer 2006).

The foundations of our current educational system was shaped in the 19th century, and according to Khan (2012, p.40) in *The One World Schoolhouse - Education Reimagined*, a 1989 study on the formal education system in America concluded that between 1883 and 1978 "[...] instructional practice in public schools remained about the same". Khan states that this has not changed between 1979 to 2012 either (ibid.).

The underlying design principles of the educational system has become tradition. Sawyer (2008) states that "[because] this traditional vision of schooling has been taken for granted for so long, it has not been explicitly named until recently" (ibid.). It has been termed as the *standard model* and by researchers it is often referred to as *instructionism*, a term coined by Seymour Papert (1993) as cited in Sawyer (ibid.). To provide a singular term to deal with this concept, I will refer to the traditional model as the *standard model*.

According to Sawyer, the foundations of the standard model are deeply rooted in the industrialist age:

> "Standard model schools were structured, scheduled, and regimented in a fashion that was explicitly designed by analogy with the industrial-age factory (Callahan, 1962), and this structural alignment facilitated the ease of transition from school student to factory worker."(ibid.)

The changes in our society have and are affecting the requirements of the school. Sawyer points out that "many [Organisation for Economic Cooperation and Development (OECD)] member countries have experienced a rapid shift from an industrial to a knowledge economy" (ibid.). Implying that work has shifted from creating physical objects to producing conceptual artefacts. Instead of operating machines, we are manipulating symbols. This type of work is knowledge-based and requires a different kind of skill set (ibid.).

3.2.1 The Origin of Formal Education

Historically, there have been a myriad of different venues for education. These have taken many paths, but they have converged on what is in many cases the same model of schooling (ibid.). The birth of the standard model took place in Prussia (Soysal and Strang 1989).

> "Prussia was the first to enact compulsory education legislation. Frederick II established a national system of education in 1763 to 'save the souls' of his subjects. [...] Although it did not immediately achieve its goal of universal schooling, enrollments expanded rapidly in Prussia as part of the state's attempt to create a 'unified nation' after its military defeat in 1806." (Ramirez and Boli (1987) as cited by Soysal and Strang (ibid.)).

This resulted in the establishment of the first mandatory and tax funded government-run school system. According to Khan (2012, p. 76), the foundation of the standard model can be traced back to this origin. This includes the following innovations which were to establish the basis of the standard model:

- The school year
- The length of a school day
- Division of the day into periods
- The separation of a discipline into “subjects”
- State regulation of teachers and training of teachers
- State regulated teaching plans
- Starting age of students
- Age-based grades

Prussia’s model would ultimately turn into the standard model, as its successful approach to schooling spread throughout the world. It can be considered a revolutionary approach, as it combined egalitarianism with a tax funded and cost-effective school; providing mobility for the working class and lifting millions into the middle class (ibid., p.77).

On the one hand, the standard model does not imply that every single school are the same; there are great variations in how schools are run, from country to country and from school to school. On the other hand, the standard model underlies how the school as an institution is organised and run.

3.2.2 The Norwegian School System

Norway has a rich history tied to schooling which dates back to the 12th century.[1] Since the 1950s, it has been mandatory with a ten year long education; seven years of primary school, and three years of lower secondary school. Students have a legally established right to attend upper secondary school.[2] Nearly everyone who has attended primary school goes into the upper secondary school (Ludvigsen et al. 2014).

The Norwegian school was built as a unitary school during the 20th century with the underlying principles of equality and individual adaption of training for everyone in a coordinated school system [3].

During the last twenty years, the system has transformed what is being referred to as the comprehensive school (my translation, in Norwegian: *fellesskolen*). Deriving on the same ambitions as the unitary school, the concept of the comprehensive school focuses on diversity and inclusion (ibid.).

[1] Store norske leksikon - Norsk utdanningshistorie: https://snl.no/Norsk_utdanningshistorie

[2] Store norske leksikon - Skole og Utdanning i norge: https://snl.no/Skole_og_utdanning_i_Norge

[3] Store norske leksikon - Grunnskolen i Norge: https://snl.no/Skole_og_utdanning_i_Norge

The primary and secondary school system is organised around a fixed set of grades; 1-10. A grade usually consists of students born in the same year. The number of students per class are regulated by law and must be educationally justifiable.[4] A regular school week is Monday to Friday with mandatory attendance. Students are graded in lower secondary school. During the ten years of mandatory school, students follow the same curriculum and are are taught a set of basic skills as defined in 2006 by the Norwegian Directorate for Education and Training:

> "In the compulsory and secondary education reform of 2006 five skills were defined as basic to learning in school, work and social life. These skills are basic in the sense that they are fundamental to learning in all subjects as well as a prerequisite for the pupil to show his/her competence and qualifications." (Education and Training 2013)

Following on these basic skills, they are defined as the following (ibid.):

- Oral skills
- Digital skills
- Reading skills
- Basic arithmetics
- Writing skills

A centralised approach to subjects are then provided by the *National Curricula* (NC). This consists of a teaching plan for grades on every subject. The current NC consists of 12 subjects where the learning goals are managed nation wide. Each subject gets a specified amount of hours, and every student nationwide should, in theory, receive the same amount of schooling for a single subject as presented in table 1[5]. See 3.1 for subject and hour distribution.

In short, this educational system falls within the standard model as described by Sawyer (2006) and Khan (2012). Although the formal educational system in Norway has gone through a series of reforms, the fundamentals of the industrial-age are still at the basis.

3.2.3 Breaking With the Standard Model

In *The One World Schoolhouse - Education Reimagined*, Khan (ibid.) criticises the current state of the educational model in the USA. He explains that the standard model – as stated by Sawyer (2006) – rests upon factory concepts from the industrial age. The differences between how the Norwegian and American school-system is organised is not clear, but they have one thing in common: the standard model.

[4] Rules about class size: http://www.fug.no/klassestoerrelse.204627.no.html

[5] Macro time schedule for course organisation in primary school: http://www.udir.no/Regelverk/Finn-regelverk-for-opplaring/Finn-regelverk-etter-tema/Innhold-i-opplaringen/Udir-1-2014-Kunnskapsloftet-fag–og-timefordeling-og-tilbudsstruktur/Udir-1-2014-Vedlegg-1/2-Grunnskolen/#a2.1

Table 3.1: Ordinary subject and hour distribution

Subject/grade (hours)	1.-4. grade	5.-7. grade	Sum 1.-7. grade	8. -10. grade	Sum primary school
RLE	-	-	427	153	580
Norwegian	931	441	1372	398	1770
Mathematics	560	328	888	313	1201
Natural sciences	-	-	328	249	577
English	138	228	366	222	588
Foreign languages	-	-	0	222	222
Social sciences	-	-	385	249	634
Arts and crafts	-	-	477	146	623
Music	-	-	285	83	368
Food and health	-	-	114	83	197
Gym	-	-	478	223	701
Elective	-	-	0	171	171
Choice of education	-	-	0	110	110
Student council work	-	-	0	-	-
Flexible time	-	-	38	0	38
Physical activity	0	76	76	0	76
Sum minimum hours spent			5 234	2 622	7 856

Hours for each subject distribution for Norwegian schools, 2014.
(Utdanningsdirektoratet 2014)

In the standard model, students are set into distinct grades based on their age. Each grade will have a fixed amount of hours of each subject, which are separated into units. Students are expected to follow the same progress as the rest of their class. This means that the students' own progression and need for comprehension is disregarded. According to Khan (2012), this follows on a principle of the industrial-age — mass-production. This is further criticised as a *Swiss-cheese* approach to learning:

> "Let's consider a few things about that inevitable test. What constitutes a passing grade? In most classrooms in most schools, students pass with 75 or 80 percent. This is customary. But if you think about it even for a moment, it's unacceptable if not disastrous. Concepts build on one another. Algebra requires arithmetic. Trigonometry flows from geometry. Calculus and physics call for all of the above. A shaky understanding early on will lead to complete bewilderment later. And yet we blithely give out passing grades for test scores of 75 or 80." (ibid., p.83)

It follows that there must be a way to better the students' learning experiences, and Khan presents an alternative way of approaching the standard model; introduced in the 1920s as a part of the *Winnetka Plan* by Carleton W. Washburne, which put forth a fundamental design change: the structure of the curriculum was changed from terms of time, into terms of certain target levels of comprehension and achievement (ibid., p.38). This concept was known as *Mastery Learning*, where students progress towards the same target level, but at their own learning speed. The underpinning values of the Winnetka Plan resemble the Norwegian unitary school: *all* students can learn, what is required is to provide the necessary conditions, and no students should be held back, or put on a track that led to academic failure.

> "Mastery learning reduced the academic spread between the slower and faster students without slowing down the faster students." (ibid., p. 40)

The Winnetka Plan showed promising results, but the nationwide implementation proved to be difficult. To truly go forth with the redesign at a national scale, the entire institution had to be reorganised. Teachers would have to be retrained and there would be a "[...] greater need of textbooks, teaching material and resources" (ibid., p.40). The plan proved to be costly and disappeared from the American school system as the standard model was more effective to maintain at a widespread basis. Today, the situation is different, and the concept of *Mastery Learning* can be implemented through edtech, providing a platform where this can be done in a cost-effective way.

3.3 The Learning Sciences

In what has been termed as the *learning sciences*, questions related to how humans learn have been investigated since the early 1970s; the formal educational system has been thoroughly investigated. The first conference was held in 1991 along with the publishing of the *Journal of Learning Sciences*. Sawyer published *The Cambridge Handbook of The Learning Sciences* in 2006; it was the first comprehensive overview of the research done in this field.

In this overview, Sawyer (2006) states that the research done within the standard model has had the role of helping schools to more effectively transmit procedures and facts to students. Following on and not investigating the underlying assumptions of the standard model. However, the case was that these assumptions had never been tested scientifically. These underlying assumptions that dictated the school system had to be investigated further:

- "Knowledge is a collection of facts about the world and procedures for how to solve problems. Facts are statements like "The earth is tilted on its axis by 23.45 degrees" and procedures are step-by-step instructions like how to do multi-digit addition by carrying to the next column.
- The goal of schooling is to get these facts and procedures into the student's head. People are considered to be educated when they possess a large collection of these facts and procedures.
- Teachers know these facts and procedures, and their job is to transmit them to students.
- Simpler facts and procedures should be learned first, followed by progressively more complex facts and procedures. The definitions of 'simplicity' and 'complexity' and the proper sequencing of material were determined either by teachers, by textbook authors, or by asking expert adults like mathematicians, scientists, or historians - not by studying how children actually learn.

- The way to determine the success of schooling is to test students to see how many of these facts and procedures they have acquired." (Sawyer 2008)

Now, these assumptions may have worked well to provide the necessary basis of learning for citizens in the industrial age, where the requirements were quite different from today. Today these assumptions are making it harder to create learning environments which result in deeper understanding. As the world's economy has changed from an industrial to a knowledge economy, the needs of schooling have changed (ibid.).

3.3.1 Implications of a Knowledge Economy

The knowledge economy has become apparent for Norwegian society and many other countries (ibid.). Educators realised by the 1990s that "[...] schools were designed for a quickly vanishing world" (ibid.). To address the needs of our current society, the memorising of facts and procedures are not enough for success. Sawyer (ibid.) state that educated graduates must have a deep understanding of the complex concepts, and be able to work creatively to produce ideas, products, theories and knowledge. The requirements for schools have changed. Erna Solberg, the current Prime Minister of Norway, comments on the importance of addressing these changes:

> "The knowledge society is all about enabling every individual person's talent to make Norway as competitive as possible – in the school and in the workplace. [...] We start building the knowledge society in the schools." - Erna Solberg, Prime Minister of Norway (my translation) [6]

Sawyer (ibid.) summarises the key findings of the learning sciences as the following:

- "The importance of learning deeper conceptual understanding, rather than superficial facts and procedures.
- The importance of learning connected and coherent knowledge, rather than knowledge compartmentalised into distinct subjects and courses.
- The importance of learning authentic knowledge in its context of use, rather than decontextualised classroom exercises.
- The importance of learning in collaboration, rather than in isolation" (ibid.)

Sawyer (ibid.) states that the key findings imply that effective learning environments will be characterised by the following:

[6] E24 - Slik bygger vi kunnskapssamfunnet. Retrieved from: http://e24.no/kommentarer/slik-bygger-vi-kunnskapssamfunnet/21527153

- "Customised learning. Each child receives a customised learning experience.
- Availability of diverse knowledge sources. Learners can acquire knowledge whenever they need it from a variety of sources: books, web sites, and experts around the globe.
- Collaborative group learning. Students learn together as they work collaboratively on authentic, inquiry-oriented projects" (ibid.)

To enable that these key findings can become a part of the educational system, it is clear that edtech may play a significant part.

3.3.2 Students' Learning in the Future Norwegian School System

The Norwegian government commissioned a committee in June 2013 to evaluate the current primary, secondary education and training against the needs and requirements of the future society (Ludvigsen et al. 2014). Their Interim Report was published by Ludvigsen et al. (ibid.) in September 2014 named 'Students' learning in the school of the future' (my translation, in Norwegian: 'Elevens læring i framtidens skole'). The third chapter of this report summarizes research findings that can be used to improve the practices in Norwegian schools to further the students' learning. The report builds on the research by, among others, Sawyer (2006), the learning sciences and international projects dealing with the future of formal schooling.

Evaluations of the Norwegian school indicate that there is room for improvement regarding the students' learning; the schools content should be based on documented knowledge on how and what students learn under certain conditions. There are are seven premises which enable great learning (p.33, my translation Ludvigsen et al. 2014):

1. Students actively participating in, and understanding the learning process.
2. Students participating in communication and cooperation.
3. Students developing in-depth understanding, and are helped to understand connections.
4. Students must be challenged in such a way that they are able to stretch their body of knowledge.
5. Teaching must be adapted to the students different knowledge base and experiences.
6. Teachers and students are both goal and progress oriented in learning.
7. The learning environment is considerate to the students relations, motivations and feelings.

How these premises are going to be implemented in the Norwegian schools is still an unanswered question. However, the use of well-designed software is predicted to be a part of the answer to this question.

3.4 Edtech in Formal Education

The adaptation of new technologies within schools is an ongoing process, and the difficulties of using computers and devices in schools may be be tied to a lack of well-designed software for use within the classroom [7]. This is significant, as when considering the usability of any design, where it is going to be used, and who is going to use it is important (Preece, Rogers and Sharp 2007, p.4). For edtech the *where* is the classroom, and the who are the teachers and students.

A study performed by Gasparini and Culén (2012) followed the introduction and use of iPads as a part of the classroom ecology throughout a year. In this study, the device itself was viewed as a learning platform. Students were free to decide which apps to use, leaving them with a myriad of different educational apps and games. They enjoyed using the iPads and started to meet before class to discuss interesting games they had found. As some of the apps contained inappropriate advertisements, a compromise had to be made. As a result, the students had to decide on two games to keep. The teacher restricted the students access to the app store, leaving her in charge of finding apps to use in class. As the year passed, the novelty of the device wore off. Students lost their interest in the iPads. The class teacher summarised the year long use of iPads with:

> "The iPad was used more and more as an extra channel in addition to PCs. It was hard to find apps that complement the curriculum. For example, we found one app about mushrooms, but the language was a problem. It was too difficult for students to understand. Anyway, there simply are no apps for my needs and at the right level for teaching. [...]" (ibid.)

It does not follow from the class teacher's experiences that the iPad itself was the problem; the lack of apps designed to fit into her curriculum and work seemed to be the defining issue of her experience with iPads in the classroom.

However, Cuban (1986) and Cuban (2009) (as cited by Gasparini and Culén 2012) state that historically, ´´[...] many waves of new technology have passed through schools and classrooms, none leaving a lasting effect." He goes on to state that computers largely "have been found to be unused or underused in most schools." The research done by Gasparini and Culén (ibid.) confirm Cuban's words and concludes that "[we] are at the same place with tablets as we were in the mid-eighties when computers were first introduced."

To explain the phenomena where computers tends to be largely underused in schools, the article 'Factors Affecting Technology Uses in Schools: An Ecological Perspective' by Zhao and Frank (2003) is cited by Gasparini and Culén (2012) . This article summarises that there are two

[7] Article from Forskning.no http://forskning.no/skole-og-utdanning/2013/11/frustrert-laerer-har-lagd-laeringsspill

main contributing factors that indicate the degree and types of computer use by teachers:

(a) The nature of the uses.
(b) The result of the teacher's analysis of the uses.

How technology can be used to support their work is a primary focus for teachers. How are teachers supposed to use computer technology within their classroom if the software is not supporting them in their work? The answer to this question begins with Zhao and Frank (2003):

> "It seems evident that, like organisms in an ecosystem, teachers use computers in ways that address their most direct needs, bring them maximal benefits, do not demand excessive time to learn, and do not require them to reorganise their current teaching practices. Thus teachers' choices of computer activities minimise costs."

In many ways, the issues discussed by Zhao and Frank (ibid.) resembles the issues which are at the foundation of what interaction design is intended to solve. Interaction design involves "designing interactive products to support the way people communicate and interact in their everyday and working lives" (Preece, Rogers and Sharp 2007, p.8). One of the main goals of these interactive products is to be usable. This means that the product should be: "[...] easy to learn, effective to use, and providing an enjoyable user experience" (ibid., p.2). The study by Gasparini and Culén (2012) does indicate that there may be a lack of well-designed software which supports the teacher in their work.

However, the fact that a computer or iPad without suitable software makes for an unhappy educational experience does not mean that such devices are completely useless. To be useful, software which supports the learning context must at least be available. I suggest a shift in perspective, where the iPad or computer is not viewed as the main interactive product. Let them be viewed as devices to enable the use of well-designed software solutions for the educational sector; supporting the needs of teachers and students.

3.5 Designing Edtech

Sawyer (2008) recognises the need for for well-designed solutions for educational use, stating that edtech may provide a new foundation for the principle of *customised learning*. Envisioning that by utilising the possibilities within todays technology, "[well-designed] software could sense each learner's unique learning style and developmental level, and tailor the presentation of material appropriately" (ibid.). This entails that students would be able to follow their own progression, leaving room for some to be faster and some to be slower. He goes on to state that the software could enable "each student [to] learn each subject at different rates; for example, learning what we think of today as "5th grade" reading and "3rd grade" math at the same time" (Sawyer 2008).

3.5.1 Khan Academy

Outside of the formal education system, Khan created *KhanAcademy.org* — one of the leading online learning platforms, with the mission to "provide a free, world-class education for anyone, anywhere" [8]. By November, 2013, KhanAcademy had over 10 million unique users per month, which had solved more than 1.4 billion assignments on the platform[9].

Khan graduated from MIT, finishing with two Bachelor degrees and a Master of Science in electrical engineering and computer science, and later attending Harvard Business School for a Master of Business Administration.[10] The development and origin of KhanAcademy can be seen as the result of an iterative design process where Khan was the user, designer, and developer. The story was explained in depth in Khan (2012). I will now provide a short summary of how this story reflects a design process:

> It all began at a family party where Khan was told about his niece's math problems. His niece lived far away from Khan, but he did not see that as a problem. This could be performed online, as Khan was used to from his work. Khan got ready to perform online lectures by buying himself a digital drawing graphics tablet to help with visualisation. It did not take long before his niece asked him if he could record his lectures and put them on youtube. This would provide her with the opportunity of pausing whenever needed, and if there was something she didn't quite understand, she could rewind, and see it again, in her own time. At the time, the max length on a youtube video was 10 minutes. This kept the videos short.
>
> To support their lectures, Khan made computer programs for automatically creating sets of assignments for math concepts. As the rumour spread about his pedagogical skills, Khan received more and more requests from family members. After a while, he saw the need of structuring the mathematical concepts he was teaching. A hierarchical knowledge map of mathematics was made. Here he could keep track of his students progress, and how the progress connected to other missing links in their knowledge. He supplemented this hierarchical knowledge map of mathematics with *learning analytics*, so he easily could track their progression. This made him able to see how his group was performing and what concepts they were struggling with. The beginning and development of Khan Academy was solely focused on how his teaching of his family could be supported by digital tools. By

[8] Khan Academy: https://www.khanacademy.org/about

[9] FastCompany: A QA with Salman Khan http://live.fastcompany.com/Event/A_QA_With_Salman_Khan

[10] Salman Khan on Wikipedia: http://en.wikipedia.org/wiki/Salman_Khan_(educator)

2009, Salman Khan quit his job and made Khan Academy his full-time priority.

Retelling his story with an IxD perspective makes for quite a few interesting points. Firstly, Salman Khan is iteratively designing and developing software to actively solve the needs of teaching his students; he actively listens to his students ideas and tries to meet their requirements as well. He follows the core activities in the process of interaction design: understanding the users, providing solutions, and continuously evaluating the made solution. This is performed in full unison with the needs for his teaching and students in mind.

Following Salman Khan's design process, the result was a series of innovations, creating a platform where the teachers needs were unanimous with the students, making use of the technological possibilities to create an easy way of learning and managing learning.

KhanAcademy has become an internet phenomena, and at the time of the study it was being used and tested in many classrooms; one of many experiences are rendered below:

> "Oakland Unity, a charter school serving east Oakland, starting using Khan Academy with their 9th graders. Oakland saw great quantitative impact from students testing in the bottom 20% of the California Standards Test to becoming the 11th-ranked high school in the entire state in 2013. The school's use of Khan Academy increased over that time, from initially using Khan Academy in a summer math camp to using it as a homework replacement to making it a core component of the Learning Lab, and then finally evolving to using Khan Academy as an integrated part of the math classroom curriculum. Oakland Unity now not only uses Khan Academy with its 9th graders, but across their student population.
>
> After piloting Khan Academy, Oakland Unity math teacher Peter McIntosh wrote a book describing his experience with the site and how he has used it to help students take responsibility for their own learning." (Excerpt from KhanAcademy web page, Classroom case studies [11])

This case is an example of how the use of well-designed edtech may lead to positive results. It seems evident that when using computers and iPads in school, there must be well-design edtech to support the use. This kind of software can support the national curriculum to motivate and engage students in different ways than traditional teaching. It provides a platform for individualised customised learning experiences and makes it possible for teachers to receive statistics and analytics on how their

[11] KhanAcademy - Classroom Case Studies. Retrieved from: https://www.khanacademy.org/coach-res/k12-classrooms/why-ka-k12/a/classroom-case-studies

students are performing. It can provide an indication of where in the curriculum their students are struggling, without spending time manually correcting and gathering this kind of information. This enables a teacher to spend more time where needed, and students to progress at their own rate through the curriculum.

3.5.2 Norwegian Edtech

At the time of this study, the market for edtech within Norway is highly active where the *Norwegian Classroom* is being presented at conferences with the slogan that: "[the] future of learning is digital and Norway contributes with producing better education for children and youth all over the world"[12]. There are a number of Norwegian companies creating software aimed for the use within schools. Among these is *Kahoot* — a globally renowned game-based quiz-software.

Another of these companies developing edtech for the Norwegian classroom is called Asio. Their product is called Enki; a multiplayer classroom game for 4-7th grade, taking both user groups of a classroom into account: the teacher, and the student. The game provides assignments from the national curriculum in mathematics, English and the natural sciences. The students progress at their own pace and teachers are granted insight into their progress through the use of a web-based dashboard.

The game is created by the teacher Aas and the use and design of it will be the main subject of this thesis. I will have a closer look into the game in Chapter 5, and a closer look into my contribution in Chapter 6. Before this, I will present some key insights from the research on educational games.

3.5.3 Educational Games

The ongoing educational reforms and technology adaptations in schools are parallel with a digital world expanding at an enormous rate. The stimuli provided by these games and platforms are competing with many students attention. In the book *Reality Is Broken: Why Games Make Us Better and How They Can Change the World* it is argued that games are tapping into our primal urges and constructing virtual environments (VE) with experiences and possibilities that the real world is not able to provide (McGonigal 2011).

A successful VE is the renowned Massive Multiplayer Online Role Playing Game (MMORPG) *World Of Warcraft* (WoW). From 2004 to 2014, more than 500 million characters were created by over a 100 million unique users from 244 countries and territories [13]. During this time, more than 5.93 million years have been spent collectively in-game. As people from all over the world are investing their time and effort in such games, McGonigal argues that such games are beating the real world:

[12] Edtechnorge.no - What is Norwegian Edtech? Retrieved from: http://edtechnorge.no/english/

[13] World of Warcraft: Azeroth by the numbers. Retrieved from: http://us.battle.net/wow/en/blog/12346804/world-of-warcraft-azeroth-by-the-numbers-1-28-2014

> "The real world just doesn't offer up as easily the carefully designed pleasures, the thrilling challenges, and the powerful social bonding afforded by virtual environments. Reality doesn't motivate us as effectively. Reality isn't engineered to maximise our potential. Reality wasn't designed from the bottom up to make us happy." (ibid., p.3)

It follows that VEs can be an untapped resource for education; if well-designed, they can provide motivation and engagement towards learning. The underlying design of a multiplayer game can be seen in relation with the seven premises of great learning:

1. Players actively participate, and understand the learning process.
2. Players communicate and cooperate.
3. Players develop in-depth understanding of the game mechanics, and are helped to understand connections between the learned skills
4. Players are challenged in such a way that they are at the the brink of their knowledge base and able to succeed only by stretching their body of knowledge
5. The game adapts to a player's knowledge base and current skill level
6. The game provides goals for the player, and feedback about their progress towards them
7. The game is considerate to a player's relations, motivations and feelings by providing autonomy

In *The Gamification of Learning and Instruction: Game-based methods and strategies for training and education*, a game is divided into different game elements which together create an environment where a player can be fully immersed:

> "A player gets caught up in playing a game because the instant **feedback** and constant **interaction** are related to the **challenge** of the game, which is defined by the **rules**, which all work within the **system** to provoke an **emotional reaction** and, finally, result in a **quantifiable outcome** within an **abstract** version of a larger system." (Kapp 2012)

It is interesting that games as an educational medium is not more common in school; meaning that there are few games which are adopted to the national curriculum and found useful for both teachers and students. In 2014, fifty percent of kids between 9-14 years old reported that they played computer or video games on a daily basis[14]. Historically speaking, using games for learning is not a new phenomenon. It has been used in military contexts for many centuries and is not an unknown technique for teachers. It seems inevitable that the creation of great games for learning can give students something extra, where the challenges engage the learners, set

[14] 'The use of video and computer games', a MediaNorge survey of 2014. Retrieved from: http://medienorge.uib.no/statistikk/medium/ikt/334

goals for them and give feedback while they practice in a safe environment (Kapp 2012, p.13).

The use of game elements outside of games is becoming a well-known technique. It has been applied by teachers and educators to provide engagement, and during the last few years the use of game elements have become common as a part of online learning platforms. When one uses game elements outside of a game, the process is called *gamification* (ibid.).

3.5.4 Gamification

Gamification is defined as using "[...] game-based mechanics, aestethics and game thinking to engage people, motivate action, promote learning, and solve problems" (ibid.). When it is used to promote learning or engagement, the behaviour changes and positive outcomes are the result of a gamification process (ibid.).

Gamification involves creating challenges to engage the learners, setting goals and giving feedback while the learners are in a safe environment for practicing (ibid., p.13).

Games for different uses than entertainment are often called *serious games*. Kapp suggests that there is no real need for a distinction between gamification and serious games (ibid.).

3.5.5 Intrinsic Versus Extrinsic Motivation

Motivation can be seen as one of the main benefits from games, research on the matter has uncovered two different types of motivation: intrinsic motivation (i.e. where the motivation comes from the within the learner), and extrinsic motivation (i.e. where an external factor is the cause of the motivation) (ibid., p.52).

The two motivational types are significantly different. Where intrinsic motivation comes from within the learner; "[...] a person undertakes an activity for its own sake, for the enjoyment it provides, the learning it permits, or the feeling of accomplishment it evokes". (ibid., p.52) An extrinsic motivation comes from an external reward or punishment; " [...] a person seeks to earn something that is not directly related to the activity. The motivation doesn't come from within the person, it comes externally" . (ibid., p.52)

There are many theories which try to capture the essence of how the motivational aspect works within games. One of these is the four factor model named ARCS: Attention, Relevance, Confidence, and Satisfaction. (ibid., p.53) In this model these four factors must be in play for a user to be motivated through an instructional game.

One must be able to capture the learner's *attention* and provide *relevant* material so the user understands why this learning should take place. One should build the user's *confidence* so that one believes it is possible to be successful, and provide *satisfaction* as the learning takes place, the "[learners] need to feel that the learning has value and is worth the continued effort" (ibid., p.54).

3.6 Adaptive Learning

For a student, the research indicates that the one of the more successful ways of providing a great learning experience is by customising their learning experiences. In 'Optimising Learning: Implicatons of Learning Sciences Research', Sawyer (2008) states that the use of technology will be critical in making the customisation of learning experiences an option. This is what has become known as adaptive learning, which is adapting assignments to a student's existing knowledge base to challenge the student in a way that they are able to stretch their body of knowledge.

This potential for technology has long been recognised by educators as it can provide an answer to the "[...] scalability and cost of individualised instruction" (Murray and Pérez 2015). What is today known as *adaptive learning* is the umbrella term which had its beginning in the educational research from the 1960s. The interest of using technology this way grew when it became well-known that individual tutoring had a significant effect on learning. (Wilson and Nichols 2015) Adaptive learning technologies are developed to automatically generate customisable learning experiences. When such technologies are developed, they are termed as adaptive learning tools: "[adaptive] learning tools are technology-based artifacts that interact with learners and vary presentation based upon that interaction" (Murray and Pérez 2015).

Historically, such systems have varied in complexity and quality. There has been a number of systems trying to solve the complexity of adaptive learning, and the "platforms underlying these systems rely heavily on artificial intelligence and complex learning algorithms" (ibid.). We will not go into depth of these technological aspects in this thesis, but rather explain the foundations of why this is an important learning tool for education.

One may view KhanAcademy's implementation of *Mastery Learning* as a form of adaptive learning. A personalised learning experience is made available by suggesting a path through a subject which is adapted to the student's individual knowledge-level. A subject such as mathematics is represented as a directed graph. The individual nodes represent concepts (e.g. addition, subtraction, multiplication) and the dependencies between these concepts are based on the direction. See Figure 3.2 for an illustration.

As a learner progresses through the concepts, they are measured on performance. This is done through formative evaluation of their assignment. The ideal adaptive learning systems use research findings to assure quality in the assertion of a learner's understanding of a given concept. One of these assessment-findings is called *distributed practice* and it:

> "[...] helps learners retain access to memorized information over long periods of time because the spacing prompts deeper processing of the learned material." (Kapp 2012, p.65)

The assessment of a learner's understanding would then not be restricted to achieving an assignment once, but rather on repeatedly

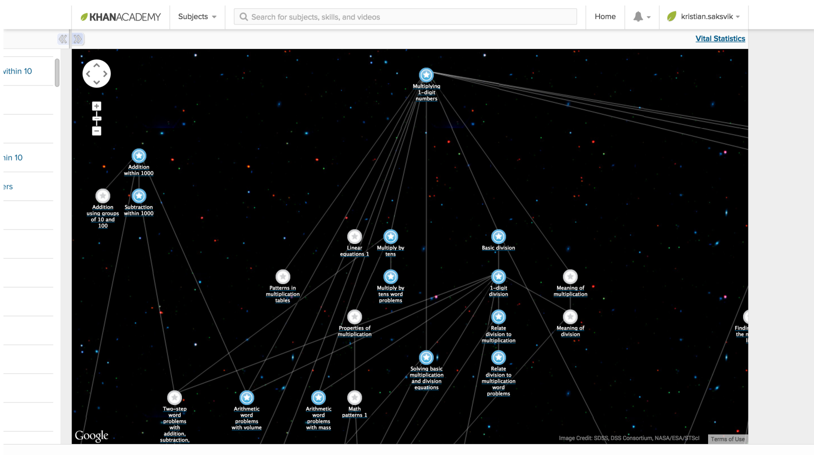


Figure 3.2: A knowledge graph from Khan Academy (2014)

succeeding on assignments within the same concept. KhanAcademy's assessment of concepts builds upon this principle and combines it with mixed repetition; giving the learner assignments from a mix of the concepts one is learning.

The umbrella term adaptive learning builds on a range of findings in educational research, among them the concept of *scaffolding*. This is often used when designing learning-games, as it enables "[...] the movement from one level to another with increasing difficulty and the need to apply more skill to master the new level [...]" (Kapp 2012, p.66). Scaffolding is defined by Kapp as the process of:

> "[...] controlling the task elements that initially are beyond the learners capacity, so that the learner can concentrate on and complete elements within his or her immediate capability. Once that task is accomplished, the learner is then led to accomplish another goal that builds upon the previous." (ibid., p.66)

By applying scaffolding to an adaptive learning system, one would constantly keep challenging the learner at a difficulty which is neither too difficult or too easy. This is one of the prerequisites for enabling the learner to experience *flow*:

> "Flow is experienced when the challenge facing a person is in almost perfect balance with the person's level of skill and abilities — he or she can accomplish the task, but it will take concentration, blocking out distractions, and a high level of effort." (ibid., p.71)

Enabling a learner to experience flow in one's learning experience may be seen as a guidepost for the gamification of learning (ibid., p.72). The concept of flow is visualised in Figure 3.3. According to Kapp there is a total of eight components which make flow possible:

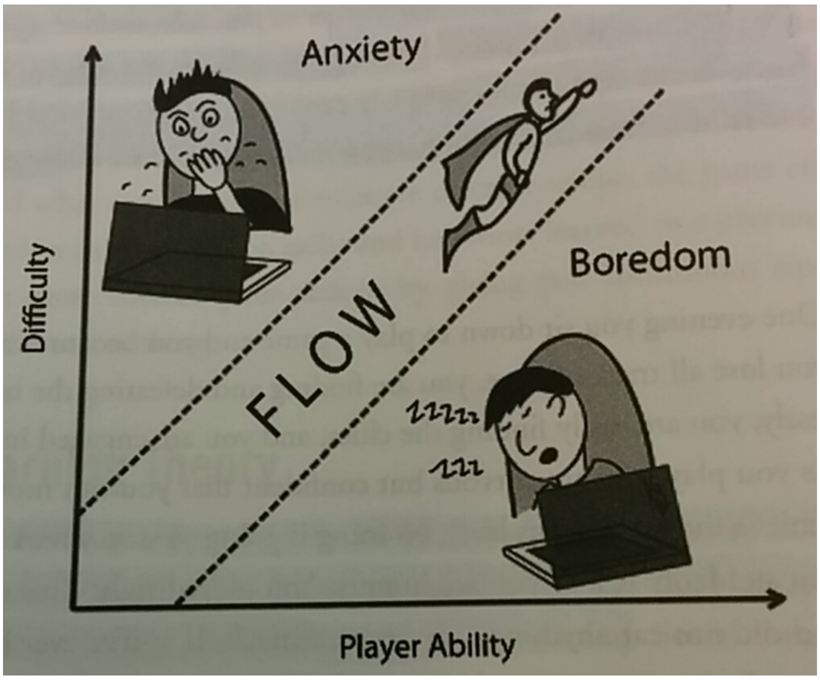


Figure 3.3: The Concept of Flow Visualised (Kapp 2012, p.72)

- "Achievable Task or Scaffolding
- Concentration
- Clear Goals
- Feedback
- Effortless Involvement
- Control Over Actions
- Concern for Self Disappears
- Loss of Sense of Time" (ibid., p.73)

The ideal adaptive learning system would enable a learning environment where the experience of flow is possible. This is not easy, as this is even a rare occurrence in instructional games. (ibid., p.72) The experience of flow is described as:

> "As you play, you are nervous but confident that you can move forward and achieve the goal of this level. Nothing is going to stop you. Four hours later, you suddenly realize you are hungry. You played right though dinner time and did not eat anything — not even a snack." (ibid., p.71)

The experience of flow, as termed by Mihaly Csikzentmihalyi, is a common experience when performing activities which has that "[...] ideal state between boredom and anxiety or frustration" (ibid., p.71)

3.6.1 Commercial Adaptive Learning Systems in Norway

In the beginning of May 2015, an adaptive learning system was released by the Norwegian company Gyldendal. The system *Smart Practice* (my translation, in Norwegian *Smart Øving*) was developed in cooperation with the American company Knewton.

Smart Practice is an adaptive learning system built for the national curriculum in mathematics. The underlying structure is built on a platform provided by Knewton, enabling the representation of subjects as knowledge graphs.

In Smart Practice, a student is provided a customised learning experience based on their performance and knowledge-level. They are recommended assignments and different ways throughout the curriculum. A part of the underlying knowledge structure for math is represented in Figure 3.4 [15].

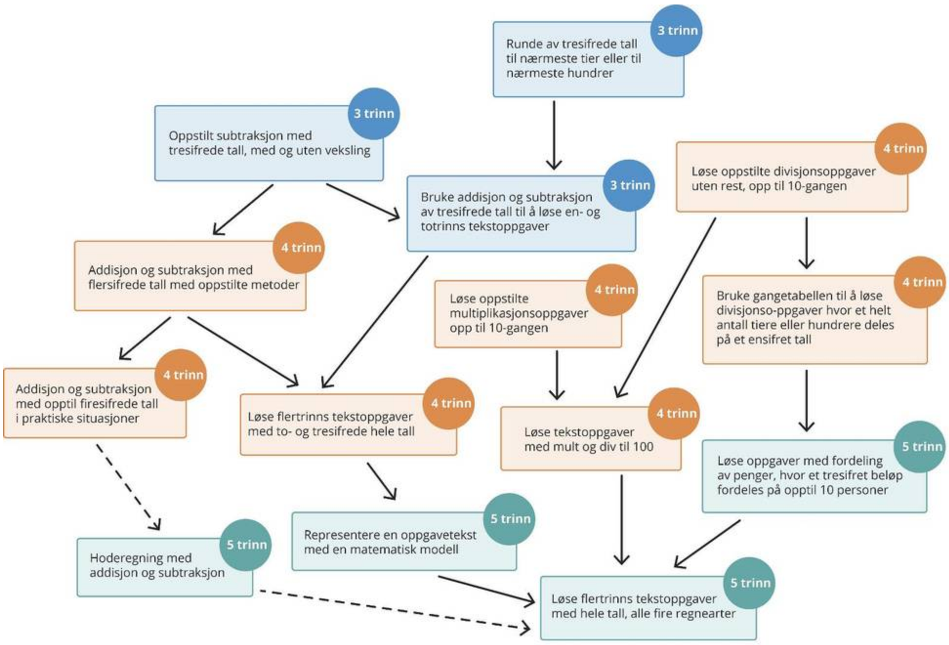


Figure 3.4: A knowledge graph of mathematics

3.7 Learning Analytics

How to use the structured educational concepts and data about a learner, is what has become the primary concern of the emerging field of *Learning Analytics and Knowledge*. Through the 'Proceedings of the 1st International Conference on Learning Analytics and Knowledge' in 2011, the definition of *Learning Analytics* was established:

> " Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the

[15] Knowledge Graphs through the Smart Øving article in Aftenposten: http://www.aftenposten.no/fakta/innsikt/Datasystemet-som-holder-elevene-i-flytsonen-8010691.html

environments in which it occurs." (Buckingham Shum et al. 2011)

Learning analytics can be used in multiple ways, but there are two common use cases which I will introduce. The first of these lays at the foundation of any adaptive learning system: the use of learning analytics as a part of the system itself, which is described as the detection of patterns, often based on "[...] data mining techniques, so that for instance recommendations can be made for resources, activities, people, etc. that are likely to be relevant" (Duval 2011). The second usage-pattern is to process the data in such a way that it can be visualised for the user, enabling the teacher or learner to draw meaning from it (ibid.). In this thesis, the latter will be the main subject of interest.

Learning analytics within education deals with extracting the correct data which would enable teachers to see, understand and help their students at the proper time as they progress through learning-software, meaning that a teacher should be able to review the knowledge-level of their students. This involves making clear visualisations of the correct type of data.

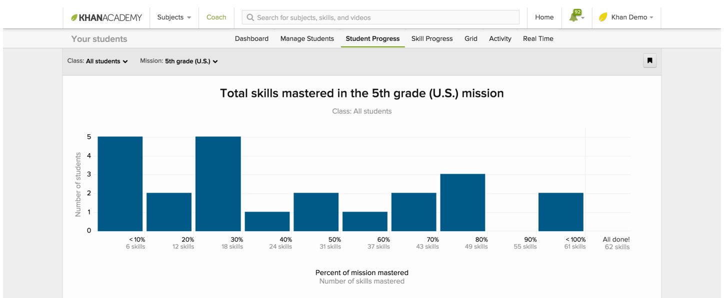


Figure 3.5: Khan Academy: teacher dashboard for a class

There are many examples of interfaces for such learning analytics, one of these is KhanAcademy for the classroom; where teachers get a dashboard to keep track on their students performance. This is represented in Figure 3.5. In this Figure we may see how a class is progressing through learning the skills defined in 5th grade mathematics (US curriculum). This is to provide the teacher with meaningful data, enabling one to see how the class is performing at a wide scale.

The learning analytics design of KhanAcademy then enables the teacher to focus on specific students, see Figure 3.6. Teachers would then be able to see where in the learning-process a student is struggling and in need of help. This gives the teacher solid evidence on how a student is performing, pinpointing exactly where their weaknesses and strengths lie.

Learning analytics used in this specific way enables the teacher to get an insight into *how* their students perform in learning-software. This can be used to help, motivate, and map out a student's knowledge in a given subject. However, this aspect is highly dependent on how the learning software is structured, and what type of information the learning analytics makes available for the teacher.

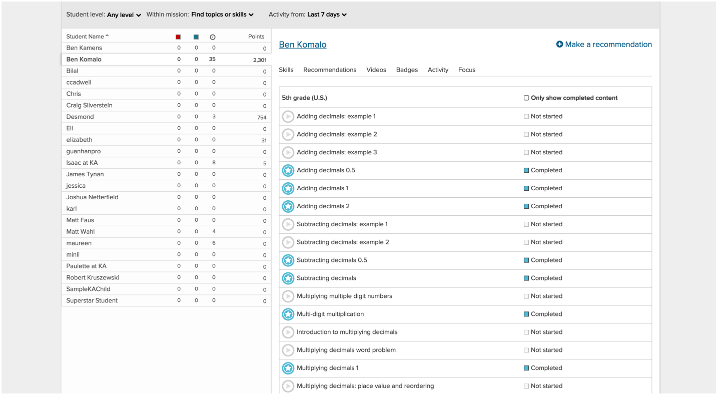


Figure 3.6: Khan Academy: teacher dashboard for an individual

It seems apparent that learning analytics is an essential part of any adaptive learning tool. It empowers both the teacher and student in the sense that the student is able to see how they are performing, and that teachers get an overview of their students' performance. In contrast to the traditional situation where students answers are manually corrected by the teacher, and it is the teachers job to map out their knowledge level, the strength of learning analytics comes into play by empowering the teacher with an automatic overview of the students performance.

Part II

The Project

Chapter 4

The Concept

In this chapter I will describe the game Enki and the learning analytics tool ERA. By the end of the chapter you will have an understanding of the conceptual design of the game for the classroom setting, and the design solutions for both students and teachers.

4.1 Enki

The Multiplayer Online Game (MOG) Enki is the result of a three year long project, created by Steinar Aas, the founder of Asio AS. The game was developed as a part of Aas's Master Thesis in 2013: 'Dataspill og verdigrunnlaget i læreplanen: Didaktiske muligheter'. During his research, he discovered the lack of well-designed digital resources for the Norwegian classroom. In fact, he discovered that Sweden and Denmark were in the same situation.

Aas (2013) suggested through his research that well-designed computer-games could be used to support learning goals in the national curriculum. He went forth to establish the company Asio AS to build what was to become the first Norwegian curriculum-adapted multiplayer learning-game. It was originally designed to provide a way of teaching students the values of the national curriculum and the game was piloted as a part of his thesis, where a total of 159 students from 5 schools within Oslo and Bærum municipality participated. In the conclusion of his study, Aas (ibid., p.71) points out that it is reasonable to assume that schools have an interest to explore computer games, especially if they provide an arena for students to meet the curriculums competence aims.

Aas (ibid.) states that computer games which represent ethic principles will provide an extra valuable dimension, as schools involvement in the sense of digital decorum for students are of increasing importance. He emphasises that the use of learning-games within schools have great potential. Schools may use multi-player games as a resource; a digital zone where the students behaviour may be registered as they work on academic assignments.

Since the delivery of Aas in 2013, he has invested his time into making the results of his research into reality. The team has kept on developing the game, and been granted funding by a number of different institutions:

- Kjeller Innovation
- Innovation Norway
- The Research Council of Norway
- Oslo and Akershus University College

During this time, the game has evolved into a educational game focusing on facilitating a learning environment for the classroom where curricular activity in mathematics, nature science and english is combined with a game experience. By January 2014, there were multiple schools throughout the country participating in a beta test, which consisted of supplying the students with the game Enki, and teachers with access to learning analytics through ERA. I will further elaborate on the designs of Enki and ERA later in this chapter, but first I will eplain how Enki and ERA is designed to work in the classroom.

4.2 Enki and ERA: a Design for the Classroom

Enki and ERA were designed to be used in a classroom-setting, but providing an easy way of distributing the game into this setting was challenging. This was mainly due to strict regulations of ICT in schools, and a design which was able to bypass the strict limitations and obstacles was needed.

Enki's first prototype, launched in 2012, had to be installed on the computer; the team travelled to the participating schools with cd-rom's to install. This was proving to be a challenging distribution model and led to many difficulties. The IT-systems in Norwegian schools are in many cases characterised by a bureaucratic implementation, meaning that that the IT-system run by many Norwegian schools consist of a standard package of software where students are unable to install new software and in some cases these restrictions apply for teachers. To enable access to the game, an ICT-responsible or in some cases the municipalities were in charge of installing the software, making it difficult to distribute the software for the teachers who were interested in testing the game. To provide an example of what this entails, a team member reported that in a specific case, a school spent over 3 months to open the required ports for the game to work.

Following these strict limitations for installing software was not going to be easy. Finding a way to bypass the strict limitations was to be an important matter for allowing the game to be easily adopted and tested by a teacher. Therefore, the team decided to build the software based on web-technology, which is natively supported by any modern browser. This includes: HyperText Markup Language 5 (HTML5), Cascading Style Sheets (CSS) and JavaScript (JS).

Making Enki and ERA with web-based technology came with many advantages: for the developers it centralised the distribution of the game and made it easy to provide updates and bug-fixes, and for the users it meant that they would be able to run both Enki and ERA on a school computer.

4.3 ERA: the Teacher's Experience

Enki is not the first educational game ever made, there is a myriad of different educational games which cater to the educational game market, but there seems to be few educational games which are designed with both user-groups of a classroom in mind. Aas wanted to solve one of the main challenges for teachers when using educational games in the classroom: giving the teacher an overview of what students do as they play[1].

It follows that the first design of ERA was made based on Aas own research on teacher's needs in this situation. He integrated learning analytics from the students performance in Enki, and allowed the teacher to oversee the in-game activities without playing. To empower a teachers role when using educational games in the classroom, ERA made it possible for teachers to be the game administrator: creating and changing accounts for their students, keeping an overview of what they did in-game, and how they communicated.

4.3.1 Design Overview

I will now provide an overview of the version of ERA that was a part of the beta test in January 2014. The design included a wide range of functionality for the teacher:

- Chat
  - See messages in class chat
  - Send messages in class chat
  - See private messages from users
  - Send private messages to users
- Deliveries
  - See uncorrected deliveries
  - See corrected deliveries
  - Correct delivery
- Statistics
  - See class statistics
  - See student statistics
- Events
  - See assignments done in-game
- Assignments
  - See where different assignments are in-game

[1] Bård Amundsen (2013). *Frustrert lærer har lagd læringsspill*. URL: http://forskning.no/skole-og-utdanning/2013/11/frustrert-laerer-har-lagd-laeringsspill.

- Administration
  - Add class
  - Add user to class
  - Change user information
  - See user password

The design was implemented as a web-application, see Figure 4.1 for an illustration. It was made available for the teacher through logging in on Enki's website.

After logging in, a teacher was met with a design where an overview of students and classes connected to the teacher's account, with contextual links for each student, it rendered them able to change their account information. A global navigation menu on the left hand side was presented to let the user navigate throughout the application.

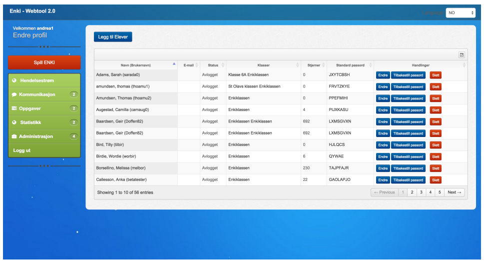


Figure 4.1: ERA: beta version

4.3.2 Chat

ERA enabled the teacher to interact with in-game players through the *live chat*, see Figure 4.2. Enabling a teacher to participate and keep watch of the in-game communication. The teacher can remove a student's chat privilege and send direct messages to their students.

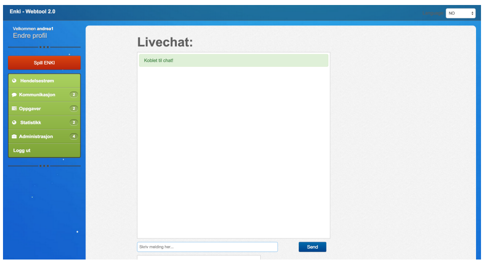


Figure 4.2: Live chat

4.3.3 Deliveries

Teachers receive text deliveries from their students, see 4.3, they can view and correct these text deliveries, which were presented alongside the assignment and solution. Teachers were able to give the students a set of stars and feedback, which students received in Enki.

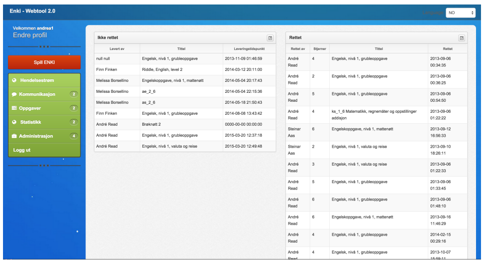


Figure 4.3: ERA: deliveries

4.3.4 Events

In Enki, an event signifies a student performing an action in-game which provides a traceable result.

ERA supplied the teacher with an event-stream, where the students recent in-game activities were shown, see Figure 4.4. An event consisted of the student's name, assignments subject, theme and number of stars achieved.

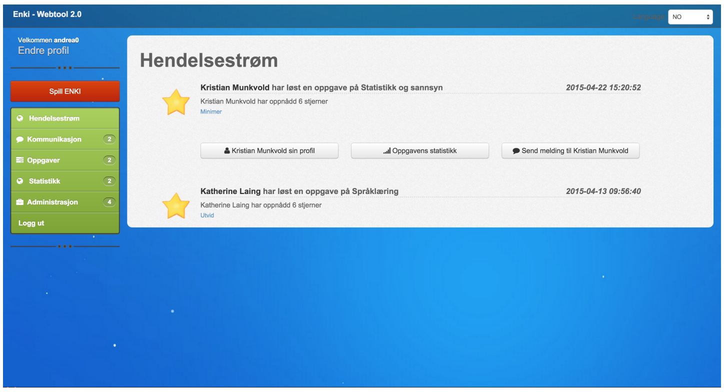


Figure 4.4: ERA: event stream

4.3.5 Statistics

ERA provided statistics for both users and classes, as illustrated in Figure 4.5. Statistics were based on the in-game activities and portrayed how well each student were performing.

The teacher could choose between the class or user overview. The statistics were separated based on subject, and showed the total progress and average stars for assignments. The progress of a student is calculated by the total stars achieved divided by the total of possible stars available.

The average of the students or class performance is calculated by the sum of all stars gathered divided by the number of assignments performed.

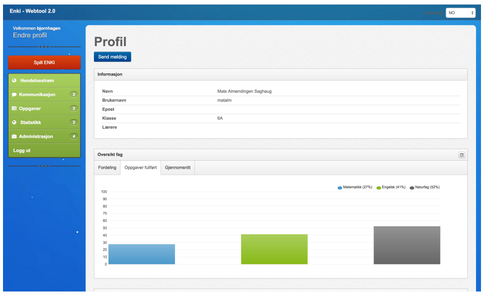


Figure 4.5: ERA: statistics

4.3.6 Administration

The administration in ERA enabled the teacher to be in control of the user-accounts, see Figure 4.6. The teacher could create classes and user-accounts for new teachers and students.

This included functionality for changing password, username and personal information tied to an account.

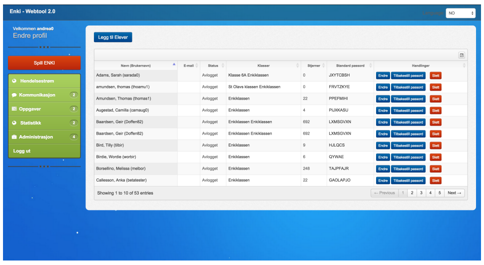


Figure 4.6: ERA: administration

4.4 Enki: the Student's Experience

Enki can be described as a platform game, where players navigate a two-dimensional environment, climbing or jumping between platforms[2]. However, where platform games often are linear in progression, Enki strongly resembles a sandbox game, which sets minimal restrictions on the player and allows it to roam freely within the game environment[3].

[2]Oxford Dictionary. *Definition of platform game*. URL: http://www.oxforddictionaries.com/definition/english/platform-game.

[3]Technopedia. *Definition of sandbox game*. URL: http://www.techopedia.com/definition/3952/sandbox-gaming.

4.4.1 Personal Avatars

The first login for each student starts the game experience. They are required to customise a personal avatar see Figure 4.7, and the following parts of the character are customisable:

- Sex
- Skin color
- Hair
- Eyes
- Eyebrows
- Nose
- Mouth
- Clothing

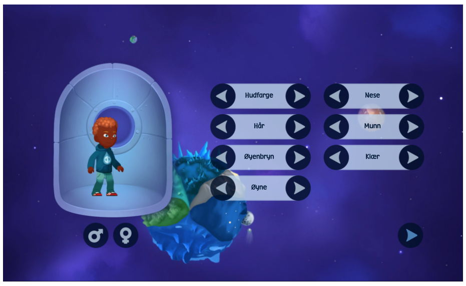


Figure 4.7: In-game avatar customisation

The personalised avatar represents the student in a third-person perspective, and the gameplay allows for further customisation on the avatar: his or hers attitude is affected by an energy level which must be kept at a decent level, new clothing for the avatar can be made through gathering required material. The combination of using a third-person perspective while making the student do positive actions can have have beneficial effects'; there is a link between "picturing yourself" performing a desired behaviour and translating that good intention into practical action in real life (Kapp 2012).

4.4.2 Learning the Gameplay

The gameplay is presented to the student through a tutorial, where students are introduced to the hows of navigation and interaction with the game environment and Non Playing Characters (NPC), the basic game mechanics are further explained. The tutorial ends by an NPC explaning the student the travelling system "Cosmo Travel", the travelling system allows the student to visit the different parts of the game universe, see figure 4.8.

4.4.3 Learning Content

Enki's learning universe consists of three distinct subjects: mathematics, the natural sciences, and English. Where each subject is represented by its

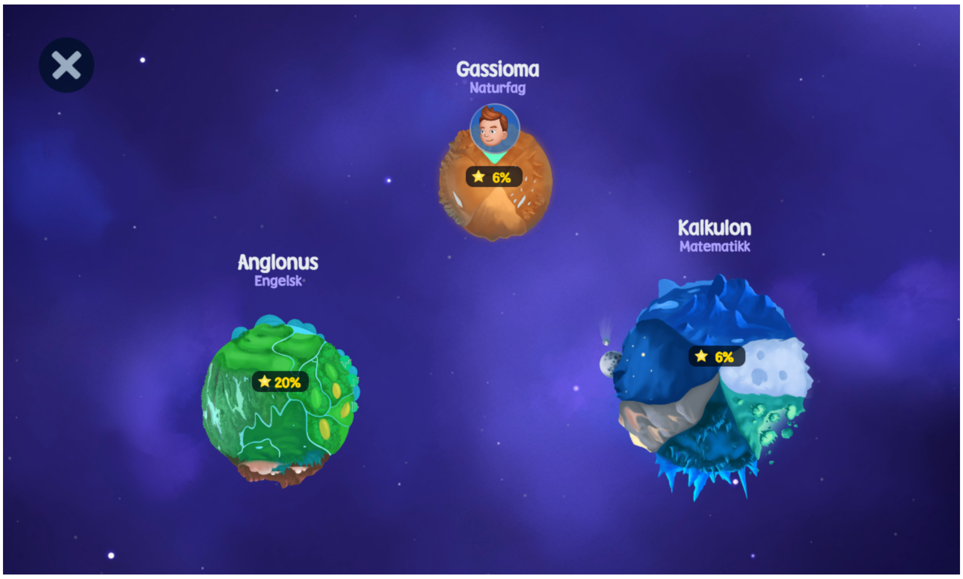


Figure 4.8: The in-game universe and planets

own planet in-game. A subject is further refined into different concepts (e.g. addition, subtraction, multiplication), and these concepts are represented as zones on each of these planets, see Figure 4.9 illustrates the overview of subjects and concepts within Enki.

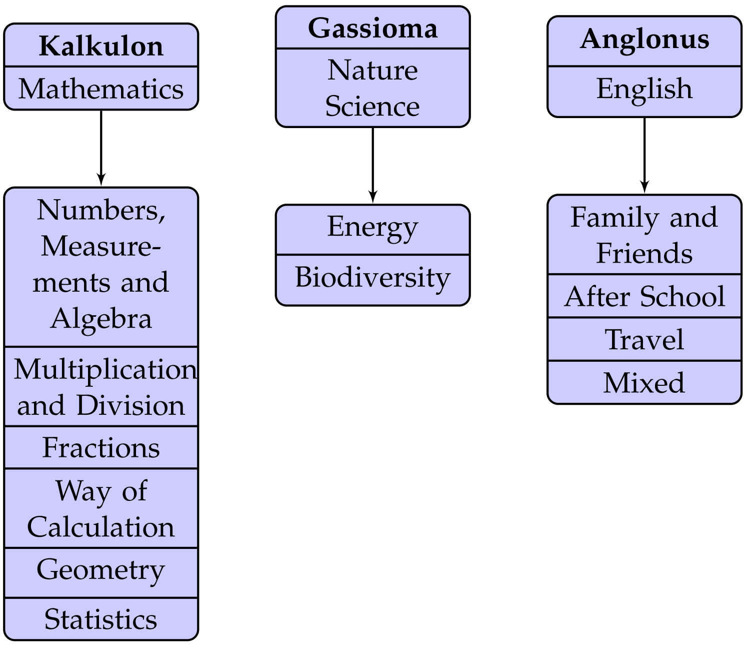


Figure 4.9: Overview of Enki

Students can navigate freely, travelling from planet-to-planet and zone-to-zone, Figure 4.10 illustrates how a chosen planet and zone is portrayed in-game. A student is shown three possible levels, where the first is unlocked. A description of the game-world introduces the student to the zone and underpinning concept.

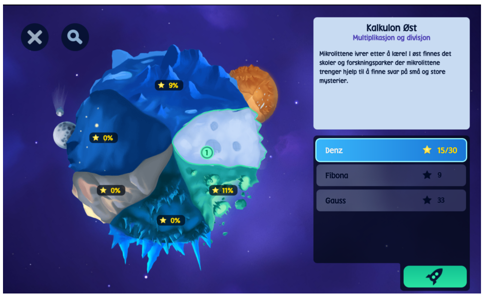


Figure 4.10: Kalkulon: the mathematics planet

4.4.4 Game Levels

A zone is divided into three levels. A student may visit the first level in every zone. Unlocking the next when achieving a set-number of stars on the current level. These stars are only gained through solving assignments. The level-system is difficulty-based: The first level contains assignments from the 5th grade, the second level increases the difficulty to the 6th grade, and the third level the 7th grade. See Figure 4.11 for an illustration.

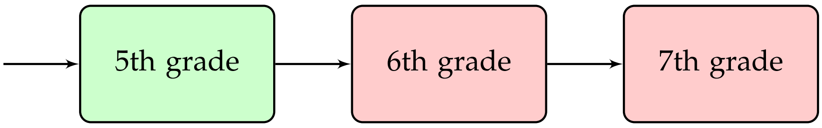


Figure 4.11: Level System

4.4.5 Gameplay

When entering a zone's level, the gameplay begins. The student is sent to the level and is able to explore and navigate the environment, see Figure 4.12. The student can interact with other students, NPCs, animals and the zone's flora, while maintaining their their avatar's energy-level and inventory.

Figure 4.12: Enki - Kalkulon West: avatar and NPC

The movement-speed is affected as the energy-levels decline, a student gains energy through eating food, but food is scarce and placed throughout the different levels. To keep their energy levels high, students must collect and store in their in-game inventory.

4.4.6 Progress Through Solving Assignments

For a student to be able to reach new levels in-game, they must collect a set number of stars through solving assignments. These are reached through NPCs, where the student goes through a scripted dialog to frame the problem for the assignment, see Figure 4.13.

Figure 4.13: Enki: Dialog with an NPC

The game consists of six different forms of assignments:

- Fill-in
- Association
- Multiple Choice
- Fractions
- Drag and drop
- Text delivery

Assignments are further split into subtasks, and a progress-circle indicates a student's progress throughout, see Figure 4.14 for an example. While solving an assignment, the game-environment is no longer in focus, meaning that a student can not be disturbed by chat-messages or in-game activities.

During the progress through the subtasks of an assignment, a sound cue is given as an indicator for right or wrong answers. The assignment is finished when all subtasks are done, and the student is given immediate feedback. This feedback contains a motivational text, stars, and in-game money; the reward is based on a student's performance, where six stars indicate that they have gotten every answer correct, see Figure 4.14 for an illustration.

Text Deliveries

Five out of six assignment types are automatically corrected and provides immediate feedback to the student. The text deliveries are an exception, as

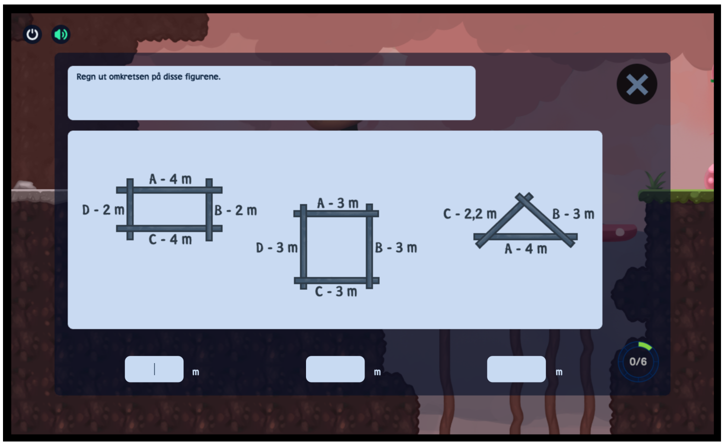


Figure 4.14: Assignment: fill-in

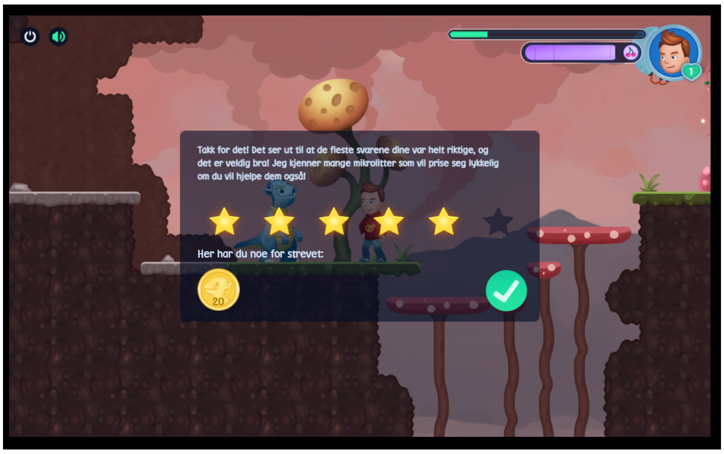


Figure 4.15: Assignment: feedback when finished

they are sent to the teacher as described in Chapter 4.3.3. When a teacher corrects a delivery, the student receives an in-game mail where they can see their teacher's feedback.

4.4.7 Chat and In-Game Communication

When students are in-game, they are able to communicate with other students in their class through the chat-system, or send direct messages directly to their teacher. Chat is available in-game through clicking on the left-hand side chat-icon, which opens a full-size chat. This chat has some limitations: all chat-messages are filtered through a list which sensors bad language. See Figure 4.16 for an illustration of the chat.

Figure 4.16: Assignment: chat system in Enki

Chapter 5

My Contribution

In this chapter I will explain my contribution to Enki. By the end of this chapter you will have an understanding of the technological solutions, design and development-process used to create and implement the new design for ERA.

5.1 The Project

Project name: ERA - Educational Resource Application
Case: Redesign and implementation of ERA
Role: Designer and Developer

In January 2014, my work with Enki began; the game was in a beta test with several schools where a sampling of the target users were testing the product to get an indication of how it was performing. In this phase, the team worked closely with the users and were out in the field to collect data. The results from the beta test indicated that there was a need for a redesign of the teacher's application (ERA).

To describe the state of the project as I entered in my role as a designer, I will introduce two concepts from software development: greenfield; a project where one does not need to consider any prior work[1], and brownfield; starting a project where prior work must be taken into account or rebuilding an existing product.[2]

Where a greenfield project has the luxury of designing completely from scratch, this was not possible in this project. The new design of ERA was a brownfield project; the prior work had to be taken into account to rebuild the existing product. The game had already been made and there was an established infrastructure, and the redesign was to support these implementations.

[1]Greenfield development, from webopedia: http://www.webopedia.com/TERM/G/greenfield.html

[2]Brownfield development, from webopedia: http://www.webopedia.com/TERM/B/brownfield.html

5.2 Phase 1: Identify Needs and Establish Requirements

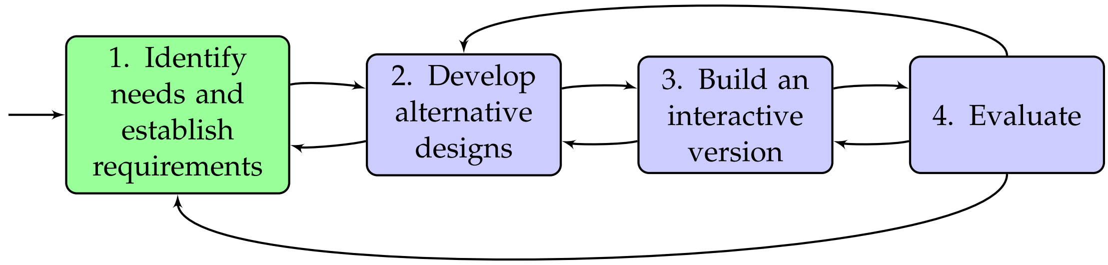


Figure 5.1: The IxD process: step 1 - identify needs and establish requirements

ERA's redesign was performed as an iterative IxD process, where the first step had two main aims: identifying the needs; understanding the users, the users context and their work, and establish requirements; producing a set of requirements to lead the design forward (Preece, Rogers and Sharp 2007). This is a part of what Zimmerman, Forlizzi and Evenson propose as the *real* knowledge about a design; the research done upfront for a design project to continually reframe a problem to make the right thing.

Identifying the needs was done through an analysis of the current design of ERA. The beta test had produced results which was used to evaluate the current design and identify the needs of the users.

To start forming the requirements for ERA, design-meetings were performed once every week to analyse the current design of ERA. The results from the beta test were combined with an analytical evaluation; the usability goals and user experience goals introduced in chapter 2.2 were used to analyse issues with the design. To validate these issues, they were discussed further with a representative from the primary user group: the teacher Steinar Aas. I will now present some of the results from this analysis.

5.2.1 Using the Previous Version as a Reference Point

ERA's design had a number of usability-issues which affected the UX. I will present three key findings based on the following usability goals: effectiveness (if the design is good at doing what it is meant to do), utility (if the design provides the right functionality that the user wants or needs), and learnability (if the design is easy to learn). (ibid., p.21, p.22).

Effectiveness and Learnability

The analysis indicated that the design was ineffective in its use; it hid important functionality from the user, there were no clear indication of what the user was to do, and it did not support the user in doing what they were meant to. There was no indication of what was important to do or what required the teachers immediate attention. As the design had a real-time integration with the game, following up on chat messages and correcting deliveries is an example of important functionality. The fact that this functionality existed was not made apparent to the user. I will now provide an example of how the design was ineffective and had weak learnability for its use.

A user would be unaware of a rising number in uncorrected deliveries. This affected the UX of both user-groups. A beta tester reported discovering over fifty uncorrected deliveries. This was a frustrating experience, as the teacher had to correct all these deliveries, while knowing that the students had been and were waiting for the in-game feedback. This was due to the navigational menu being implemented as a dropdown-menu, which in effect kept the deliveries hidden. See Figure 5.2 for how the menu looks unopened and opened. In addition, there were no way of figuring out how many uncorrected deliveries without actively seeking out this information, this meant that a user would have to be active in the search for this kind of information.

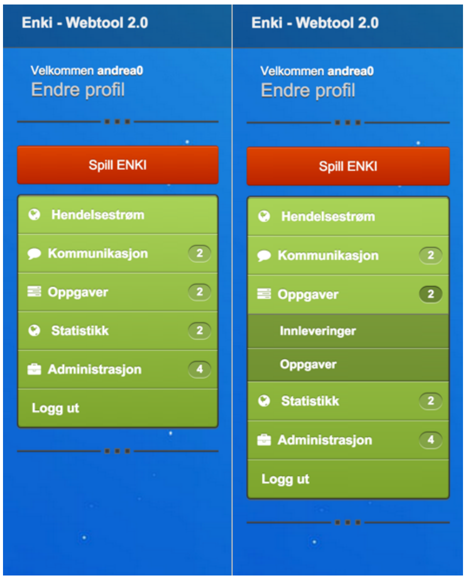


Figure 5.2: ERA: dropdown menu in both states

Utility

The analysis indicated that the design had low utility, as the design did not cater to the users main needs or wants. The design seemed to disregard one of the more important needs of the teacher: to keep an overview. I will now provide an example of this.

As students were playing the game, it was not possible for a teacher to get an overview of what has been going on in the chat, without keeping that window open. A usage scenario may make it clear why this is important:

> There are twenty-five students sitting at their computer playing Enki in the classroom. Students are chatting, solving assignments and raising their hands to ask for help. The teacher is keeping an eye on the chat, as some students in the class has had a tendency to bully.
>
> One of the students raises their hand, and asks the teacher to correct a delivery. The teacher visits the deliveries page in ERA,

and corrects the student’s delivery.

The teacher navigates back to the chat, and the chat is empty; there is no history of what messages that has been sent, and the teacher is only able to see what students are saying from that moment.

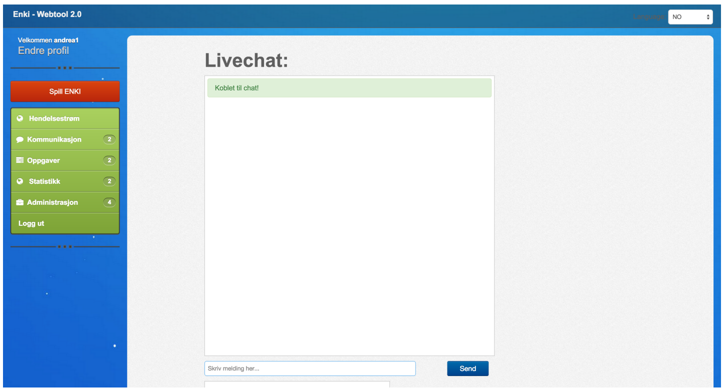


Figure 5.3: ERA: opening the chat

The scenario illustrates how the design conflicts with one of the needs of the teacher; getting an overview of what is going in-game.

To summarise, there were a number of usability-issues tied to current design. These would be taken into account throughout the design-process which would be leading up to the redesign of ERA.

5.2.2 Establishing Requirements

Establishing requirements can be seen as making a living version of an understanding of the user’s needs, situation, context and goals. According to Preece, Rogers and Sharp (2007), there are three types of requirements which are to be considered to inform a design:

- Functional requirements
- Data requirements
- Environmental requirements

Functional Requirements

A functional requirement is an operation or action that the system must support. (Cooper, Reimann and Cronin 2007, p.127) These provide the basic actions which are able to be performed in the given system. These may vary in specificity. I have chosen to express the most central functional requirements as a use-case diagram (Preece, Rogers and Sharp 2007, p.512). This use-case diagram is seen in Figure 5.4, keep in mind that the diagram expresses the functionality in ERA as it is today.

The functional requirements which could not be expressed within the diagram are listed here:

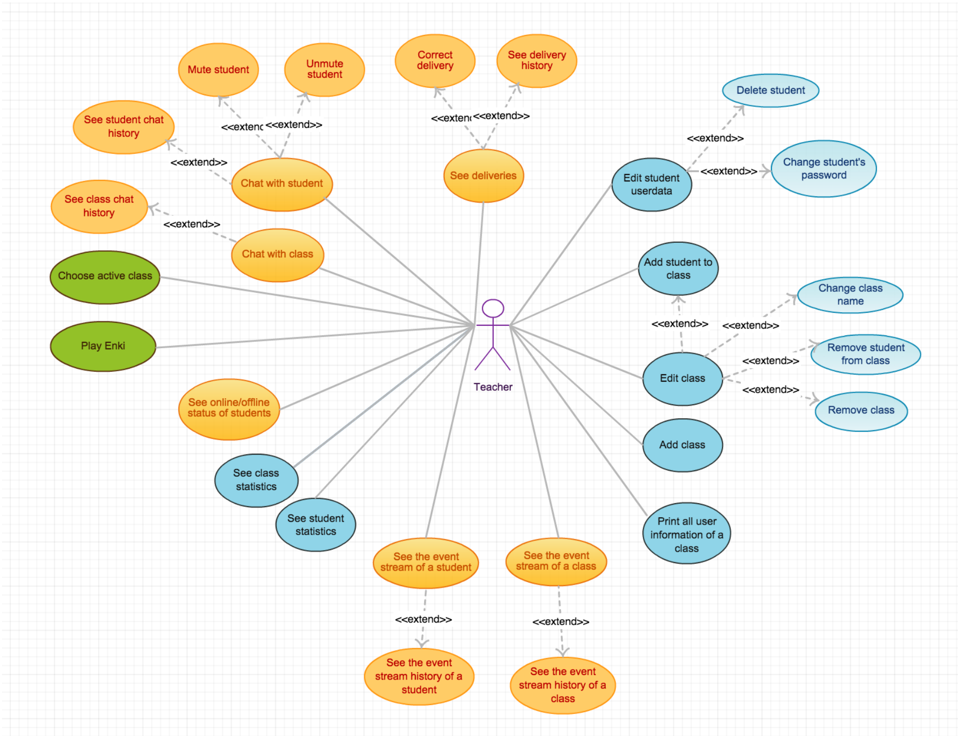


Figure 5.4: Use case diagram for ERA

- ERA must support authentication of users
- ERA must support multiple languages
  - Norwegian
  - Swedish
- ERA must show the number of uncorrected deliveries for the selected class
- ERA must show chat messages as they are sent
- ERA must show statistics of an user based on subject
- ERA must show statistics of an user based on a subject's category
- ERA must show statistics of a class based on subject
- ERA must show statistics of a class based on a subject's category
- ERA must have an user-guide of Enki and ERA

Data Requirements

Data requirements helps to capture the type of data an application is to support. (ibid.)

In ERA's case, the application would be used in the classroom. This means that a high number of real-time data would have to be supported. Granting the teacher the possibility to keep an overview of the real-time actions of what their students are doing in-game.

Environmental Requirements

The environmental requirements are based on what conditions the interactive product is to be used in. (Preece, Rogers and Sharp 2007) In ERA's case the environmental context is the classroom. Preece, Rogers and Sharp (ibid.) further defines four aspects of environmental requirements which must be taken into account. These will now be presented.

Physically the classroom holds few challenges; socially, it is more complicated. A teacher is expected to help one's students, which leaves little time to use ERA while they are playing. This signifies the importance of highlighting important events in ERA, making it easier for a teacher to perform the most necessary actions.

Organisationally ERA calls for the teacher to be able to share responsibilities, allowing other teachers or substitutes access to their class. There would be little-to-no time for training or manuals in how to use the application, which signified the need for an instructional or easy-to-use application.

Technically ERA would have to be able to run on any modern browser, as there would be no control over what kind of hardware or operating system ERA would be accessed from.

5.3 Phase 2: Develop Alternative Designs

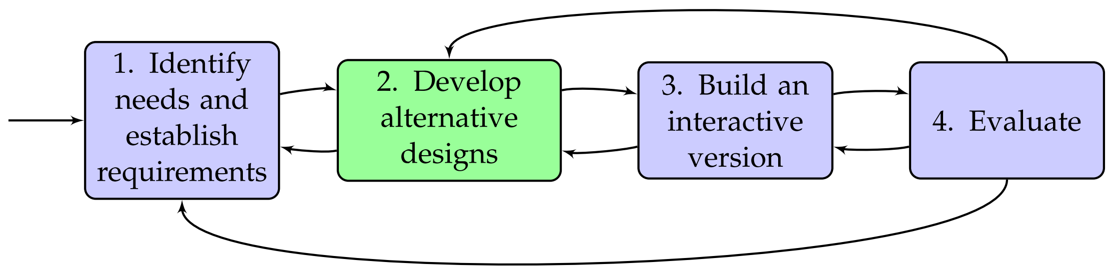


Figure 5.5: The IxD process: step 2 - develop alternative designs

When moving from requirements to the first design, creating a concept which frames the design is a fundamental part of the process. This is where a conceptual model comes into play. A conceptual model is a simplified explanation of how a system actually works. (Norman 2002) It is an abstraction of the system, which outlines the possibilities of what one can do with a product and the concepts needed to understand the possible interactions. (Preece, Rogers and Sharp 2007, p.50)

According to Johnson and Henderson (2002), a conceptual model describes and specifies:

- Metaphors and analogies
- Concepts
- Relationships
- Mappings

A well-defined conceptual model is the idealised view of how a system works from the designer's perspective. Johnson and Henderson (ibid.) state that it allows users to:

> "[...] predict [a system's] behavior and generalize what they learn to new situations. If the designers take the trouble to design and refine a conceptual model for the system before they design a user interface for it, users will be able to more quickly 'figure it out.'"(ibid.)

To improve ERA's design, a conceptual model for the design had to be made. When creating a direct mapping between the system's operation and the task-domain, it can significantly better the chances that it would be understood, reproduced and adopted by users. (Norman (1986) Johnson and Henderson (ibid., as cited by)).

5.3.1 ERA's Conceptual Model

ERA's conceptual model was built on concepts, relationships, metaphors and mappings from the classroom and school.

The classroom is the main metaphor, and the idea is that a teacher should be able to keep an overview of the current activity going on. The in-game activity is represented in this digital classroom. Enabling a teacher to select which class he is working with, showing only information from the students in that class.

To provide an easily understandable digital classroom, the main interface-metaphor was to be the familiar Facebook design. Classes and students was to have profiles to show specific information about them, and the stream of events and chat would be easily understandable. The intention was to make it easier for teachers to understand how to use ERA through applying the same metaphors of a well-established design.

The conceptual model consists of the following concepts:

- Classes
- Deliveries
- Class-lists
- Teachers
- Students
- Online/offline-status
- Student-lists
- Events
- Deliveries
- Chat
- Muting

- Administration
- Statistics.

A class contains a collection of students and teachers, statistics, and is connected to a unique chat. A teacher can be connected to multiple classes, and is in control of the digital classroom. A student is connected to one class, and has a relationship to one's deliveries, statistics, chat history, online or offline status, and collection of events. A mailbox contains uncorrected and corrected deliveries.

5.3.2 Prototyping ERA

To get from the conceptual model to a concrete design, a number of our meetings were spent sketching out ideas in collaboration. The ideas would be developed further as low-fidelity prototypes to explain the different concepts. After discussing different concepts with the team, I decided on a direction for the design.

The first prototype that was to provide the foundation for ERA's design was based on the described interface metaphor. This prototype focused on making it easy for a teacher to get an overview of the digital classroom, see Figure 5.6 for the low-fidelity prototype.

In this prototype, the class chat, and where the students are in-game and an online or offline status is readily available through the chat on the bottom right-hand side. Real-time updates of their students in-game progress pops up on the top right-hand side. The top represents a global navigation menu; planning, overview, follow-up, and administration, the left-hand side is dedicated to a local navigation menu; unread messages, deliveries, and live statistics. The top-left side highlights the number of uncorrected deliveries.

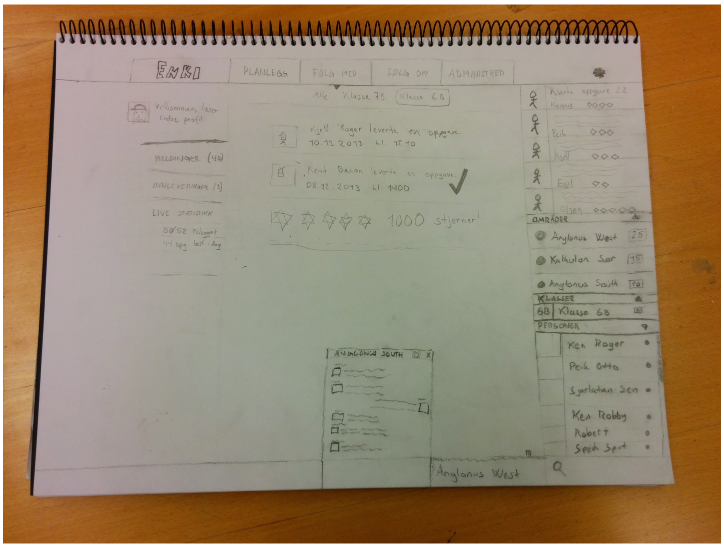


Figure 5.6: The concept for ERA's low-fidelity prototype

The intention was to create an easy way of transferring the game-data and social aspects from Enki to well-known real-time concepts, and to make it easier for teachers to understand how to use ERA through applying the same concepts of a well-established design.

The prototype was evaluated with the project team, and its end result was presented to an outside teacher — familiar with the beta-version. The new concept was explained thoroughly to establish a proof of concept. The test was in itself low on validity, but the choice was made to go forth with the implementation of an interactive version; the deadline was near, and there was a lot of work to be done.

5.4 Phase 3: Build an Interactive Version

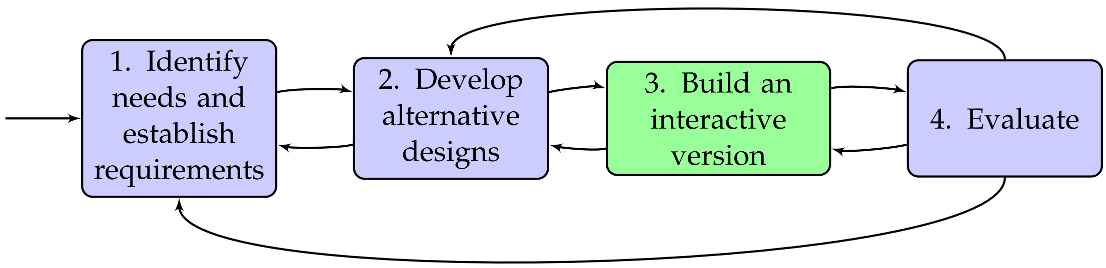


Figure 5.7: The IxD process: step 3 - build an interactive version

Interactive versions of a prototype can come in many forms: from paper-board prototypes to working prototypes. I will now introduce what Zimmerman, Forlizzi and Evenson (2007) refer to as the *how* knowledge; the technological choices, and how they affect the design.

The first interactive version was an evolutionary prototype, and because of time constraints, optimising for both development of functionality and design in unison was imperative. This approach made it possible for ERA's prototype to evolve into the final product (Preece, Rogers and Sharp 2007, p.538).

To make evolutionary prototyping a viable option, a layered software architecture was chosen to decrease the dependencies between the interface components and the application logic. The underlying choices of how to develop ERA was made to make it easier to support an iterative design-process, as it is critical to be able to make changes based on feedback.

I will now introduce the *how* knowledge and choices made to support the development of ERA.

5.4.1 Version-Control Management

To support the development of the working prototype, the version control system *Git* was used:

> "Git is a free and open source distributed version control system designed to handle everything from small to very large

projects with speed and efficiency."[3]

Git enables distributed collaboration on projects by providing a system which keeps track on changes in a codebase. An individual change is represented by a commit which contains a description of the developer's choice.

5.4.2 Development Environment

In software development, the term *development environment*[4] constitutes a set of tools, processes, frameworks and dependencies which are used by the developer to create an application. To make it easier to develop ERA, a package containing an easily reproducible development environment was made. The package was built with *npm*, the package manager for the *Node.js* platform.

This meant that after downloading ERA's code-base through git, the package containing the necessary set of tools, processes, routines, and frameworks could be installed through a single command. Following the installation of the package, a set of runnable routines were made available. These included a set of routines to support the development: running the application in the browser, automatically updating the application when code-changes occurred, automated testing, and packaging the application for production.

5.4.3 Technological Choices

ERA was built on technology which made it available for use in any modern browser, which was due to the lack of control over what kind of device and platform a user could be using to access it. This application would primarily be used in the classroom from school computers. A safe technological choice for ERA would then be to follow the web-standards. Web-standards ensure that the program may run in any modern browser. This includes the programming languages which are supported in the web-standards: HyperText Markup Language 5 (HTML5), Cascading Style Sheets 3 (CSS3) and JavaScript (JS).

The Software Architecture: Single-Page Application

When making the technological choices for development, a significant decision is the software architecture. Software architecture is defined as:

> "The highest-level breakdown of a system into its parts; the decisions that are hard to change; there are multiple architectures in a system; what is architecturally significant can

[3] About Git, Fetched from: https://git-scm.com/

[4] Definition of Development Environment, http://www.techopedia.com/definition/16376/development-environment

change over a system's lifetime; and, in the end, architecture boils down to whatever the important stuff is." [5]

ERA's software architecture was based on a software architecture pattern called *Single-Page Application* (SPA). An SPA enables a fluid user-experience, as the entire application is loaded at the first page-load in a browser. The fluid user-experience is generated through the way an SPA behaves in the browser. It dynamically requests new data from a data-service, and shows this information without the browser needing to reload.

This type of architecture divides the server and client into two distinct roles. At the first request, the client accesses a website which hosts the SPA. After this is done, the client is running the SPA, able to use any defined server within the SPA as a data-service. An SPA architecture is illustrated in Figure 5.8[6].

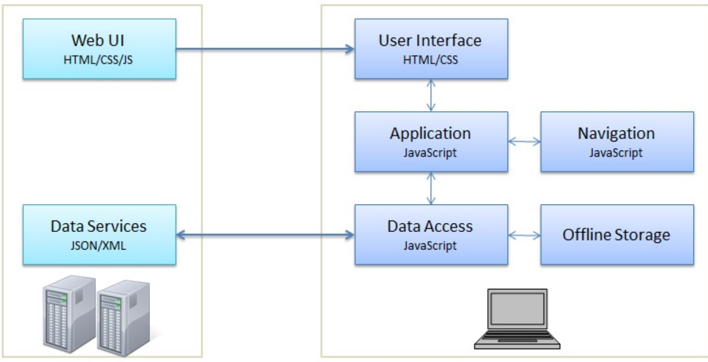


Figure 5.8: Illustration of an SPA

As a design choice, developing ERA as an SPA had many advantages. Firstly, an SPA made ERA into a dynamic application. It requests data as users need it, and automatically receives updates through a real-time connection, reducing server load, and enabling the processing of data to take place on the client. This made it possible to present updates for the user as they happened. Secondly, an SPA enabled a single data-structure to be modelled for the application, where static and dynamic data could be represented together in unison. Thirdly, the implementation could be done independently of a data-service; I will explain what this means later in this chapter.

An SPA Framework: AngularJS

To create ERA, an SPA framework named AngularJS was chosen to support the development. This framework can be related to the Figure 5.8, as it is made to solve challenges faced when developing SPAs. One particular challenge addressed by AngularJS is the binding between the

[5]Software Architecture, as defined in Chapter 1: What is Software Architecture? On Microsoft Developer Network: https://msdn.microsoft.com/en-us/library/ee658098.aspx

[6]Single-Page Application Architecture: https://ssnenov.wordpress.com/2013/03/24/single-page-up-with-kendo-ui/

static HTML and CSS-layer, and the JavaScript-layer, enabling dynamic updates between what is called the presentation layer (what the client sees in the browser), and the underlying logical layer (the application which is running in the browser). This concept is further explained on the AngularJS website:

> "HTML is great for declaring static documents, but it falters when we try to use it for declaring dynamic views in web-applications. AngularJS lets you extend HTML vocabulary for your application. The resulting environment is extraordinarily expressive, readable, and quick to develop." [7]

This reduced the complexity of developing ERA, as the framework helps to separate the presentation layer and the logical layer; enabling an easier way of separating between how it looks and behaves, and how the application functions. This is an important aspect when developing an evolutionary prototype, as the design specifications are subject to change.

Developing ERA Without Implementing a Data-Service

During the development of an SPA, a significant drawback is the need to continuously develop the data-service in parallel; the data-service is what would serve the required data which ERA is dependent on. Figure 5.8 illustrates the role of the data-service in terms of an SPA. AngularJS has an implementation to bypass this limitation when doing automated end-to-end testing of the application; where end-to-end means that the application is run in a browser, and an automated script goes through a set of tests which should produce a set of predefined results. However, using this implementation without the automated tests was possible. Taking advantage of the in-built support for an abstract HTTP-implementation — replacing the data-service with a fake one.

This was used to develop ERA with a fake data-service; specifying the exact result of what the data-service should return with what is called a *mock-object* in software engineering. A mock object is defined as a simulated object that mimics the behaviour of a real object in a controlled way. [8]

Using a fake data-service returning mock-objects made it easy to specify what, and test the different situations which ERA had to support. An example of this can be illustrated through a few questions: How should the design support a teacher which has no registered class? How should the design support a teacher with only a single class? How should the design support a teacher with multiple classes?

As the results of the fake data-service was easily changed, this way of developing produced several advantages. Firstly, ERA's implementation with a fake-service was a living specification of the real data-service; helping the developers to know exactly how the data-service should work.

[7] Why Angularjs according to AngularJS: https://angularjs.org/

[8] Mock Objects Definition, Fetched from: http://searchsoftwarequality.techtarget.com/definition/mock-object

Secondly, ERA can be developed without being dependent on a data-service; which made it easier to rapidly develop and specify the required data and functionality. Thirdly, switching between a fake data-service and a real data-service was easily performed through removing a single line of code. Fourthly, this type of work enabled a quick way of testing how the design performs in terms of the different situations it was meant to support.

5.4.4 Project Management

Because of the size of the ERA project, a project management tool was used to benefit the development and design-process. This enabled a distribution of the workload, especially when dealing with the technical implementations and server dependencies of ERA.

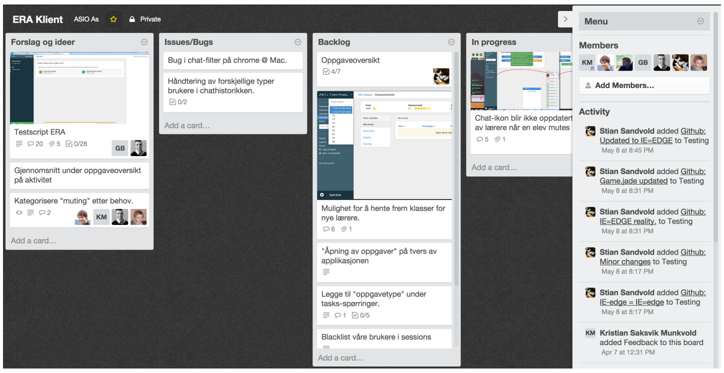


Figure 5.9: ERA in the project management tool *Trello*

An online-service named *Trello* was used for the project management, which enabled the use of: lists; where each list would represent a step in the development-process (e.g. Backlog, In Progress, Test, Ready), and cards; which are dedicated to a specific task (e.g. Redesign chat-message structure, or Implement Functionality for deliveries). Together with social functionality, this gave a structure to the project and enabled the team to collaborate and easily give feedback.

5.4.5 The First Production-Ready Evolutionary Prototype

The implementation began in May 2014, and the evolutionary prototyping and design-process took three months before the first production-ready version of ERA was ready. During this time, the team had been collaborating to develop ERA, the real-time functionality, and the data-service in unison. In August 2014, the first version was released. Keep in mind that the version that is presented here has gone through numerous iterations along with the evaluation-step that will be presented in the next section.

Design Overview

Figure 5.10 is a screenshot of the design as it was implemented in August 2014. This diverges from the design-sketch illustrated in Figure 5.6 in a number of ways. This was due to the time constraints, there was simply not enough time and resources available to implement everything. Priorities had to be made; where the key usability goals of utility and effectiveness in the classroom-setting was deemed the most important. I will now explain the layout of this design and how it works.

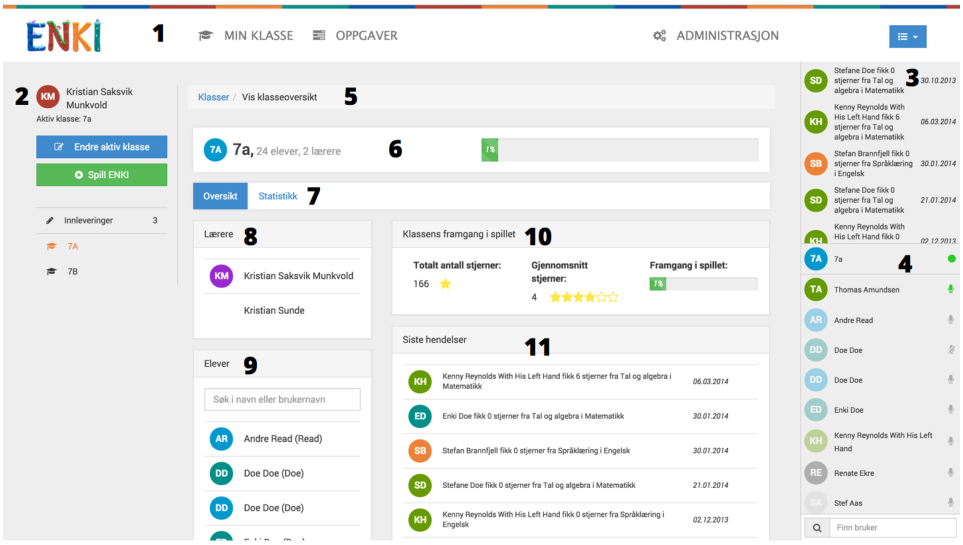


Figure 5.10: ERA, first version: design overview

The numbers in Figure 5.10 provides an overview of the different parts of the layout, where the navigation terminology is based on Morville and Rosenfeld (2003):

1. Global menu
   - My class (Link to the active class overview)
   - Assignments (Link to an overview of assignments)
   - Dropdown menu
     - Change language (Supporting Norwegian and Swedish)
     - Log out
2. A local menu
   - Change active class (Link to change class)
   - Play Enki (Link to enter the game)
   - Deliveries with no. of uncorrected (Link to the delivery-inbox)
   - List of classes (Navigate through a teacher's classes without making them active)
3. Event Stream (Showing the latest events for the selected class. Updating automatically as new events occur in-game)
4. Chat and Student Overview

    - Class chat and online status (Contextual link to open chat room and view history)
    - List of students and online status (Contextual link to open chat room and view history)

5. Breadcrumb (Showing the user what page it is on)
6. Class Overview (Showing the Active Class, number of students and teachers, and in-game progress)
7. Contextual Links (Overview or Statistics)
8. Teachers (Showing a list over the teachers)
9. Students (Showing a list over the students. Clicking on a student provides contextual links to each student profile)
10. In-Game Class Progress (Showing how many stars the class has gathered in-game, their average score, and their total in-game progress)
11. Event stream (Showing the latest events of the students in class)

As a user was to navigate between the different options and use-cases in the design, the right hand side of the design would be kept in view. It was only the centre, and the local menu which would change content. This was to provide utility and effectiveness, as a teacher could keep watch on what was going on in-game while performing use-cases.

Choosing Active Class

As the user logged in, if the user had multiple classes, the first step for the user was to choose which class he was to work with. This is illustrated through Figure 5.11.

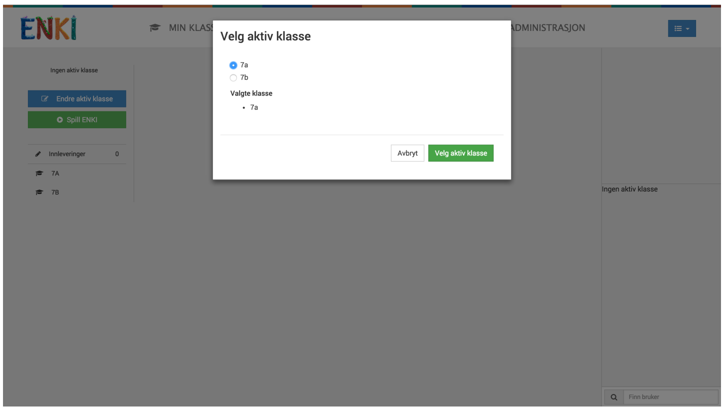


Figure 5.11: ERA, first version: choose active class

The Deliveries System Design

The number of uncorrected deliveries and link to the deliveries part was represented in the local menu as introduced in Figure 5.10. As the user clicked this link, the delivery system opens. The design was to ensure that a teacher could keep an overview of in-game activities and chat. See Figure 5.12 for an illustration of the deliveries inbox.

The design of the delivery system built on the interface metaphor of a mailbox-system, and had the uncorrected deliveries as the primary focus, and teachers were able to switch between these and all deliveries through a toggle-button. A search bar on the top was provided to enable the teacher to filter the deliveries based on subject, category or student.

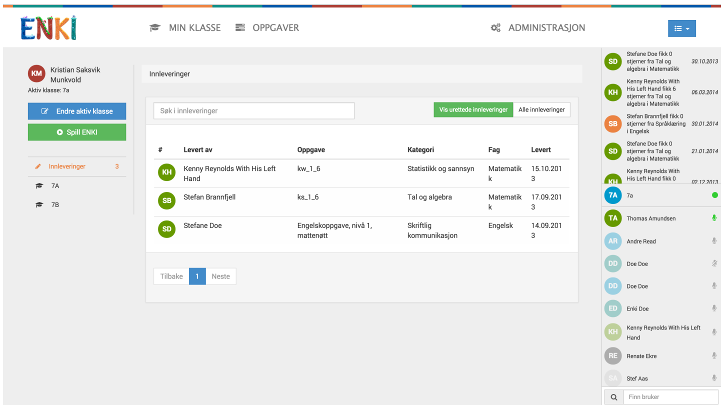


Figure 5.12: ERA, first version: delivery inbox

As a user clicked a delivery, this delivery was brought into view; here presented with the task, solution, delivery time, the students answer, and the opportunity to give feedback through a comment and a set of stars. See Figure 5.15

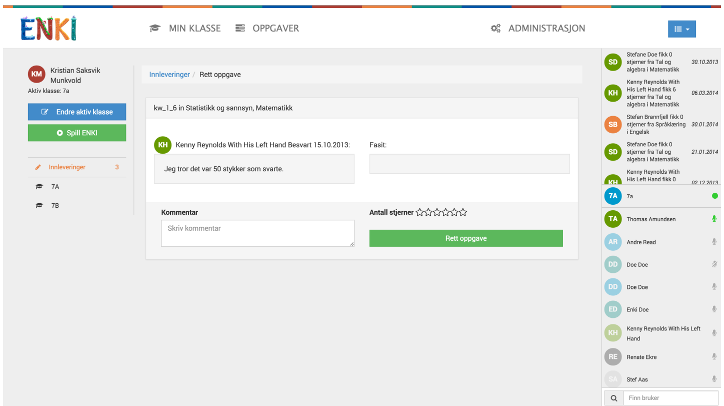
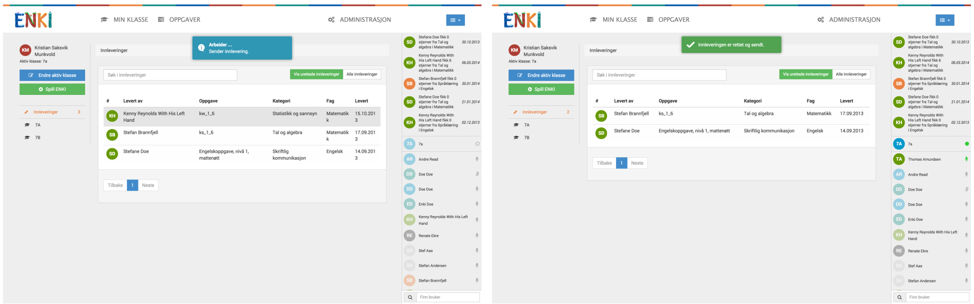


Figure 5.13: ERA, first version: correcting a delivery

Feedback Design

As correcting deliveries was one of the important task in the system, there had to be an efficient way of doing this. Therefore, the design principle called feedback was put into play. As a user corrected a delivery, he was sent back to the delivery-inbox. The corrected delivery was faded into grey and the status of it being sent was shown through a notification. This was to ensure efficiency and safety while performing the task. Illustrated through Figure 5.14.

This type of feedback design was used throughout the different tasks in ERA to ensure that feedback was given to the user in a consistent manner



(a) After correcting delivery, a user is sent to inbox and given feedback

(b) Delivery is confirmed as sent to the student and removed from the inbox

Figure 5.14: ERA, first version: feedback design on important tasks

The Avatar System

To make a consistent way for users to identify a specific student, an avatar system based on initials and colour-coding was created. Whenever a user is represented in the interface, this avatar occurs along with the user's name. This was to allow an user to scan for information related to a specific student.

The avatar system ensured that students with the same initials are differentiated by colour: Kristian Munkvold becomes KM with the colour green, and Kjell Monke becomes KM with the colour blue.

The Chat System Design

This design of ERA made the chat-aspect a central part of the design, it was designed to represent the status of the digital classroom, and give the teacher an easy way of getting an overview. The bottom right was dedicated to showing status of the selected class.

The design consisted of the selected class, followed by each student sorted by online status and name. A search-field followed on the bottom, enabling the user to search by name. Each student could be muted by clicking the microphone-icon, and their muted status was portrayed through this icon which would change into a muted-microphone.

Whenever there was activity in the chat, this would pop up as an active window on the bottom. This was to give the teacher an immediate overview of what was going on in the chat. This is illustrated by 5.15.

An open chat window was to grant the teacher with an overview of chat activity. However, as there could be an high number of possible messages, this was restricted to thirty messages at a time. Therefore, an infinite scroll system was implemented. Infinite scroll enables the automatic loading of

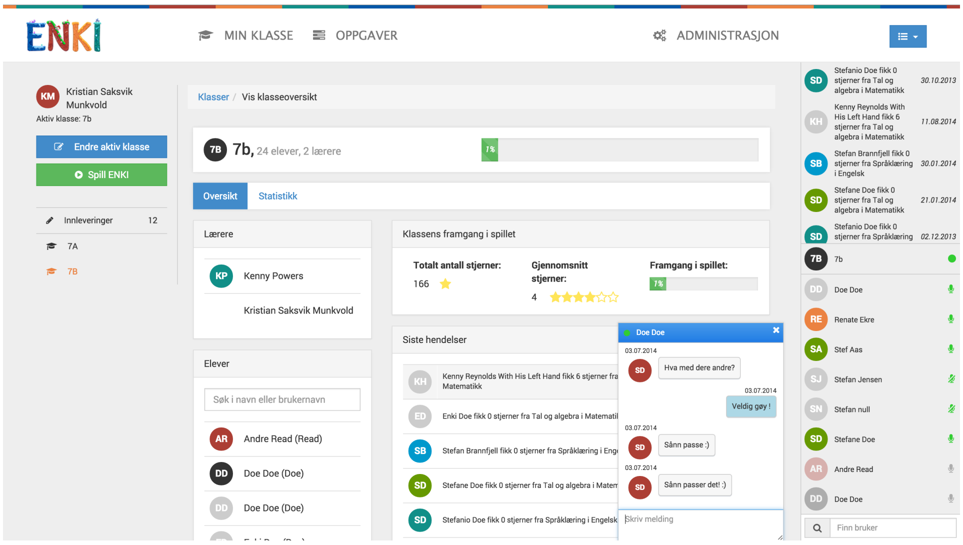


Figure 5.15: ERA, first version: student chat

more content, in this case, more chat messages. This was expressed through sending an automatic request to get more messages as the user reached the end of the chat window.

The Class Overview Design

The class overview was designed to provide an overview of teachers, students, events, and progress for a single class. The header showed the name of the class, number of students and teachers and progress. Below the header a contextual menu enabled the user to change between an overview of the class and statistics. The design has contextual links for accessing the profiles of the students, and an event stream showing the latest of in-game assignments from the students. This is illustrated in Figure 5.16.

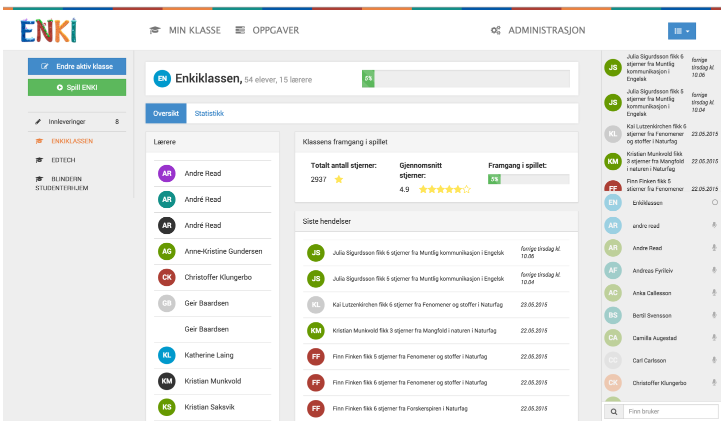


Figure 5.16: ERA, first version: class overview

The Profile Design

A user profile was consistent with the class overview design. The header showed the name and username of a student, and its total in-game progress. The contextual menu enabled an user to change between an overview and the statistics. This was followed on the left-hand side with an overview of the student's progress; total stars, average and in-game progress. The right-hand showed the last events tied to the student. This is illustrated in Figure 5.17.

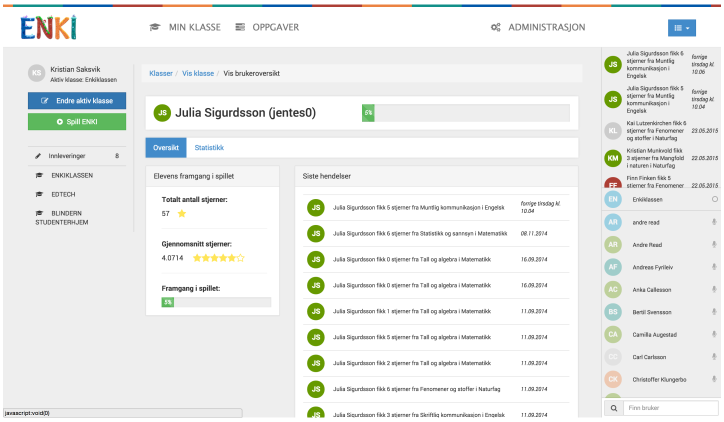
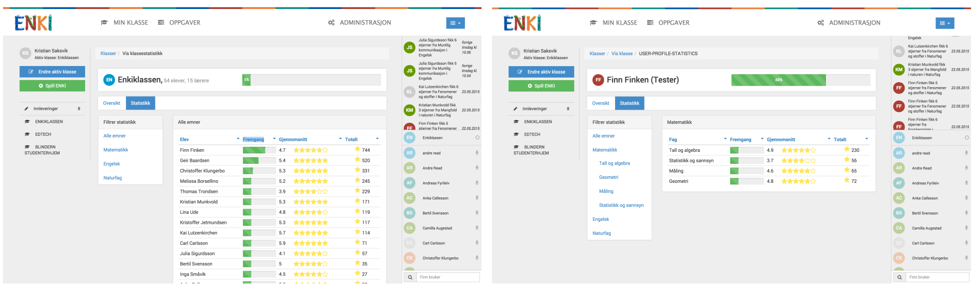


Figure 5.17: ERA, first version: profile design

The Statistics Design

The statistics of a class or user could be reached through the contextual menu when visiting the profiles. When visiting the statistics from a class perspective, all students were presented, and from a student perspective, detailed statistics regarding that student was presented. Here a teacher could get an overview of how the students were progressing through the game. The statistics were separated into four categories; the combined results, mathematics, nature science, and english, and further into subcategories for each subject; the progress, average score, and total stars were shown grouped by students. This design is illustrated in Figure 5.18.

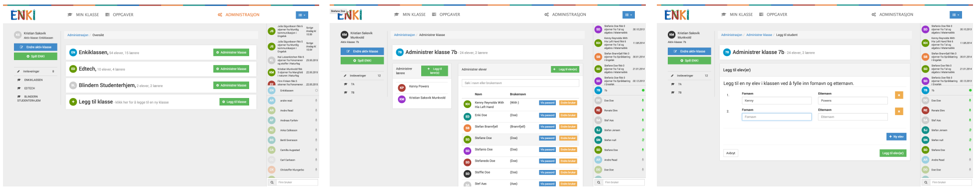


(a) Class statistics (b) Student statistics

Figure 5.18: ERA, first version: statistics design

The Administration Design

ERA needed a way of adding users and classes to empower the teacher. This was to provide a teacher with the possibility to get going on his own. However, Enki's onboarding process was done manually. Meaning that no user would be able to enter the application without a register class. Therefore, the design was made to make it possible for a teacher to add classes, and teachers and students into those classes, to get more users going with ERA and Enki. This is illustrated in Figure 5.19.



(a) Administration classes (b) Administration of class (c) Adding Users

Figure 5.19: ERA, first version: administration design

5.5 Phase 4: Evaluate

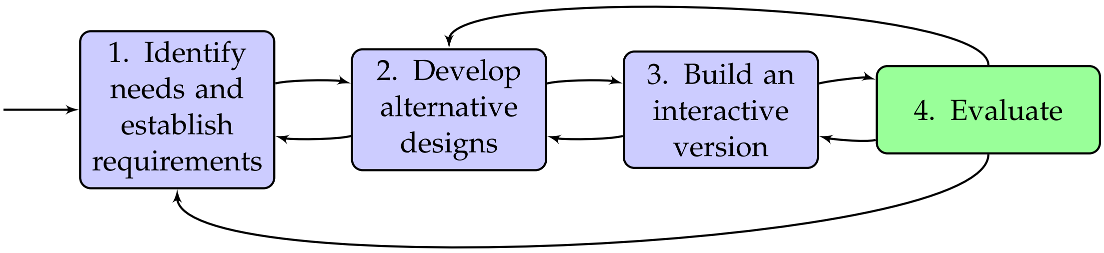
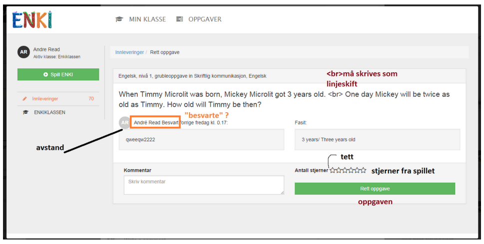


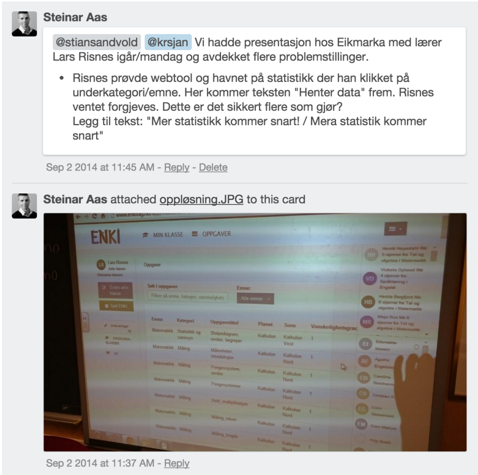
Figure 5.20: The IxD process: step 4 - evaluate

The evaluation of ERA was an ongoing process ever since the development started. To make this a routine-based process, different server environments were put into place. The first of these was a development server. A development server mimics the environment of a production server, and enables the testing of the application in a real environment. These differ in the following way: A user would be served the application through a production server, and our team would be able to serve the application for testing on a development server.

The newest evolutionary prototype was automatically updated on the development server whenever a new version was ready through git (the version control system); enabling the team to continuously evaluate the prototype. As each new design or feature was ready, it was announced on Trello. Each version of the design was thoroughly evaluated, and feedback given was taken into account in later versions. An example of such feedback is seen in Figure 5.21a.



(a) Example feedback in ERA



(b) Example of feedback in ERA

Figure 5.21: Example of continuous ERA evaluations

When a new design or feature was quality-assured by the team and ready for production, it was made available for the users. As the team worked closely with the users of the product, this resulted in a continuous loop of feedback through e-mails, phone-calls and field visits. This feedback loop enabled a continuous evaluation of the design. It has provided an iterative process for feedback, and made sure that bugs and design-flaws have been identified early in the process. An example of such feedback is shown in Figure 5.21b

This iterative feedback-loop has led to to a continuously evolving design in ERA, the result of this iterative design-process will now be presented.

5.6 The Result of the Design Process

Since the design and development-process began in May 2014, a number of different versions have been in production. During this period, a total of 1075 commits has been made to the git-repository across three different branches. These make up the revisions and new implementations which contribute to the evolutionary prototype; leading up to the final product ERA. The changes made are based on user feedback and analysis of use since the launch in August 2014. I will now present the design of the current version.

5.6.1 Design Issues in the First Version

The version described in Chapter 5.4.5 was thoroughly tested on users as it was set into production at the deadline in August. An analysis of the feedback from users indicated that the version had usability and UX issues. I will now explain how these issues were represented in the design.

The design was low on constraints; it did not restrict the number of interactions a user was able to do at a single screen (Preece, Rogers and Sharp 2007, p.31). The design had a high number of possible actions at every interaction. An example of this was ERA's separation of the global menu, local menu, contextual menu, and contextual links. This is illustrated through Figure 5.22.

In addition, the analysis indicated that users were unable to separate between setting a class as active, and choosing a class to view from the local menu. This directly interfered with the conceptual model by allowing the user to open a class without setting it as active. See the local menu in Figure 5.22 for an illustration.

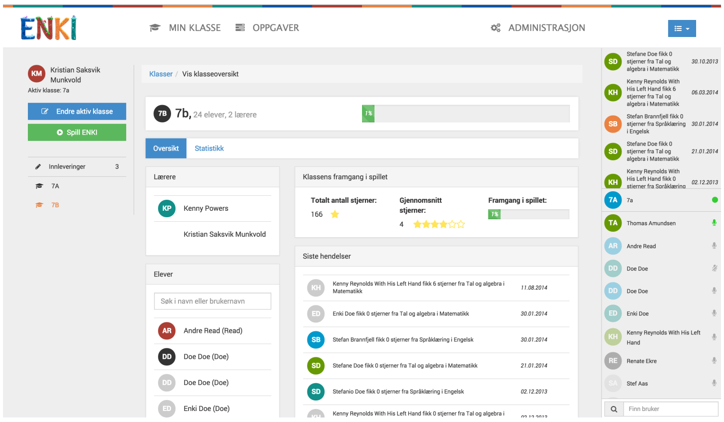


Figure 5.22: Design issues in ERA: selected class is not active.

5.6.2 Redesigning ERA

Adding constraints to a design is the process of restricting the users choices in an interface, in effect making it easier to know what to do next. As the analysis had indicated that the high number of possible actions in the user-interface was leading to problems, a number of steps had to be taken to prevent this. A complete redesign of the interface ensued. However, the main cause for this design-flaw can be traced back to the prioritisation which had taken place between the low-fidelity prototype in Figure 5.6 and the implementation, where effectiveness and utility in the classroom setting was set as the priority. I had simply run out of time to implement the functionality which would have supported the initial design, in effect making the design ineffective and inconsistent with the original sketches.

It follows that from not implementing a clear separation between planning, overview, follow-up, and administration, the separation between a global and local menu were more confusing than helping.

Constraining the Number of Options

ERA's redesign had a clear focus: constraining the number of options a user could choose from at any given time and increasing the usability of the design. This was done through a full redesign of the interface, as illustrated in Figure 5.23.

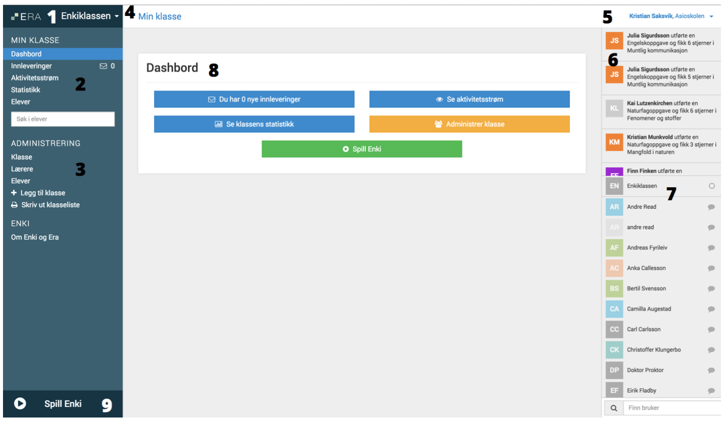


Figure 5.23: ERA redesigned: overview

1. Global menu: Change Active Class (Name of active class is shown. By clicking all classes related to the user is shown in a dropdown menu.)
2. Global menu: My Class (Dynamic: Changes based on user context)
   (a) Dashboard (Shows important functionality tied to a class)
   (b) Deliveries with no. of uncorrected (Link to the delivery-inbox)
   (c) Event stream (Shows events for the active class)
   (d) Statistics (Shows statistics for the active class)
   (e) Students (Shows list of students in class)
   (f) Search field (Search field for finding a specific student through typing and autocompletion)
3. Global menu: Administration (Dynamic: changes based on user context)
   (a) Class (Shows class overview for administration)
   (b) Teachers (Shows teacher overview of the active class)
   (c) Students (Shows student overview of the active class)
   (d) Add class (Shows an interface for adding a new class)
   (e) Print class-list (Shows a printable list of the class)
4. Global menu: Enki (Static)
   (a) About Enki and ERA (Shows an explanation of how ERA and Enki works)
5. Breadcrumbs (Dynamic: Showing the user the title of what page he is on)
6. User info and dropdown indicator (Clicking enables the user to change language or log out)

7. Event Stream (Showing latest events for the active class)
8. Chat (Showing active class and students)
9. Dashboard (Gives an overview of important functionality)
10. Play Enki (Clicking starts the game)

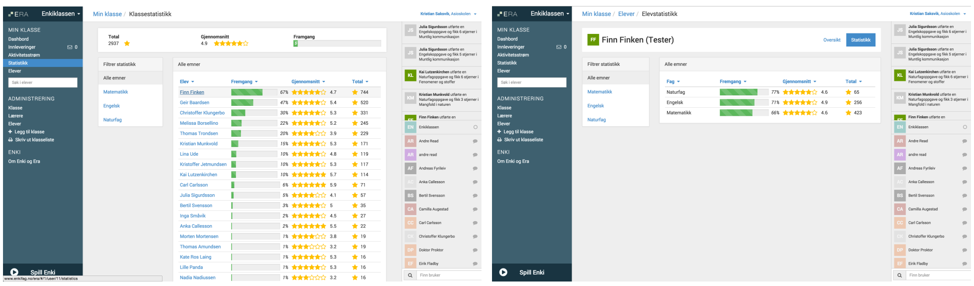
The redesign was to create a consistent UX by enforcing the ideas expressed in the underlying conceptual model, this meant constraining the number of options, which in turn meant that only a single class could be viewable at a time. In addition, important functionality was made highly visible through the contextual global menu, which is only visible after activating a class.

5.6.3 Redesigning User Interaction Flow

User feedback indicated that ERA was ineffective in allowing a user to navigate back and forth from required information. An example of this was navigating from class statistics to a specific student's statistics. There was simply no effective way of doing this.

To increase ERA's effectiveness, two other design principles of IxD had to be put into play: affordance and visibility. Affordance refers to how an attribute of an object allows users to know how to use it, and visibility refers to how visible the functionality within a system is. (Preece, Rogers and Sharp 2007, p.33)

The redesign took these principles into account, and tried to optimise for an easy flow between use-cases; putting them in relation to each other by making the conceptual model clearer. Affordance was put into play by making it apparent what a user could interact with, and visibility was enabled by making relevant functionality apparent. Examples of how this expressed in the interface is shown in Figure 5.24, 5.25 .



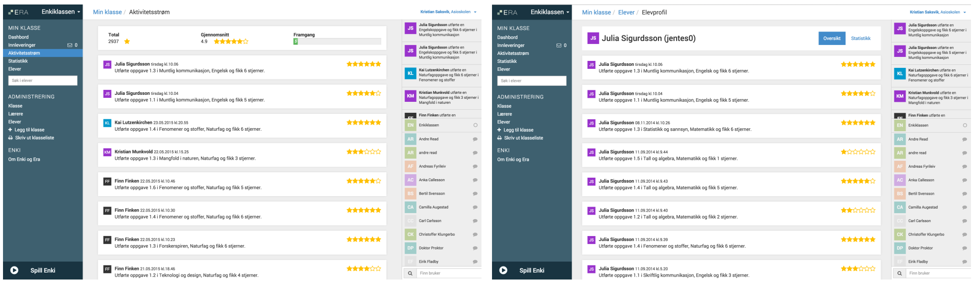
(a) Class statistics (b) User statistics

Figure 5.24: ERA: redesigning user interaction flow for statistics

5.6.4 Designing for Users With a Varying Amount of Classes

There were three possible entry points when a user logged on to use ERA:

1. No Registered Class
2. A Single Class



(a) Class events (b) User events

Figure 5.25: ERA: redesigning user interaction flow for event stream

3. Multiple Classes

These entry points had to be handled correctly. A user with multiple classes would be greeted with the possibility to select which class to work with. See 5.26 for an illustration. When a user with a single class visited, the class would automatically be loaded. When a user with no registered class visited, an onboarding process would be set into motion.

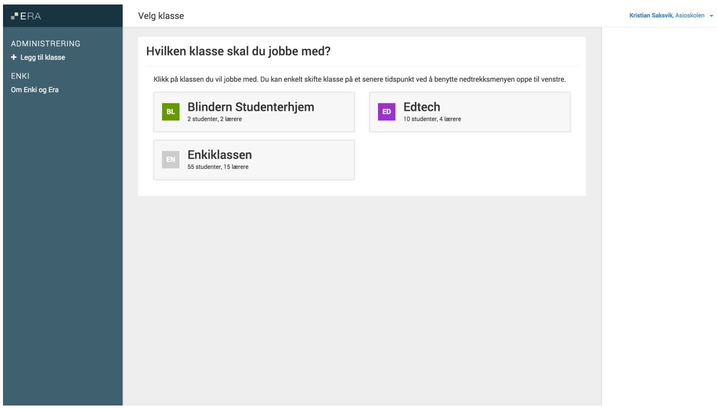


Figure 5.26: ERA: multiple classes

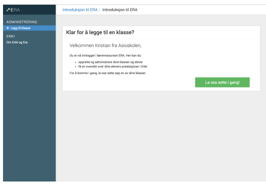
5.6.5 Creating User Onboarding

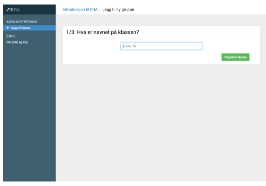
Parallel with the redesign, the launch in August called for new requirements; a high number of registrations from teachers created a need for getting a user going with Enki and ERA without instruction or any help from the team at Enki. There were simply to many registrations for the sales team to manually register the classes and students of the high amount of users. Therefore, the functionality of user onboarding was added; the process of increasing the chance for a new user to become successful when trying out a product[9].

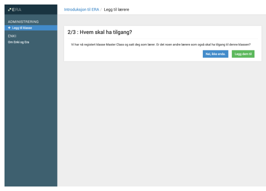
A design for first time users was put into place. Creating a way for first time users to register a class, and the first students and teachers for

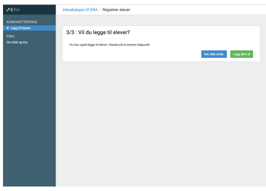
[9]User Onboarding Definition from: https://www.useronboard.com/

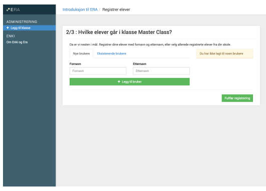
this class. As this was finished, they were introduced to the possible functionality of ERA through the dashboard. This design is illustrated in 5.27.


(a) Welcome screen


(b) Register class


(c) Add teachers?


(d) Add students?


(e) Adding students

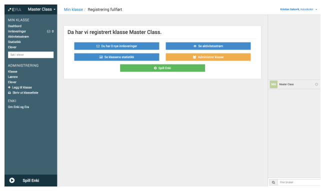

(f) Finished registration

Figure 5.27: ERA: onboarding users

5.6.6 Designing a Help Resource for New Users

Along with user onboarding, a need for a resource for new users indicated that they were unable to understand exactly how they could use Enki and ERA. To grant an understanding of these possibilities, a help-page was created. This was represented in the global menu, and readily available before starting the registration process. The help-page explained how the game and ERA worked in a classroom-setting, and was designed to create an overview of the game content, and what type of functionality ERA provides. This is illustrated in Figure 5.28.

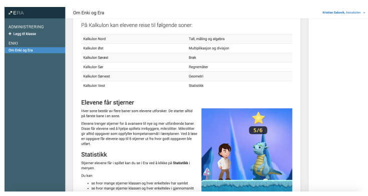


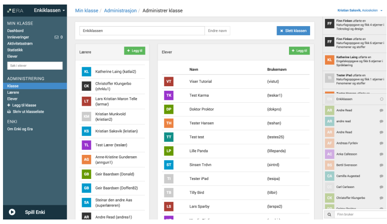
Figure 5.28: ERA: about Enki and ERA

5.6.7 Empowering Users Through Administration Privileges

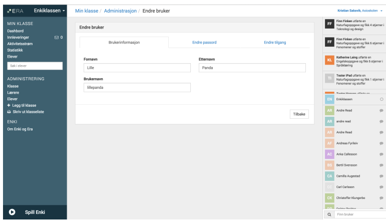
To empower the teacher to control the game in a classroom situation, a design for likely usage scenarios was implemented. This included:

1. Distribution: Adding a print function of the user-information of all students and teachers of a class
2. Updates: Enabling a way of showing, changing passwords and user-information for students
3. Removals: Adding a way for a teacher to remove users and classes
4. Reuse: Adding existing teachers and users into a new or existing class

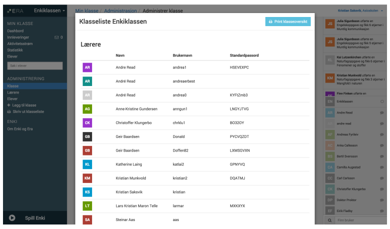
The design and implementation of these functionalities are illustrated in Figure 5.29.



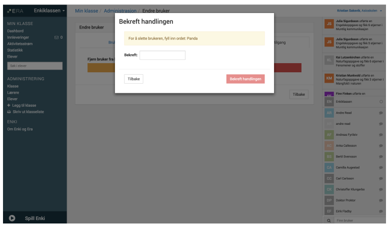
(a) Class overview



(b) Updating user information



(c) Class list for distribution



(d) Removing users

Figure 5.29: ERA: Administration of users

5.7 Launching the Redesign

The new version of ERA was launched on the 11th of October. User feedback indicated that the user onboarding in the new version allowed them to get going on their own; this was supported by the usage statistics. This is illustrated in Figure 5.30, indicating a significant rise in the user numbers after the new version of ERA was launched.

With a stable version of ERA's design, the scene was set to perform a summative evaluation to thoroughly investigate how Enki and ERA performed in a classroom setting.

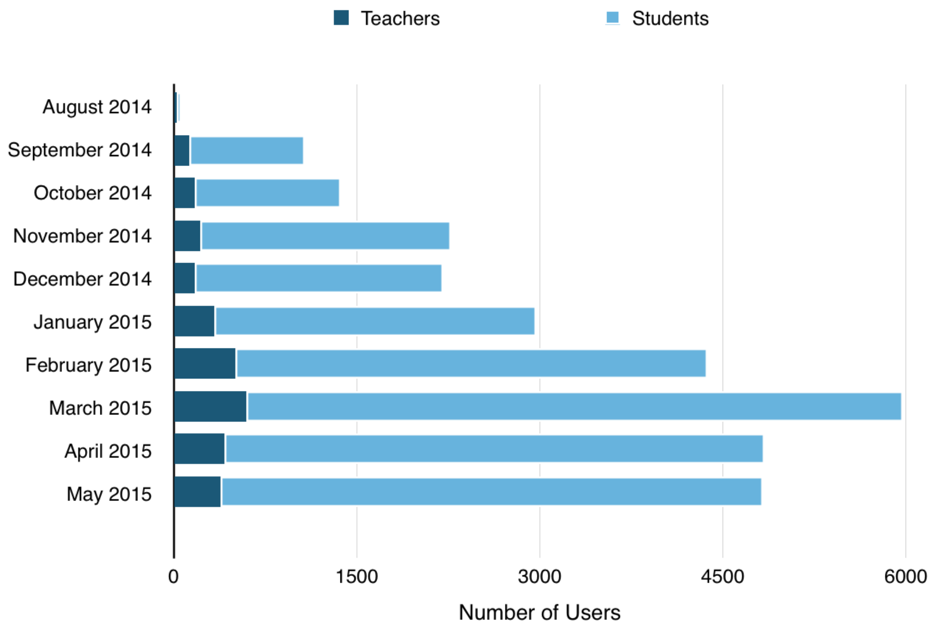


Figure 5.30: Teacher and student usage statistics, from August 2014, to May 2015.

Part III

The Case Study

Chapter 6

Research Approach

In this chapter I justify the research approach used for evaluating Enki and ERA. I will introduce the methodological approach chosen, the reasons why, and the research design.

Initially, I wanted to focus my investigation on the teachers' experience with ERA. However, a significant challenge emerged: the boundaries between the experience of Enki, ERA, and the classroom were close to non-existing for teachers. It was difficult to discuss these in separation, as a teachers' experience is related to the experience of how the game affects their students' learning. This made it close to impossible to research ERA's UX without considering how Enki and ERA affects both user groups in the classroom. Therefore, the research design is made for evaluating how both user groups use Enki and ERA in its natural context: the classroom.

6.1 Evaluation Through a Collective Case Study

A collective case study was performed to evaluate the use of the game and ERA. Case studies are seen as useful tools for evaluating interfaces and gathering new requirements (Lazar, Feng and Hochheiser 2010, p.144). In this case, it allowed for an in-depth investigation in multiple settings, enabling the exploration of Enki and ERA in its natural context across multiple classrooms. Thus making it possible to uncover similarities and differences between how Enki and ERA were used in a classroom setting.

According to Yin (2003) Baxter and Jack (as cited by 2008), there are four criteria for when to use a case study:

(a) "How" and "why" questions are the focus of the study.
(b) The behaviour of those involved in the study can not be manipulated.
(c) Contextual conditions are relevant to the phenomenon under study.
(d) The boundaries between phenomenon and the context is unclear.

Considering the case of Enki and ERA made it easy to see how using a case study methodology would benefit the evaluation:

(a) The focus of the study was to investigate how and why Enki and ERA support a teacher in a classroom-setting

(b) The behaviour of the participants could not be manipulated. The use of Enki and ERA can only be studied in its natural context.
(c) Enki and ERA is designed for the classroom, and how the design performs in this context is relevant for the study.
(d) The boundaries between the phenomena; Enki and ERA, and the context; the classroom, is not clear.

It was clear that a collective case study would benefit the evaluation of Enki and ERA, evaluating a design through this method explores a quite different perspective than what a lab-based usability study would uncover. Lazar, Feng and Hochheiser explain the differences:

> "By observing and closely examining these activities "in the wild", free from the pre-determined goals and narrowly-defined questions that often accompany usability studies and controlled experiments, researchers can develop detailed understanding of interaction techniques and coping strategies — understandings that might be hard (if not impossible) to develop through usability studies." (Lazar, Feng and Hochheiser 2010, p.148)

It follows that the choice of using a collective case study enabled an exploration of *how* Enki and ERA was used by different teachers in a classroom-setting, and *why* they used it in this manner; uncovering design issues which are based on the context and user needs. This would then illuminate the similarities and differences between the case, and enable replication of findings across cases. (Baxter and Jack 2008) Performing such an evaluation was to enable a validation of how well the designs of both Enki and ERA affected the classroom-setting for the involved user-groups.

6.2 Research Design

The research performed in this thesis is an evaluation done through a collective case study within the interpretive research paradigm. The methods used are interviews, observations, data from the game registry, and document analysis. I will now introduce the case study's design, and which measures that was taken to quality assure the study.

6.2.1 Research Questions

A research question is defined as a goal of a study (Lazar, Feng and Hochheiser 2010, p.162). For this particular project, there are two distinct goals: the first goal involved is descriptive; how is Enki and ERA's design experienced by teachers and students in the classroom, and how is the design supporting the teacher. The second goal is normative and establishes how Enki and ERA can be redesigned based on the findings from this research and relevant theory from the document analysis covered in Chapter 3. The research questions are:

1. How is Enki and ERA experienced by teachers and students in the classroom?
2. Why are teachers using Enki and ERA in their classroom?
3. How is Enki and ERA supporting the teacher?
4. How can Enki and ERA be redesigned to better support the teacher?

6.2.2 Selecting Cases

To select cases, a systematical investigation was performed in January 2015; A search for schools with a weekly activity pattern which indicated a regular and high usage pattern was performed through Enki's database. As a case study is time demanding, it was important to identify participants which had an interest in committing some resources into the research project, and finding the right participants was key (ibid., p.163). In addition, making sure that several appropriate participants were represented in the study would ensure high external validity. (ibid.).

A list of possible participants was generated through measuring their weekly use based on these criteria:

- Number of active users
- Assignments solved
- Geographical closeness to Oslo (Done manually)

Following the results on this list, twelve schools were qualified for the study.

6.2.3 Types of Participation

To ensure a wide range of participants, schools who indicated that they did not have time for the study was offered the alternative of participating with a teacher for an interview. This resulted in two different types of participation: class participation, and teacher-only participation.

Class Participation

Class participation enabled teachers to bring their class into the study, and to take part in the following activities:

- Depth interview with the class teacher
- Observation(s) of the class while using Enki
- Group interviews with students
- Access to game data

Teacher-Only Participation

Teacher-only participation was offered as an alternative, enabling teachers to participate in the following activities:

- Teacher interview
- Access to game data

6.2.4 Possible Validity Bias

It is important to keep in mind that the selection represents schools with a relatively high usage of Enki. This is an indication of a possible bias in the results, as the cases consist of schools that are using the game often, leading to an overrepresentation of schools and teachers which may be positive to the use of the game. The game-registry shows multiple counts of schools testing Enki and not going forth to use it. As a result of trying to predict this bias, a number of these schools have been contacted for participation in the study. Unfortunately, none have responded.

6.2.5 Data Gathering Methods

Document Analysis

A document analysis has been performed and the results have been presented throughout this thesis. Emails, documents, news articles, and other sources have been used to supplement the findings

Interviews

Interviews with teachers that had an experience of using Enki and ERA in class was fundamental for the study. Teacher interviews was semi-structured in form and guided by a pre-written script. They were performed at school during normal school hours. Students were group interviewed to provide a different perspective on how the game was used. The groups consisted of three to five participants and was performed during regular school hours. Teacher interviews were audio recorded and transcribed. Group interviews were audio recorded, but not transcribed as it was considered a time-demanding activity, which would not benefit the study; partly due to the unison between the students of the classes interviewed.

Observation

Semi-participant observations were performed to document how Enki and ERA was used in the participating classes. During these observations the teacher was the main focus, observing how Enki and ERA was used in relation to how the students were helped and what they were helped with, and how ERA supported the teachers actions. Underways I asked questions to clarify if needed, and took field notes. These were thoroughly transcribed afterwards.

Game data

The game uses a relational database to store information about its users. To get additional information about how teachers and students used the game, this was used to document usage through quantitative data. This included collecting time-based statistics of usage, and statistics of solved assignments for each subject and category.

6.3 Analysis

The data analysis was performed through iterations of coding, categorisation, comparisons, and interpretations. Firstly, each source in a individual case was coded. Secondly, a comparison between the codings across the multiple cases and sources took place. Thirdly, the results was interpreted by comparing and replicating findings across the multiple sources and cases. Fourthly, these findings were subject to direct interpretation.

6.4 Ethical Issues

This study involved collecting data about children in a school-situation. This could potentially contain sensitive data about their performance at school. To make sure that this would not be an issue, all collected data has been anonymised through replacing the students name, class, and school name with fictional names.

6.4.1 Consent Forms

When performing research in upper primary school, all students are underage. It is considered good practice in such situations to inform parents of what research that is going on, and ask for their consent in regards to their childrens' participation in the study. This was done through a consent form, which stated the following: the purpose of the study, that participation was voluntary, and the type of data that would be collected.

These were further developed into two different consent forms and both types sent to the teacher of the participating classes, the first explaining the study as it was for teachers, and the second how it was for students.

Chapter 7

Participants

In this chapter I will introduce the participants in the case study. Five schools have been visited: Alpha, Beta, Charlie, Delta, and Echo school. Three classes participated: 5A (Alpha), 6B (Beta) , and 6C (Charlie). 5A and 6B were visited twice, observations lasted between one to two school hours (a school hour is 45 minutes). 6C was only visited once [1]. From these five schools, a total of seven teachers from different grades in upper-primary school were interviewed. Five of these have been full depth-interviews with a duration of one to one and a half hour.

7.1 Overview of Participants

A total of 12 schools were contacted and invited to participate in the study. Five of these schools said yes, and are as a result represented, see Table 7.1 for an overview of these schools. The school names have been anonymised and given fictional names as a replacement.

Table 7.1: Participating schools

School	No. of Students in Enki	No. Of Assignments
Alpha School	138	3177
Beta School	71	1915
Charlie School	66	3745
Delta School	74	1438
Echo School	26	980

Usage, 1st of December, 2014 - 28th of February, 2015.

7.1.1 Alpha School

Alpha School is a primary school located within Oslo city with circa 550 students and a workforce of around 70 people. Enki has been used at all upper primary levels since the beginning of November 2014.

[1]Repeating observations are not needed when results start to repeat themselves.

7.1.2 Beta School

Beta School is a primary school located in one of Oslo's neighbouring counties. The school has around 500 students, and a workforce of circa 40 people. The fifth and sixth grade has been using Enki since the beginning of September 2014.

7.1.3 Charlie School

Charlie School is a primary school located in one of Oslo's neighbouring counties. The school consists of around 150 students and a workforce of circa 20 people. The use of Enki is well-established as all upper primary levels have been using Enki since the beginning of November 2014.

7.1.4 Delta School

Delta School is a primary school located in one of Oslo's neighbouring counties. The school has circa 250 students and a workforce of around 40 people. Within the school there is a heavy technological focus. They have been using Enki since the beginning of September 2014 in the upper primary levels.

7.1.5 Echo School

Echo School is a primary school located in one of Oslo's neighbouring counties. The school has around 250 students and a workforce of around 40 people. A sixth grade class tested Enki in January 2015. The school has discontinued the use.

7.2 Participating Classes

Three classes signed up for the class participation part of the study. A list of classes and activity levels is shown in Table 7.2.

Table 7.2: Participating classes

School	Class	Teacher	No. Of Students	No. Of Assignments
Alpha School	5A	Annie	28	888
Beta School	6B	Benny	27	2823
Charlie School	6C	Christine	20	1462

7.2.1 5A, Alpha School

5A started playing Enki at the beginning of January 2015. They are 27 students with their class teacher Annie. When they play Enki, Annie books the computer-room and is responsible for the class during this time. Their usage of the game has been irregular, and the statistics indicate that they have had a total of five play sessions in school, see Figure 7.1. During two sessions, one in the end of February 2015 (Week 9) and one in the beginning of March 2015 (Week 10), the class was observed while playing the game. Both sessions were during the last school hours on Mondays, and the game was played for a school hour each time.

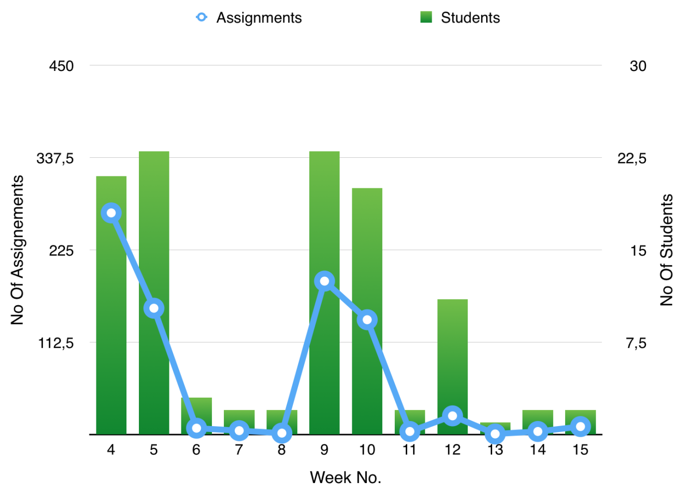


Figure 7.1: Usage pattern, 5A, Alpha School

7.2.2 6B, Beta School

6B started playing Enki in the beginning of September 2014, since then they have played nearly every school week, see Figure 7.2. The class was observed twice, one in the end of February 2015 (Week 9), and one in the beginning of March (Week 10). During each of these sessions, the game was played in the school's computer room for a school hour. The class teacher Benny was supported by his assistant while playing Enki. The assistant at that time had played through the entire game and solved every in-game assignment, supporting Benny by helping students with assignments.

7.2.3 6C, Charlie School

6C started playing Enki at the beginning of November 2014. The class had 19 students and the class teacher Christine. The usage statistics indicate that they used the game every school week until school ended for Christmas holiday in December. After school start in January, the usage has been less frequent. See Figure 7.3 for detailed statistics.

In the end of March 2015 (Week 13), 6C was observed in their classroom playing Enki. Students fetched their laptops and sat in groups playing Enki for nearly thirty minutes.

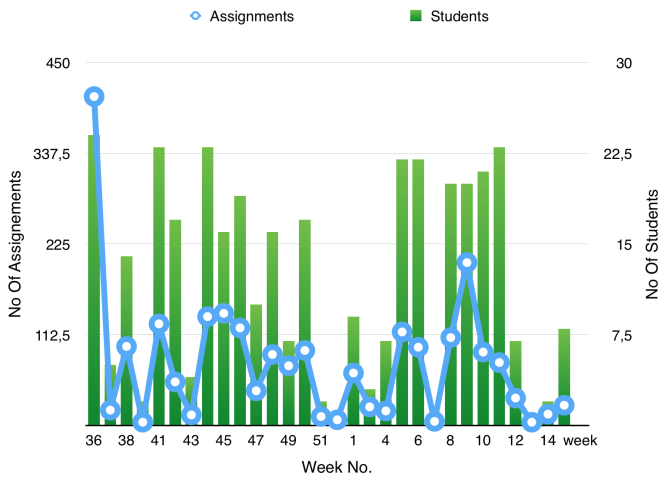


Figure 7.2: Usage pattern, 6B, Beta School

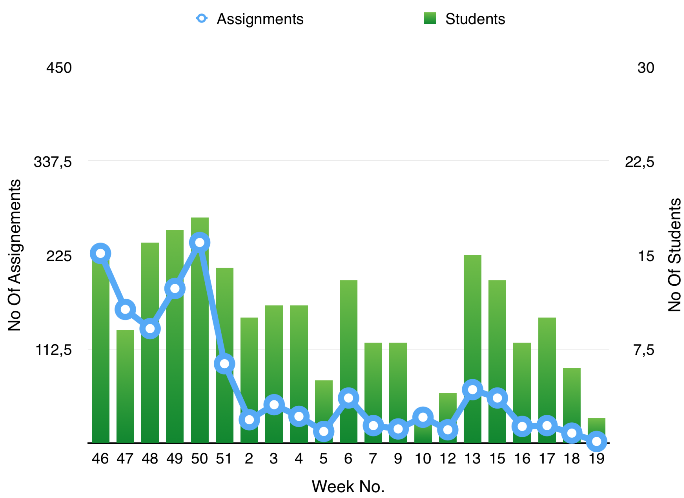


Figure 7.3: Usage pattern, 6C, Charlie School

7.3 Participating Teachers

Three teachers signed up for the teacher only study; three teachers signed up for the class study. A list of these participants and their activity level in Enki is shown in Table 7.3. The teacher's names have been replaced by fictional ones.

7.3.1 Alice, Alpha School

Alice has been teaching for over ten years, and at the time of the study she had two positions at school: 40% inspector, and 60% class teacher. She

Table 7.3: Participating teachers

Teacher	School	Class	Students	Participation Type
Alice	Alpha School	5B	21	Teacher Only
Annie	Alpha School	5A	23	Class
Benny	Beta School	6B	24	Class
Christine	Charlie School	6C	15	Class
Eric	Echo School	6E	23	Teacher Only
Denise	Delta School	7A	12	Teacher Only

teaches her fifth grade class in mathematics, Norwegian, English and social studies. Prior to her technology use as a teacher, she has had no formal training or background in information and communications technology (ICT).

7.3.2 Annie, Alpha School

Annie is educated as a teacher, and has a Master's in Nordic Studies. She has been working as a teacher in primary school for ten years and has no formal training or background in ICT.

7.3.3 Benny, Beta School

Benny has been a teacher since 2001, he has been using Enki as a part of his teaching since the beginning of September 2014. At Beta School, he has the responsibilities for the Information and Communication Technology (ICT). This has been a part of his work description for ten years, and he is now primarily teaching mathematics and natural science.

7.3.4 Christine, Charlie School

Christine has been working as a teacher for around ten years. At the time of this study she was teaching Norwegian, english, mathematics, social sciences and religion. She has no background in ICT.

7.3.5 Eric, Echo School

Eric has been a teacher since the beginning of 2007, at the time of the study he was class teacher for the sixth grade. As a part of his education he specialised in ICT, and is now the ICT responsible.

7.3.6 Denise, Delta School

Denise has been using Enki for close to two years and has been teaching for over fifteen. At the time of this study, she was the class teacher for 7A. She has mainly been working with the upper primary level, and her current class is consist of 16 students. Since their school began using the learning platform *Fronter* in 2002, she has had the responsibility for the pedagogy in ICT, and before this she had no experience with ICT.

Chapter 8

Findings

In this chapter I will present the analysis as a synthesis of the observations, interviews and game data. These findings deal with different parts of the system and design, and have been structured accordingly.

Therefore this chapter is divided into four different parts, each part related to a different type of finding: the first part focuses on findings which are related to the use of Enki, the second part deals with findings related to the use of ERA, the third part deals with cross-functionality between Enki and ERA, the fourth part is related to findings of a technical nature. The findings are isolated into sub-chapters in each part, where the finding itself is comprised as the heading; the text that follows is the data explaining the findings.

8.1 Enki

Findings related to the game itself will be presented in this section. This deals with how the current design of Enki is affecting the UX of teachers and students.

8.1.1 Enki is Often an Enjoyable Experience

Enki has been reported by all teachers as an enjoyable experience for the students and teachers. Throughout the field studies, students have been observed as positive to the upcoming use. There are outliers, as two teachers report that they have a student each in class which does not enjoy the game format. However, teachers confirm and report that the use of the game has been mostly positive, providing engagement and motivation for their students. During my visits to Annie's class, this was confirmed through my observations:

> "[...] 'The scientist is back." she says, "I guess you know what that means?", one of the students yell out "Are we going to play Enki?". The teacher gives an affirmative nod as the class shouts for joy." (Excerpt from field notes. Annie, 5A)

Students have an overall positive attitude towards Enki, this was confirmed through group-interviews, observations, and interviews with their teachers. The students positive experience with the game has resulted in several interesting episodes. The document analysis uncovered an incident where a principal changed his mind about buying the game; this after receiving an application which stressed the importance of Enki written by the students whom had tried it themselves. In addition, during a field visit outside of this study a drawing of Enki was found in the classroom, see Figure 8.1.

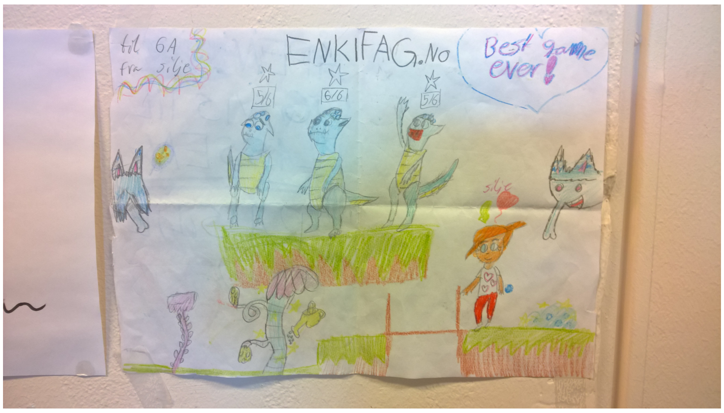


Figure 8.1: Picture of Enki drawn by a student

This enjoyable experience makes for an engaging environment for the students, and the use of the game is also reported as enjoyable by teachers. Annie summarises the use thus:

> "It's really wonderful and comfortable; that may be the biggest reason for us to do this once a week. Every week there's a day where we have five lessons, Mondays ... and it's too many lessons for us. [...] Like now, they've actually done some work, focused and they have had a good time. They go home being happy — they're only ten years old — and to be in school until 15:15. It's a really long day for them. It's even a long day for me to teach continuously. So, it's really comfortable for me to sit back, chat with them online and just help them with some assignments." (Excerpt from Interview, Annie)

I infer that Enki provides a positive classroom experience for both teachers and students, where several teachers report that the game enables them to meet their students at a new arena, and that it enables a new role for them in class; a more supportive role, where they help when needed instead of instructing. This is what is termed as a *flipped classroom*, where students engage in problem solving (traditionally done as homework) as a part of class (Khan 2012, p.155).

8.1.2 Enki is Used by Students After School Hours

Students report that they would organise themselves to meet in Enki after school hours and that this would happen frequently when Enki was new for them. As time went by, however, students reported decreasing activity. The teachers confirm this, and report that home activity would decrease over time. However, they report a correlation of using it in class and the students organising to play at home.

The game statistics in Figure 8.2 confirm these statements and indicate that there is a steady number of students who play the game after school hours. Teachers have reported to encourage their students to play at home, and one of the teachers in this study used the game exclusively for homework.

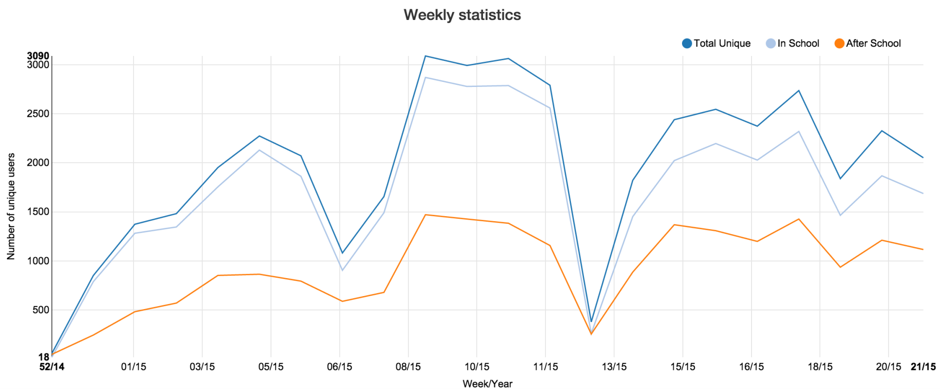


Figure 8.2: Weekly statistics: January 2015 to May 2015

8.1.3 Enki Motivates Students to Progress

Teachers agree that Enki engages and excites the students. During my observations, this has been confirmed at every visit. Students have seemed motivated to solve assignments and the observations indicate that Enki's reward system make students experience positive emotions when receiving good feedback on assignments. Denise commented on how using Enki and other games affected her students:

> "When we use games, they start training on stuff without them even realising it. The ones that have some kind of "fear" for math — and there's a lot of kids growing up with that — they can see that they are able to do it and they get a sense of mastery. They are eager, and if they come across problems in Enki, they seek help. It is so important for them to make it. They receive stars, and we know that if we have students that struggle with mathematics, they can start skipping assignments, Then you have to [interfere] ... Here they control themselves a lot more, and if they don't make it they are unable to make progress in-game. They won't get the

> stars and the stuff that they want. When we use books nothing will happen before I go out to collect them." (Excerpt from interview, Denise)

I interpret that the instant feedback on assignments contributes to motivate a student. They know immediately if they master the assignment, which makes it easier for the weakest students to ask for help. Teachers report that they are motivated to progress in-game, and that it is easier for them to provide instruction and support. Denise states that her weakest students benefit from Enki:

> "They benefit from it a lot more, and they ask for more help than otherwise because its important for them to get further in-game. They can see how much they achieve on an assignment, and then they know if they made it or not. They ask a lot more, and they ask for help. Then they are more eager to get the help. A student may sit and struggle with something, then you start explaining, and you can see their eyes turn glassy as they lose interest in the explanation, because it was too difficult for them, but with Enki they are more motivated and they participate more when they are being helped, because its important for them to make it." (Excerpt from interview, Denise)

This beneficial effect is described by several teachers, and I interpret that Enki provides a learning environment where they are motivated to progress. This effect is further commented by Benny:

> "When using Enki I can see that some of the weakest students benefit from using the screen and computer, maybe they are used to master that arena; when you are in sixth-grade, and you have through six years felt that you do not master anything in an exercise book, then there might be something that blocks your thoughts which using the computer opens up.
>
> That's just my thoughts on it, without being able to prove it. However, I can see that some students are uneasy in class when they sit with books and they do not get that sense of coping. They don't have order in their notebook, but are then able to calm down and collect their thoughts to answer better. I can see this in Enki, but also when they do other assignments on the computer." (Excerpt from interview, Benny)

I interpret from this that the use of the computer-game format to create a learning environment for curricular activity is motivating for the students. The weakest students are motivated to ask for more help and to proceed within the curriculum as it is represented in the game.

8.1.4 Enki Does Not Adapt to Students Individual Needs

The interviews uncovered that several teachers experienced that their students were struggling with the in-game assignments. They indicated that Enki was a demotivating experience for these students. Eric, who used the game to provide math homework had his students in a situation where they were solving assignments on their own, unable to ask for help or guidance from a teacher. Eric commented thus:

> "It is a great motivational factor, and there were many who thought that it was really fun to do math there. I think that it is really good, it is a good way to practice what we have talked about. I do not think I would have benefited from trying it on a lower grade which does not have the competence. [...] They expect that we have the tools to be able to solve the different assignments, and it is clear that the weakest students in class who struggle with math also struggle in Enki when solving assignments. They notice that they are not able to solve the assignment, and that they will get fewer stars than their friend or whatever. "I need help to make it", its positive in one way, because they get help to make it, but its negative that they can see that they are not able to make it, and that they are not getting the sense of mastery that they should have." (Excerpt from interview, Eric)

I interpret that Eric finds it important that his students experience a sense of mastery when using Enki, and that it is this sense of mastery which drives their motivation to progress in-game. When he was asked if the game was too challenging for his weakest students, he stated:

> "Yes. They are the ones who have it the toughest because they have to do it so many times to progress. They are the ones whom give me the impression that the game is monotonous as well. They do the least because they see that this actually is a little bit tiring — To sit and calculate that many times to get that answer." (Excerpt from interview, Eric)

I interpret this lack of adaptation as affecting the motivation for weak students, reported as the exact opposite of Denise and Benny. However, when considering the different circumstances of use between these teachers, a pattern comes into play.

Denise and Benny used Enki in an environment where struggling students could easily be identified and helped: Denise used it in a classroom with a seventh grade class of 12 (a relatively low number of students), and Benny in a sixth grade class with 24 students where both he and his assistant — which had finished all assignments within the game — provided assistance. Eric and Annie had quite different circumstances, where it was tougher to identify and in some cases impossible to help the struggling students: Eric used the game as homework for his sixth grade class and there was no help or instruction available for his students as they played, and Annie used Enki on her fifth grade class with 24 students where she single-handedly tried to help the ones in need: it made for a challenging experience, as I observed several situations where multiple students needed help at the same time.

I interpret that these different circumstances entice different needs, when there are few help resources available for the students, it makes for a more negative experience for both teachers and students as Enki does not adapt to the students individual skill level. In small classes with help available, this is not a problem, in bigger classes this makes the use of Enki more challenging:

> "Well, in Enki's case I think that the differentiation doesn't work well. I can see that some of my weakest math-students are trying to solve rather difficult assignments. Because they have been going at it for a while, then you reach that level just because you have solved that many tasks, roughly independent of how you have achieved. You don't differentiate between the ones who are skilful and the ones that need a lot of training to master something. I have students who are really good, who play around with easy assignments. [...] I don't think it gives good differentiation, I could have done that way better myself." (Excerpt from interview, Annie)

Annie's claim is supported by Eric which also brings up adaptivity as an issue with Enki:

> "I think in terms of differentiation. How well do they perform on these assignments? Should they have had any easier assignments than these? Some of these were actually quite hard for this grade. In relation to the level some of these are on, the assignments were difficult. Perhaps they would have benefited from some easier assignments. That may be what I miss the most. I am not sure if my students have missed it, or if they have been pleased with the difficulty. The feedback given to me underway is that some of the students have grown tired because it is difficult. It becomes a guessing game some places, they haven't understood everything and there is some frustration when they don't make it." (Excerpt from interview, Eric)

I interpret that when teachers use Enki in situations where it is difficult for them to support all their students, they recognise the importance of Enki itself to provide some form of adaptation, help, and guidance for the student. I interpret that they find it important that Enki should be able to adapt and map out a students current skill level, and present assignments which are adapted to them. When students are presented with an assignment which is either too hard or too easy, teachers regard it as a subpar learning experience: if its too hard, it can become a guessing game, and if its too easy, they are not challenged to learn. This indicates that it is important for teachers that Enki adapts to the students individual needs.

8.1.5 Enki Does Not Provide In-Game Instruction

Several teachers report that they are unsure if their students are guessing on assignments, others report that their students are unable to solve the in-game assignments due to incomplete knowledge of how. When students play Enki and they are unable to get or ask for help, there are no in-game mechanisms that help the students. This issue was clear for Eric, who used the game as homework:

> "They send me a delivery, and I give some feedback and ask them to try again. They retry, then I try to give them some hints; look at this, you misunderstood this part of the question, this is how it works, etc. Then I talk with them at school, and they really don't understand what they are supposed to do and they need a thorough explanation before they are able to say ´´Ahh, that's what I am supposed to do". I think that the system should be able to help them some more, and push out some hints to the students. Just so they would be able to actually understand what they should do, and that they don't just get a message that this is wrong, but an indication of what was wrong and why." (Excerpt from interview, Eric)

It follows from 8.1.4 that the game can be experienced as boring or frustrating when students are given assignments which are outside of their skill level. When teachers or other helpers are unavailable for the student, the game does not provide any instruction, hints, or tips, I infer that it is hard for students to have a learning experience when playing the game by themselves.

8.1.6 Assignments in Enki Containing Errors Go Unreported

The game consists of a big number of assignments. The field studies uncovered errors and misleading descriptions within them. Two episodes observed in Annie's class describes the scene:

> Lana asks her teacher for help on an assignment. She is unable to find the correct answer in the alternatives for the sub-exercise she is trying to solve. Annie indicates that the correct alternative is not there. She points out that Lana has to pick whatever answer to keep going. (Excerpt from field notes, Alpha School)

This was interpreted as frustrating for both Annie and Lana. Annie had instructed her students to visit the same zone and this assignment was one of the first ones on this level; every student would go through this assignment with an error. The second episode was of a different nature:

> Jenny is raising her hand, Annie walks over to help. Jenny is in the middle of an assignment, and says that she has been

> having trouble with understanding what she is to do. I observe that the assignment is within the subject of fractions. The assignments description reads "How many eggs are ordinary?" This is to be deduced from the assignment's picture, which shows a number of eggs placed in egg cartons. These eggs are in different colours and has red dots on them. I interpret that Annie is trying to piece out how this assignment is meant to be solved. She says "This is a difficult question, I don't know the answer either. There are no ordinary eggs here". (Excerpt from field notes, Alpha School)

During the interview with Annie, she brings this up as an issue:

> "A lot of the assignments are good. Some of the assignments are awkwardly formulated. These students are perhaps especially vulnerable for awkward formulations. They do not talk Norwegian that well, and then it's extremely tough when the Norwegian is bad. Just like that assignment where she was to search for ordinary eggs and the eggs are dotted and in different colours. What is it that is ordinary about those eggs then? There are also a number of assignments which I don't understand, I get stuck ... I don't understand what they ask for. Most of the assignments are OK, and they give great training!" (Excerpt from interview, Annie)

When asked if she would report this kind of issue, she states that she would not take the trouble to do so, and describes why:

> "When I go around helping my students, I won't go back here to report or something like that — I keep on helping my students. In addition, I don't know the name of the assignment: I would have to go back here to figure out what assignment it was, and I can't see which one it is before she has finished solving it. " (Excerpt from interview, Annie)

These findings indicate that there is no defined way for teachers to report errors in the assignments which affect their students. This affects the user-experience of the game, and may lower the credibility of the product.

8.1.7 Formative Evaluation is Only Available Through Sound

As two out of three classes in this study play Enki without sound, these students do not receive any formative evaluation. This is made available through the sound cues as they solve assignments as described in Chapter 4.4.6, they are only able to rely on the final feedback as their source of evaluation. I infer that this makes it difficult for a student to see which sub-exercises they did correctly or incorrectly, making it harder to quality assure their own thinking and learn how to do an assignment correctly.

8.1.8 Students Can Benefit From a Scratchpad

Students playing Enki have been observed in many cases asking for scratchpads when solving assignments. They would proceed by using it actively throughout the session when solving exercises. Enabling this as an in-game feature would make it easier for students to quality assure their own thinking before answering.

8.1.9 Enki is Evaluated by Teachers Before Use

Teachers report that before they adopt the game for use in the classroom, they perform a subjective evaluation of the game. During Annie's evaluation, the game was considered inapplicable for her use:

> "The administration bought it, and I was given access and a list of my students. I logged on to check it out, and I didn't get it. Perhaps it was because I am the grade's natural science teacher, and I was checking if I could use it for that. I tried the natural science planet. It was garbage. It was totally useless. It wasn't really a game, it was just textbook material and some answers for that. The texts were too difficult for our students at least. Then I thought ... This is a joke. Has anyone decided that we are going to use money on this? I didn't want to play a part in this, so I just didn't use it." (Excerpt from interview, Annie)

Annie reported that to she changed her mind about the game after attending a mandatory course about Enki, where she was introduced to Kalkulon — the math-planet — which made her reconsider. However, the teachers reports differ, and for Benny the game was considered as applicable from the start:

> "It was a revelation in terms of how a game could be adapted for subjects. There are so many others resources available, but they are limited in relation to Enki. For example it is often a training game where the entire game revolves around the multiplication tables. It is nothing but click here and ... It is so much more simple. What I like about Enki is that it provides an extra boost as it has a game experience. It is so much more than a game where the only action is numbers popping up and one is supposed to click the right one. The fact that you have multiple subjects and possibilities is a big advantage with Enki." (Excerpt from interview, Bennie)

This indicates that for a teacher to use Enki on his or her class, a teacher's subjective analysis of the game's experience must be positive and show how it can be relevant for their classroom's learning experience.

8.1.10 Some Students and Teachers Struggle With Gameplay

The field studies uncovered that many students were playing the game in a different manner than the game-designers intended. I observed students playing without any energy on their avatars, and spending lots of time on navigating in-game instead of solving assignments. Teachers report that their students handle the game differently. Some teachers report they have given the technical challenges to their students and themselves the pedagogical responsibility:

> "I am not a game-person my self, so my poor avatar it drags itself around like a half-dead zombie and I have no clue of how to get it food or something like that, but I have realised that the kids like it. We agreed on it: I take care of the pedagogical and the mathematics of it, and they can figure out the technical stuff themselves." (Denise, Delta School)

Other teachers are unable to do this, as they have students who are unable to learn the game by themselves. Here the teacher will also instruct their students on how to use the game properly. Annie comments on this issue:

> "I am happy that they can play without having full energy. Its clear that if you had it — there is a level-system — if it had been that when you reached level two or three, then you wouldn't survive without energy. That might have worked. But there is something about taking one thing at a time as well. Some of these kids are the ones that are unable to calculate with plus and minus, and then it will be to much at once." (Excerpt from interview, Annie)

My field visit to Annie's class uncovered that it is not given that every kid in school is able to figure out how to play the computer-game on their own:

> Jane asks Annie for help. She has a low amount of energy on her avatar. I have observed Jane playing earlier; navigating around the level for an extended time not doing anything. She had been trying to jump across an obstacle without being able to for quite some time. She does not interact with the in-game-environment. When Annie arrives she asks the student if they should get some food for her avatar. She walks right past multiple places where this is possible, but does not interact with these places. I interpret that neither Annie or Jane seem to have a grip on the game-mechanics. Jane's avatar is now facing a tree. The tree is glistening, and Annie suggests that she should click on it.
>
> As Jane clicks the tree, an interaction-circle appears with a watering can. She seems uncertain of what to do. Annie

suggests that she should use the watering can. Jane proceeds to click on her backpack where the watering can is in her inventory. She holds her mouse over the watering can. Nothing happens. It takes a small while before she tries clicking on the tree again. Now she clicks the watering can in the interaction-circle. The tree is now being watered in-game, and fruit appears on the tree. Jane tries to take the fruit by clicking the tree.

> Annie suggests that she should click the fruit-symbol in the interaction-circle instead. Jane does this, and goes forth to click the fruit in the inventory to eat it, the avatar receives a low amount of energy, "It helped a little bit at least" Annie says. Jane keeps walking around in-game, walking towards an NPC with the text 0/6 stars above its head. Annie suggests that Jane should interact with the NPC, and turns around to walk back to her desk. On our way back, she tells me "some students don't know how to play computer-games and need training". (Excerpt from field notes, Annie)

I interpret from this that when teachers and students play Enki, there are many who do not understand how the gameplay works. Although Enki has a mandatory tutorial for anyone who plays the game for the first time, it can be inefficient in explaining how the gameplay works for inexperienced gamers. The findings indicate that the tutorial is not working properly.

8.1.11 Enki is Mainly Used for Mathematics During School Hours

Game statistics have been retrieved to see how Enki is used during school hours based on in-game subjects (i.e. mathematics, natural science, english). This was done by summarising how many assignments were done during school-hours from January to May in 2015. Figure 8.3 indicates that Enki is mostly used for mathematics, with a total of 54% of all assignments solved.

To provide a deeper view of how these numbers converge, the usage was further divided into the different categories within each subject (i.e. for mathematics: fractions, multiplication, etc.). The result is shown in Figure 8.4 and indicates that *Numbers and Algebra* has the highest number of solved assignments, followed by *Language Learning*.

8.2 ERA

Findings related to the use of ERA will be presented in this section. This deals with how the current design ERA is affecting the UX of teachers.

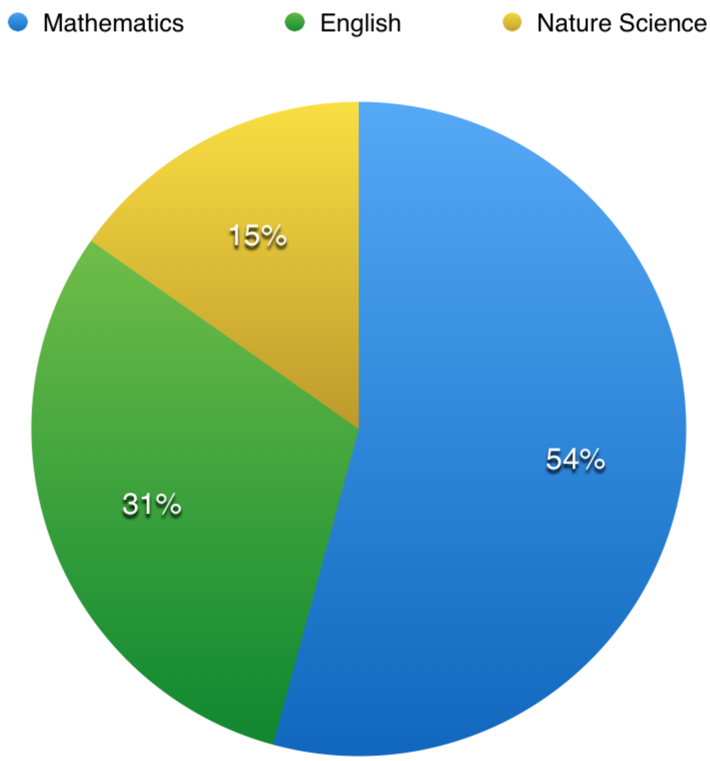


Figure 8.3: Enki usage statistics by subject

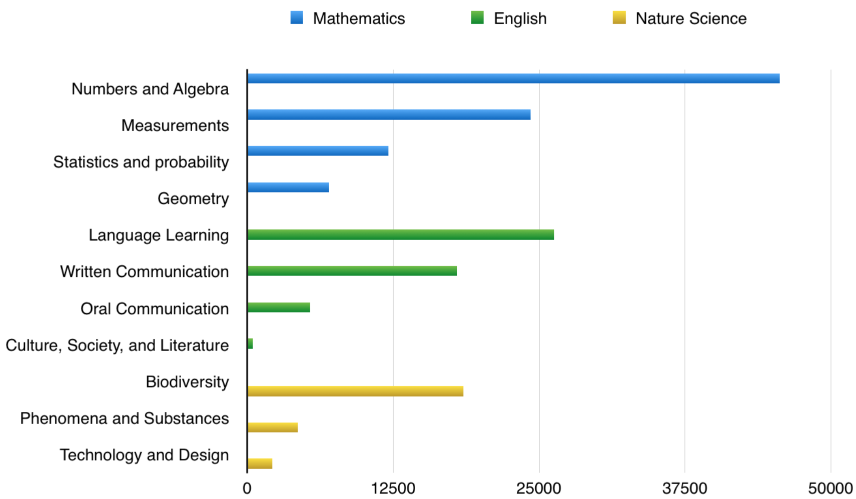


Figure 8.4: Enki usage statistics by category

8.2.1 ERA Makes it Possible for Teachers to Start Using Enki on Their Own

During the interviews, teachers reported that they had used ERA to create their own class, fill it with their students, and to distribute this information. Benny and Denise — who were the ICT-Responsible at their school — reported to have used ERA to give access to their colleagues. This is supported by the usage statistics presented in Figure 5.30, where there has been a significant increase in the number of students generated by teachers. Denise, who had been using Enki since its beta phase comments:

> "It is easier now, teachers can add students themselves. In the beginning it was a bit tough, but its become easier in the last versions. It does not take that much time anymore, in the beginning we used a lot more time on it, and to figure out how it worked. Now the teacher has a lot more freedom to add students, and when new students start in the class its so much easier. It has become significantly better." (Excerpt from interview, Denise)

This indicates that the teachers are able to use ERA to get started with Enki on their own.

8.2.2 ERA is Used by Teachers When Students are Playing Enki

Teachers report and are observed using ERA when students are playing Enki. They used the application in a similar fashion throughout the field studies. Several report using a combination of both Enki and ERA, starting out together in the game, and then later using ERA to follow-up on the students.

The typical usage scenario was for teachers to sign-in on a computer located in some distance from the students, and whenever able they would return to this base to get an overview of what the students were doing. Annie and Benny kept a close watch on the chat and event stream, actively following up on their students. Christine spent most of the time with her students, spending only a few minutes on ERA. During the observations, Annie and Benny used ERA actively to find information about how their students were performing, and to correct deliveries.

8.2.3 ERA is Ineffective in Portraying Relevant Information

During the field visits, Annie and Benny have been observed to sigh and comment on that ERA can be slow when viewing the statistics; there has been several incidents where ERA has had a load-time of more than 10 seconds. This is restricted to when teachers view the class statistics and specify a subject within. However, it seems that the experienced slowness is increased by how effective ERA is at portraying relevant information for the teachers, Annie comments thus:

> "It takes time. I run back and forth because my students need help with the assignment, it takes time to find the information I need. I am not able to go through all my students in one hour. I just finished a session, and there's three students which I have been unable to check-up on." (Excerpt from interview, Annie)

This is an indication that ERA is ineffective at providing teachers with relevant information which can be used in the classroom setting to further support and evaluate their students' performance.

8.2.4 ERA's Design Does Not Provide a Satisfactory Overview of Students Activity

ERA does not provide a satisfactory overview of the students' activity in a classroom situation. Teachers report that it is hard to keep an overview of what exactly all their students are doing, and observations indicate that they employ what Lazar, Feng and Hochheiser (2010, p.148) refers to as a coping strategies to make ERA work in the classroom.

Benny has an assistant to help in the classroom, his coping strategy was to limit his focus to two-three students. Annie on the other hand, was alone in the computer room with 24 students. During her sessions with Enki, she would constantly be on her feet as her students were asking for help. When she returned to ERA, she checked up on her students progress in a systematic way: navigating through the students list, and for each of them review the latest events, manually comparing the data. When I asked about what she was looking for, she stated:

> "I am looking for students who has scored between 1-5 stars on an assignment, and I try to figure out who is doing what, if they try again when they get bad results, who I need to check up on, and who I can give positive feedback to." (Excerpt from field notes, Annie)

When reviewing her students event stream, she compared timestamps on the assignments to get an idea of how often they solved assignments and made sure that assignments which had received less than six stars had been retried. When she was asked about the use of ERA, she stated:

> "It could be better, and it could be easier. [...] I would love to have an easy way of ... When I have [the student] here in the chat, if I could hold my mouse over to see where they are in-game and what they are doing. That would have been so great. If I could hold my mouse over here [pointing at a user in the chat] and see where they are right now and for example the last four assignments they had solved. If that would have been available so that I don't have to go through the list to see what they have done. That would have been beautiful. More Mac-type solutions on things. It is very PC-game in a way. Its a bit cumbersome. (Excerpt from interview, Annie)

I interpret that the much needed information is available through ERA, but that it is a cumbersome process to collect and compare it. This is an indication that ERA does not comply with Annie's needs, and that she employs the following coping strategy to find the information she needs to properly evaluate her students:

> "I am looking at which assignments they do, how well they do them. If they do it again when their score is bad. Mostly I check if they try again when they do it bad. If they are interested in getting it right, or if they just keep going. If they give up and don't ask for help." (Excerpt from interview, Annie)

Benny also comments on this issue, and outlines a different coping strategy:

> " I use it primarily to see how they perform, and as I said earlier, when I know there is something some of my students struggle with in mathematics, I focus on these two-three students so that I can pick up on it. When they get two stars on that assignment, I can seek out that particular student and help them with that assignment and get that talk. Many students benefit from having that dialogue, just talking while solving the assignment, and get explanations underway." (Excerpt from interview, Benny)

I interpret that this is a strong indication that ERA is in need of a redesign based on the teachers needs and requirements for evaluating their students performance in the classroom. It indicates that there is a need for change in how learning analytics are presented, and which metrics that are important. This can make it easier for teachers to evaluate the performance of a class and its students.

8.2.5 ERA Does Not Provide an Overview of What Assignments Exists In-Game

Teachers report that they are unable to see what kind of assignments exist in-game and what assignments their students are doing. Annie, Benny, and Christine describes the same problem:

> "I find it difficult to see what assignments the students have been doing. That is; I see it's Assignment 1.3 in fractions, mathematics. But what exactly is Assignment 1.3?" (Excerpt from interview, Benny)

> "I wish I could have a better overview for the subjects. I can see that they have received i.e. 2 stars on an assignment. In an assignment it would have been exciting to see how they have solved it, or what the assignment actually is." (Excerpt from interview, Christine)

> "The assignment is called Assignment 2.2., but I am unsure of what assignment 2.2 is, the only way I can see it is if I actually see the student perform the assignment." (Excerpt from interview, Annie)

This is a strong indication that a primary need of the teacher has not been met by ERA: Teachers need to see which assignments are available in-game and what these assignments involves. I interpret that this lack of transparency between Enki and ERA can be causing adaptation problems, as it is only solvable through a time-demanding visit to the game.

8.2.6 ERA Provides No Information About How and What Students Answer

Teachers report being unsure about how their students tackle the in-game assignments. Although teachers are presented with a student's result on an assignment, there is no information about how and what a student was answering, which makes it hard for a teacher to ensure that their students are using the game for a learning experience. Alice comments on this experience:

> " The students think it is wonderful. From 1-10, 10! ... And why? Because it's play ... Its fun to play. And I can see that when they don't master the assignments anymore, they have understood that they get 1 star even though they don't write anything in the assignments they deliver to me. For the other assignments they just guess. So if I think about using this to map out students knowledge in certain themes then I can not use it. There is close to no documented writing, there is no other form of documentation than the deliveries. Has the student done the assignments because he needs the stars? Or is it because they want to learn? Has it gone wrong because they do not know how? Or were they just guessing?" (Excerpt from interview, Alice)

Christine comments further about this issue:

> "I'm unsure about how my students act when they meet difficult assignments. Are they just guessing or are they actually doing their best to solve this assignment? I am not sure about that. I have experienced that the text-description changes during the assignments sub-tasks, and I am pretty sure that the students are not reading the description for every sub-task." (Excerpt from interview, Christine)

Benny follows up on this theme by stating that he does not receive enough information to know what kind of strategies his students employ to solve assignments:

> "I need to see what the assignment is, and how many times the student has tried. That will tell me if they are guessing. [...] I only see that they have received six stars, but if you get six stars on the fifth try, that tells me something else than if you got six stars the first time." (Excerpt from interview, Benny)

This indicates that the current design of ERA disregards a teacher's needs regarding the evaluation of their students in-game performance. The teachers are unable to get an understanding of their students' strategy and understanding, as they are not provided with metrics and information regarding how and what the students answer on an assignment.

8.2.7 ERA Does Not Show the Teacher Time-Based Data

ERA is currently providing statistics for the teachers, but they do not provide a teacher with the possibility to constrain data based on time, which again means that teachers are unable to see time-based material. During my field visit to Annie, I asked her how many of her students were playing the game after-school. She was unsure, and did not know how to find out:

> "I can go in and check who has been logged on before this session we just had. It takes some time though, I need to ... Well, I need to check out all of their individual profiles ... don't I?
>
> [Annie uses ERA to navigate through the list to identify her students who has been playing after school.]
>
> This will take some time, I need to go through them all and check" (Excerpt from interview, Annie)

When asked if it was problematic that it was hard to navigate through this kind of information, she replied: "It's like that, it's a bit ... Its the same when they are here working as well." (Excerpt from interview, Annie)

I interpret from this that ERA does not provide a proper way of navigating through information in a time-based manner. Meaning that every single piece of information which is supplied through the statistics is accumulated. The teacher will then have to use their memory to be able to distinguish between sessions.

One of the teachers has used his creativity to bypass this weakness in the design. Benny takes screenshots to capture this kind of information, and uses it actively for his class:

> "I use ERA to look at statistics before class, and then we use it for motivation. I would tell my class how the current state of the group is, and tell them individually how many stars they have. Then I would tell them that we would have a look afterwards at how many stars they have accumulated." (Excerpt from interview, Benny)

Benny also uses this information to motivate by creating a weekly updated leaderboard. Here his top-three students will be shown off through adding a screen-shot of ERA on their learning platform: *It's Learning*. Benny states that one of his students who have had a lot of absence because of illness, dominate this leader-board by playing from home.

This indicates that there is a need for time-based data in ERA, which could make it easier for teachers to see which of their students who were playing the game from home, and to identify who has been working actively with assignments during a specific session.

8.3 Cross-Functional Issues

As Enki and ERA are strongly linked together, some of the design-aspects are cross-functional. This includes the systems for chat, events and deliveries. Cross-functionality may be complex as the permutations (e.g. the number of cases which may occur) increase. In practice that means that something as straightforward as a chat-system, increases in complexity as the game and tool is brought together. Testing the possible cases of cross-functionality in a controlled environment is hard to do. This led to the discovery of interesting design-flaws during the field studies.

8.3.1 The Deliveries' Design is Ineffective

Students can send text deliveries through Enki which are received and corrected by teachers in ERA and sent back to the student in-game. This functionality is reported as a positive way of documenting the hows and whats of a student's in-game strategy and progress. Several teachers report that they use such deliveries to enforce strict rules on what students are supposed to deliver. Eric comments thus:

> "Here they had to write some more and explain, so I told my class: I want full denomination and I want an explanation. Write too much rather than too little. [...] They agreed and then their answers got better and better." (Excerpt from interview, Eric)

The interviews uncovered that the design of the cross-functional delivery system has some issues. Eric reported that the first time he opened ERA to see how his students had done on the homework, he found a very high number of deliveries in his inbox. When going through this list, he realised that there were multiple deliveries from the same student on the same assignment. He comments further on this issue:

> "One thing that was a bit annoying was that the students could deliver the same assignment multiple times. Many of them did not understand what was going on when they did the assignment. They deliver the answer "136" for example, and

> then they don't get any feedback momentarily, because it is sent to me. They did not get it right away, so a lot of them they kept on delivering many times with different answers. I had a great number of deliveries in the inbox, then I would correct the first one and give the student a full score. Then the next one is that same delivery with a different answer — or the same — that was a bit annoying. Its great to be able to give feedback and comments, but it takes time when you have 25 students who has raided everywhere and done a lot of different assignments." (Excerpt from interview, Eric)

I infer that both the students and teachers UX are affected by this flaw. The game has no constraints on the students ability to deliver the same assignment, and ERA does not prevent multiple deliveries from the same student. In Eric's words, this is annoying for teachers, as they have to do extra work, correcting different versions of the same assignment for the same student multiple times.

Now, how are students affected by this design issue? My interpretation of this matter is that the more deliveries a teacher has to correct, the longer time it will take before a student receives feedback. Teachers report that their students dislike waiting for feedback, and Alice comments thus:

> "What my students think is lame, is the feedback on assignments I need to correct. I need to participate for that. If they play at home, then I am not correcting them each day." (Excerpt from interview, Alice)

When students do not receive feedback within a reasonable time-span, the learning-potential may be lost as students are unable to remember which assignment they have done, this poses as a problem when considering that Enki's interface does not show the assignment tied to the given assignment. Annie comments on this issue:

> "When they send me a delivery, they don't get that instant feedback, and then it may take ... It is completely random if I have time to correct it the same day. When they send a delivery it may take up to four days, then they don't even remember what assignment they receive feedback on. The deliveries are not completely ... It is great that I am able to ask them to do it, but it is not that great that they send them on their own initiative." (Excerpt from interview, Annie)

Annie's frustration over the deliveries can be linked to her assumption that her students forget which assignments they have done, and that they receive rewards and feedback on something they can hardly remember. She suggested in her interview that the deliveries could be a feature which she controlled, and that her students were unable to deliver unless she wanted them to.

It seems clear that the design issues tied to the delivery system is affecting both teachers and students' UX in a negative way, and there is clearly a room for improvement.

8.3.2 The Chat Design is Ineffective

The observations uncovered that two out of three teachers use the chat to give important messages to their class, but such messages are not seen by the students:

> A few minutes after sending an important chat-message, Benny instructs the class to have a look at the chat. The assistant asks if everyone is supposed to have access to that message, "Yes" Benny answers. One of the students call out that he can't see the message. I walk over to confirm. This is correct, and the student next to him asks me "Why can't Kenny see the message?" (Excerpt from field notes, second visit, Beta School)

In this case, the student in question could not see the message because he had just restarted his game — losing all chat history. In addition, the chat is unavailable for students as they are solving assignments, and students have been observed to ignore the new chat message indicator. I interpret that teachers expect that their students will see their messages, and as they go unnoticed they get frustrated and hardly see the point of using the chat.

Several teachers reported not using the chat in ERA. Alice, when informed about the chat functionality, went through the chat-history of her class and students. In this session she discovered several private messages from her students, her students had asked for help without her noticing, and others had complimented her on her abilities as a teacher. Alice commented that this was great, but the fact that she had been unable to notice these messages before this time seemed like bad news. As we sat there together, she tried to answer one of her offline students, but this is not possible in ERA. She commented thus: "it would be nice if I could send messages to my students even when they are offline, to keep this chat going" (Excerpt from interview, Alice).

I interpret that teachers find it hard to understand how to use the chat effectively, they are unsure if their students receive the class messages and private messages alike. The ruleset of seeing and sending messages imposed on teachers and students chat are different which further complicates the matter, as teachers are able to see the full history of the chat with their students and class, students are only able to see chat-messages which are received from the moment they enter the game, where teachers can only send messages to his online students, students can send messages to their teachers regardless of their online or offline status.

I interpret that this design conflicts with a teachers expectations of how a chat is supposed to work, and that it is hard for a teacher to use it effectively in their communication with their students. Further the design of it affects the students' UX, as they can send messages which is never to be seen or answered by the teacher, further invalidating the chat's effectiveness in doing what it is supposed to: acting as a communication channel between teachers and students.

8.3.3 A Lack of Labelling Between Enki and ERA

For teachers to see which assignments are in-game, they have to play themselves. This was described in 8.2.5, but even if teachers are able to see which assignments are in-game, they cannot tell a student where to find a specific assignment. Annie commented thus:

> "I am able to see the assignments, but they are called Assignment 1.1, Assignment 1.2 and Assignment 1.3. The students are not able to see these names, and the NPCs do not have names. In fact, there is nothing that enables me to give some direction to my students of which assignment they should solve. [...] The point is not that I need to know which assignments are in-game — I am unable to tell the students. I can not explain them what I want them to do.
>
> There are no in-game signs which I can ask them to follow ... I can ask them to go to certain zone on the planet, then I am able to see them there. I am not able to tell them to talk with the fourth NPC that they see ... Because that depends on which way the student goes. It is just ... it is not easy." (Excerpt from interview, Annie)

The lack of labelling would make it hard for teachers to point out specific assignments which students are to do. This can further be illustrated by the following scenario: a student has played the game at home and received 2 stars on assignment 2.3, the teacher is interested in having the student repeat this task when they play Enki in class, but the student does not remember where it is and the teacher is unable to help the student find it. This poses a problem, as Enki and ERA does not provide a way for the teacher to point students to specific in-game assignments.

8.4 Technical Malfunctions

In this section I will present findings which are related to technical malfunctions.

8.4.1 Technical Malfunctions is an Issue With Enki

Technical malfunctions have been observed and reported during my field studies. Teachers indicate that these malfunctions have a negative impact on their user experience. Denise — an experienced user — comments:

> "What I miss with this kind of platform, is that it works technically. The average teacher will give up after a few times

> [...] You will spend 10-15 minutes to get your class to the computer-room, if then something doesn't work technically, you will not do this many times before you figure out that it is not worth the effort." (Excerpt from interview with Denise, Delta School)

This indicates that longterm users of Enki has had a steady degree of technical issues with the platform.

8.4.2 Technical Errors Go Unreported

The technical errors are represented in both user-groups; affecting both teachers and students. Benny's class have experienced malfunctions which causes the game to freeze, rendering the student unable to continue and forced to restart. The malfunction has lasted throughout their use of Enki. Benny — head of ICT at Beta School — comments:

> "Earlier I would have noted this and reported this to the developers. I don't do that anymore." (Excerpt from field notes, Benny, Beta School)

There may be a high number of unreported technical issues, as teachers indicate that they let these technical malfunctions go unreported.

8.4.3 Game Unavailable for an Entire Class

A major technical malfunction may render an entire class unable to use the game. My first visit to Annie's class provided a first-hand experience on how such an event unfolds:

> As the students are trying to sign-on to the game, they raise their hands throughout the classroom. I observe that Enki's website is slow, and hardly responding to the student's actions. There is no error-message or indication that something is wrong. Multiple students are clicking repeatedly on the log-on button, they seem impatient.
>
> I observe that one of the students has managed to sign in and the game has started to load. The student exclaims "loading the game takes forever!" Annie responds with "is anyone else experiencing that their computers are really slow today?" — "yeah", they exclaim in unison. Annie moves from student to student to inspect their screens. She instructs the class to be quiet as she calls the school's ICT-responsible.
>
> No one answers the phone.
>
> I observe a student comparing the load time between VG (Verdens Gang, vg.no) and Enki (enkifag.no). He raises his hand to get Annie's attention and exclaims that there probably is something wrong with the game. The student demonstrates

> the difference between VG and Enki. Annie tells the class that the game-provider has an error.
>
> During this time, one of her students has successfully signed in and is now playing the game. As Annie notices, she tells her class to be patient — You will get in soon, she says.
>
> I walk around the classroom and observe students clicking repeatedly on the sign-in button. Other students have progressed through the sign-in process, and are now loading the game. This is progressing slowly. The students are impatient, and some press the reload-button of the browser to restart the loading of the game. (Excerpt from field notes, first visit, 5A - Alpha School)

I interpret Annie as frustrated throughout this experience, and her students as disappointed. She spent nearly 30 minutes to get her students signed-in to the game and had to prolong the class as they finally were able to play. She told me that "if this had happened the first time, I would never have tried it again" (Excerpt from field notes, first visit, 5A - Alpha School).

There were no error-messages or indications that there was something wrong on Enki's part. This indicates a lack of error reporting worked into the design.

8.4.4 Game Malfunctions by Flashing

During my visit in Benny's class, I observed a student's game malfunction, causing the game to flash in different colours at a highly rapid speed.

> Benny asks "What happened? ... Have you done something special?" "I am not sure", Ingrid answers. She is close to finishing a assignment — 11/12 sub-exercises finished — and continues in spite of the heavy flashing. Watching her screen is difficult, and is stressing for my eyes. Benny asks her to restart the game. Ingrid complies, and sighs as the game reloads and leaves her back at the beginning. The flashing is gone." (Excerpt from field notes, Beta School)

This kind of malfunction is severe, as it may cause great distress for the user. Epileptic seizures may be provoked through flashing bright lights[1].

8.4.5 Game Malfunctions When Loading

During my field study in Christine's class, there were several students which were having technical difficulties when trying to play the game; these students were observed to use Internet Explorer 10. The student would be able to sign-on through the game's website, the game would start loading and at 100% it would stop. Christine tried to resolve the situation by making the student use Google Chrome, and when this did

[1] Epileptic Triggers : http://www.epilepsy.com/learn/triggers-seizures

not work, she would solve the situation by letting students play together on one computer. The students who were unable to play seemed frustrated by the experience: there were no error-messages or indications that something was wrong on his computer.

8.4.6 Game Crashes and Must Be Restarted

Benny's class has experienced a high number of game crashes. Students report that this is common, and that they are able to keep on playing by restarting the game. This is done by reloading in the browser:

> Benny has started to correct assignments. I observe Lisa while she receives the feedback. On the screen, a flying envelope appears on their screen and flies up to the top-left corner. She clicks the blinking envelope, and opens the in-game message from the teacher. Six stars and positive feedback makes Lisa smile. When she is about to finish reading, the game crashes.
>
> She seems stressed about this, and while restarting the game, I ask her why. "I might lose my stars", she answers. She smiles in relief when she realises that this did not happen. (Excerpt from field notes, second visit, 6B, Beta School)

Students indicate that this may happen anytime during the game and experience it as frustrating when it happens during an assignment.

8.4.7 ERA Malfunctions by not Updating in Real-Time

Teachers have been observed using ERA to provide information about what the class is doing in-game. In certain cases, ERA has been observed to not update in real-time:

> The time is 09:48, Benny is sitting at the desk watching the event stream in ERA. I observe that the newest assignment is from 09:33. I ask Benny about the time-issue. As Benny sees the time-stamp, he stands up and asks his class if they have all gone to "Anglonus North" — "Yes", the students answer in unison.
>
> Benny sits down and clicks reload in the browser. ERA is reloaded and now shows a completely different event-history. Benny scrolls throughout the event stream, which is filled with assignments from his class the last fifteen minutes.

This incident is not isolated. During the interview with Annie, she questions the technical quality of the product:

> "It's the same when the students sit and work as well, I get the new deliveries, but the event stream does not update. So ... I don't get that. One day I can see everything they work with, and then the next day it doesn't look like they do anything. I

> know that they do, I can see them, so I think the technique is a bit sketchy as well." (Excerpt from interview with Annie)

As teachers are not informed by any error-messages or indications that something is not working when this happens, these reports indicate that ERA may be losing credibility and reliability.

8.4.8 ERA Shows Incorrect Information When Game Malfunctions

For teachers to keep control of the class, it is essential that ERA reports correct data. During my visit to Benny's class, a malfunction caused ERA to show wrong information about one of his students. Implying that he was offline:

> Benny is using ERA to correct assignments and chat with his students. He notices that one of his students which is sitting by his computer in class is marked as offline. Benny comments that this is peculiar, and walks over to check. He can see that the student is in-game. Benny asks if his game has crashed recently. "Yes", the student says. (Excerpt from field notes, second visit, 6B)

Such an error has direct consequences for the functionality in ERA, as the teacher is unable to chat with offline users. Teachers report that such incidents are negative for their UX.

Chapter 9

Discussion

In this chapter I will discuss how the findings of the collective case study is related to the theory in Chapter 2 and 3. The discussion will build up towards answering the following research questions:

1. How is Enki and ERA experienced by teachers and students in the classroom?
2. Why are teachers using Enki and ERA in their classroom?
3. How is Enki and ERA supporting the teacher?
4. How can Enki and ERA be redesigned to better support the teacher?

To make it clear which findings are interpreted and discussed, they will be marked with a parentheses and the number relating to the findings chapter.

9.1 Getting Educational Games Into the Classroom

When making an educational game to be used in the classroom, a comprehensive understanding of how teachers work must be at the base of the design. It follows from Zhao and Frank (2003) that the teacher's choice of computer activities is one that minimises costs, meaning that the activity must support them in providing appropriate learning activities. As described in chapter 4.2, the switch from a physical CD-ROM distribution to a web-based distribution was significant for Enki, enabled many teachers to independently discover, sign up, and make use of Enki in their classroom without consulting their superiors.

Before the game will make it into the classroom, a teacher's subjective analysis of Enki will result in approval or refusal (ibid.). This analysis is made to ensure that the game is effective at providing a learning experience for their students (8.1.9). As Enki and ERA do not provide any support for the teacher during this analysis, the only way a teacher can analyse the game is through playing it themselves. As this is a game meant for children, their subjective experience of what makes for a learning experience makes for a biased and time-demanding experience (8.2.5, 8.1.10). It is hard for a teacher to evaluate the game's content, and when considering this in relation to the possibility that many are inexperienced with computer games, it makes for a more difficult onboarding process for teachers (8.1.10).

9.2 Enki and ERA's UX

Using Enki and ERA in a classroom situation is regarded as an enjoyable UX for students and teachers (8.1.1). The design enabled the teachers of this study to easily adopt a multiplayer educational game for their class, creating what they report to be a motivating and engaging learning environment for their students (8.2.1, 8.1.3). ERA has some functions that provide the teacher with a sense of control regarding in-game activity, and for using it within a classroom setting (8.2.2).

Many teachers indicate that they have a positive experience with how Enki works in the classroom. The game changes the teachers role significantly as they are no longer the centre of attention. The students perform an activity which motivates them and they concentrate. They are then able to spend their time assisting those who need help. Teachers have indicated that it is useful to have access to ERA as they can follow up on students in-game activities, the chat, and identify the ones who are in need of support (8.1.1).

The evaluation made it clear that teacher's work differ from class to class, grade to grade, and school to school: differing in size, students skill level, and available resources. These different circumstances entail different experiences with Enki and ERA. To illustrate how such differences can affect a teacher's perception of how Enki and ERA performs, a comparison of Annie and Denise's follows.

Denise teaches a 7th grade class consisting of 12 students, when using Enki she experiences that her students are well-motivated to ask for help as they come across challenging in-game assignments. She does not use ERA all that much in class, but rather spends her time walking around to help her students.

Annie, on the other hand, teaches a 5th grade which is twice the size of Denise's. She reports that Enki is not adopting to her students skill level, and that ERA is ineffective in supporting her with the right learning analytics.

These are contrasting experiences, and when evaluating the design, I regard Annie's case as particularly valuable: it illustrates how the design performs in a circumstance where the UX is put to the test. Her students do not have the prerequisites to solve many of the in-game assignments, and few help resources were available as they played (8.1.4, 8.1.5). She depended on the design to improve her position in this situation, and her UX reflects how Enki and ERA failed to support her needs (8.2.3).

9.3 Enki's UX

In the classroom, Enki was designed to create a learning environment where students can play together and focus on solving their individual assignments. This was done by providing students with a learning environment which combines a game experience with curricular activity. The evaluation has made it clear that students across all classes are eager and interested in using Enki: indicating an enjoyable UX (8.1.1). They were positive and interested in the use of Enki at school, and some students would organise and play the game together after school (8.1.2). This indicates that although this is a educational game with curricular activity, many were undertaking the activity for their own sake, for the learning, enjoyment, or sense of mastery that it evokes (8.1.3). This follows from the definition of intrinsic motivation (Kapp 2012).

The evaluation uncovered that the game has utility in a classroom setting, but the findings indicate that there is significant room for improvement for their students learning experience in Enki:

1. Enki does not adapt to students individual needs (8.1.4)
2. Enki does not give in-game instruction (8.1.5)
3. Enki does not provide a way of reporting errors for an assignment (8.1.6)
4. Enki does not give students visual formative evaluation (8.1.7)
5. Enki does not make it possible for students to draft their answers (8.1.8)
6. Enki's gameplay is not intuitive for teachers and students (8.1.10)

It follows from these findings that there is a need to redesign Enki's learning experience. The current design makes it hard for teachers to see how their students are benefiting from using the game as a learning tool. The learning design can be improved to provide a more beneficial learning experience, improving the learning experience at home and in the classroom.

9.3.1 Enki's Learning Experience

Enki's gameplay is not intuitive for several students and teachers. As the use of Enki is facilitated by a teacher, there is an expectation from students that he or she can help students with the gameplay. This can be a problem, as some teachers have less knowledge about the gameplay than students. In some classes, teachers report that they will assist with the assignments, and that the students themselves are responsible for helping each other with the gameplay. In other classes this is more problematic, as teachers are expected to help with the assignments and gameplay (8.1.10).

It follows that when there are no in-game mechanism which provides the necessary guidance both teachers and students may struggle. Enki has a short in-game tutorial as described in Chapter 4, but it is not possible to replay it,T and during gameplay there are few hints or tips of how to go about the game. This makes for a difficult and frustrating UX, where some are unable to proceed within the game's environment on their own (8.1.10).

A guidepost for a educational game experience is to enable a learner to achieve flow. This is done by providing experiences which are challenging but achievable, providing the ideal state between boredom and anxiety or frustration (Kapp 2012, p.71). For this to be possible, it seems apparent that Enki should adhere to what research has found about games and learning.

When examining the underlying design of Enki's learning experience — consisting of planets, levels, and assignments — it is clear that it follows the national curriculum for the upper primary level. For a student to solve the assignments, they must have the prerequisites. However, when students do not have the prerequisites, it makes for a frustrating and in certain cases a boring UX (8.1.4).

It follows that Enki's learning design is better at supporting the students which are on-track with the curriculum or in the higher grades. They are able to keep going in-game without any assistance, and can successfully reach new levels on their own. However, the lack of adaptation to a student's individual skill level does affect all students: weak students can get too hard assignments, and strong students can get it too easy (8.1.4).

On the one hand, this design resembles what Sawyer terms as the standard model: students follow the same progression through the game, and are expected to be at the same level as they enter. Considering that 5th graders will have the same game experience as seventh graders, it seems likely that the 7th graders will advance in the game more easily. The game may serve as repetition for most seventh graders and fifth graders may experience challenges where they are unable to proceed (8.1.4, 8.1.5).

On the other hand, the design does allow a student to progress throughout the game at their own pace. The measurement for progression is not time, but a target level of comprehension and achievement. It resembles the concept of *Mastery Learning* as introduced by Khan: the comprehension of a subject is what triggers advancement within the game; in my opinion this is what makes Enki an interesting resource for the classroom. Students can advance at their own rate, and the teachers are able to see how they progress throughout the defined curriculum. Whether you are in the fifth or seventh grade, you are able to play through the same game and show mastery in the same curriculum.

It follows that enabling *Mastery Learning* is positive for the learning experience, but when considering how Enki assesses a student's mastery of a concept, remnants from the standard model comes back into play. The assessment model resembles what Khan terms as *swiss-cheese learning*, and can be explained thus: for a student to proceed to the next level he must collect twenty out of thirty stars, enabling the student to proceed to the next level with four out of six stars on every assignment. These assignments are only required to be solved once, and there are no mechanisms in place to motivate a student to properly solve the assignment instead of guessing (8.2.6). This swiss-cheese approach to assessment enable students to advance to a concept's next level without quality assuring their mastery.

This is a problem, since advancement is thoroughly based on gaining stars on these assignments, and there are few mechanisms which motivate a player to redo an assignment where they have failed or to make them solve the assignment perfectly. The responsibility is therefore handed to the teacher to ensure that their students have a learning experience with Enki (8.2.4).

This situation is certainly not improved when students are unable to understand how to solve an assignment, as the game does not provide instruction, hints or tips. A student is dependent on outside help, making a teacher's or helper's presence vital for the student's advancement (8.1.5). On the one hand, providing the assumption that a helper is readily available and that a student will ask for help, the lack of instruction will enhance sociability and provide a motivation to ask for help (8.1.3). On the other hand, research finds that instructional support in educational games is a necessity to facilitate learning. If there is no instructional support, the player will learn to play the game rather then learn the specific knowledge embedded in the game (ibid., p.84).

It follows that if one provides the assumption that a helper is unavailable (i.e. preoccupied with other students, when a student plays at home, etc) or the student is unwilling to ask, it can make for a demotivating experience. This can facilitate unwanted in-game behaviour, as students try to solve assignments which are outside of their skill level. In such cases, a viable option can be guessing as they do not know how to proceed. This would ensure in-game advancement as stars are rewarded, even though they have some answers wrong (8.1.4, 8.2.6). They get better at the game, but not at learning what is embedded in the game.

This is complicated further by the lack of visual formative evaluation, where the only feedback enabling a student to know if a sub-exercise is right or wrong is given through sound (8.1.7). This makes for a challenging experience for the many classes which does not use headsets at school, they are unable to assess their own performance until receiving the final reward and they are unable to quality assure their possible answers in complicated assignments by drafting their answers (8.1.8).

9.3.2 Redesigning Enki

It follows from this that there are multiple game aspects which affect the students learning experience in a negative way, and as a teacher's evaluation and experience with the game relies on their students' learning outcome, this is a strong indication that this part of the game needs to be improved. I can not claim to be a master of learning and game design, but to improve the student's learning experience, I recommend that further work must be done on the following aspects to ensure a great learning experience for the students using Enki:

Scaffolding gameplay: There is no system in place which scaffolds the gameplay experience. A learner can be introduced to new gameplay elements in a step-by-step manner: not as an isolated tutorial, but as a part of the game itself. This introduces the new concepts such that a learner is led to accomplish goals that build upon the previous ones: scaffolding the gameplay experience (Kapp 2012, p.66).

Adaptive learning: There is no system which takes a student's skill level into account when they solve assignments. Adaptive learning is at the basis of providing flow for a learner, and relates strongly to several of the principles of learning as summarised by Ludvigsen et al. (2014).

Instructional support: An instructional game without instructional support does not entice a learning experience, but rather a game experience (Kapp 2012, p.84). The learner gets good at the game instead of learning what the game is meant to teach. If students could receive tips and hints on how to solve an assignment as they solve it, this would increase the learning potential of the game.

Reward system: There is no reward system in play which entices students to seek out the full score of an assignment, and there is little which separates receiving four, five, and six stars. The reward system could be improved to motivate for receiving a full score, and to motivate students to fully master concepts.

Assessment model: The assessment model does not ensure that a concept is mastered before progressing to the next level. This causes problems which could be improved by using spaced and mixed repetition together with a stricter regime for mastering assignments.

Formative evaluation: Student's are not receiving visual formative evaluation, making it hard for them to know if they are solving assignments correctly or not. Formative evaluation must be in place as it is an important part of a learning experience, giving an indication if the current strategy is working or not.

9.4 ERA's UX

ERA was designed to grant teachers the necessary tools for starting and running a classroom game and to give them an overview of how and what their students were doing in Enki by providing learning analytics. The evaluation made it clear that ERA provides the teacher with the possibility to get started with the game for the classroom (8.2.1), and that ERA is used actively by the teachers when their students are playing the game to keep watch on their students' communication and in-game activities (8.2.2). Although the tool has some utility in a classroom setting, there are several findings which indicate that the teacher's UX with ERA can be improved:

1. ERA is ineffective in portraying relevant information (8.2.3)
2. ERA does not provide a satisfactory overview of students' in-game activity (8.2.4)
3. ERA does not provide an overview of what assignments their students are doing (8.2.5)
4. ERA does not provide any information about how and what students answer (8.2.6)

5. ERA does not show teachers time based data (8.2.7)

It follows from these findings that there is a need to redesign how ERA works. The current design leaves many of the teachers needs unfulfilled, and can be improved to provide accurate learning analytics both inside and outside of a classroom situation.

9.4.1 ERA is Ineffective in Giving a Realtime Overview

In a classroom situation, teachers have limited time to identify relevant information about their students in-game performance. Teachers indicate that ERA is ineffective at portraying relevant information and is not helping teachers to easily make decisions on which students to follow up on (8.2.3). There is a significant amount of data trapped within ERA which could improve its utility (8.2.4)

ERA does not provide an effective way for the teacher to to make decisions on who to follow up on. They can view information about their class and students' in-game activities through the activity stream and the statistics. The activity stream shows events in a chronological order, and the statistics show the accumulated results of in-game performance. Neither of these views accumulate data which make it easy for a teacher to find students of interest.

It follows that for a teacher to utilise this in a classroom setting, manual comparison and navigation is needed to find students of interest. Annie had a defined coping strategy: she figured out where her students were playing, checking if and how often they were solving assignments, how they performed, and if they were to try again when not achieving a full score (8.2.3, 8.2.4).

9.4.2 ERA's Learning Analytics is Ineffective

ERA's real-time data is comprised of learning analytics, which provides real-time events on what their students are doing and how they are performing on assignments, helping teachers to make decisions on which students they should follow up on. However, this information is experienced as insufficient (8.2.5, 8.2.6). To elaborate, this can be illustrated through an example: *Kenny Rekdal, 10.06.2015 14:40, finished assignment 1.1 i Measurements, Mathematics and received 4 stars*. The information provided in this event makes for many unanswered questions for the teacher:

1. What is assignment 1.2?
2. What did Kenny answer?
3. How many tries did he have?
4. How much time did he spend?

To find these answers, a teacher would have to actively seek out Kenny in the classroom and ask him to repeat the assignment while he or she was watching. The event is only valid within a limited time frame, and is not providing beneficial learning analytics for the teacher.

It follows that events are ineffective in portraying information for use outside of this limited time-frame. After an event has occurred, the information can only be utilised as an indication if a student has been doing assignments, and how these went. The design does not give the teacher the necessary information to identify the contents of an assignment. This provides a frustrating UX for teachers, as ERA is ineffective in giving information that helps teachers understand their students' learning.

9.4.3 ERA's Presentation of Learning Analytics is Ineffective

ERA collects a significant amount of data over time which represents students' performance in Enki's subjects. These learning analytics are at the basis of the statistics, providing an indication of how the students are performing and what they are doing in-game. As time passes, however, the information loses relevance. There is no way for a teacher to constrain the data based on time, the only way to view the statistics is in terms of aggregate numbers, not individual data points (8.2.7). In addition, the statistical results are aggregated to a category level, making it hard for a teacher to know what exact assignments their students are struggling with.

I interpret that this makes for a challenging situation, as it makes teachers more prone to use the event-stream to track how their students are performing, making a high-level view on their class unavailable.

There is a significant amount of valuable data trapped within these statistics. It can be used to utilise an important overview of how the students perform within a session or a week, and to show who has been working from home. Unfortunately, the current design makes this very hard. However, a coping strategy was employed by Benny, who took a screenshot every week to make a leaderboard for the top three Enki performers. It is clear that when a teacher goes to great lengths to make the game better for their students, one should learn from it. This particular teacher used leaderboards to motivate the students to collect as many stars they could each week. Enabling time-based constraints on statistics could make for an easier way of finding this kind of data.

9.4.4 Redesigning ERA

It follows from this discussion and findings that ERA has significant room for improvement. The following list is comprised of my suggestions of changes, but keep in mind that there is further work that must be done to ensure the quality of these suggestions before they are implemented.

Making assignments accessible: There is no possibility of seeing which assignments students are solving through ERA. By making this a part of ERA's design, it would make it easier for teachers to recognise which parts of a concept a student is struggling with, which in turn could make Enki and ERA a more viable option to map out students knowledge.

Making assignments a central part of the statistics: It is currently not possible for teachers to see an overview of which assignments their class is struggling with. The current statistics is category based, which makes it impossible for a teacher to recognise which assignment his or her students are struggling with. This assignment-based overview could be given in multiple views, and must make it possible for a teacher to see the class average on an assignment and an individual student's score.

Constraining statistics based on time: There is currently no way of filtering data based on time, as statistics is accumulated from the beginning of using the game. By providing time-based statistics, a teacher could be able to see how their students perform from week to week. This could further be used as a motivational tool, and for a teacher to further understand how the students solve assignments with Enki.

Enabling a realtime overview of class activity: There is no way for a teacher to identify students of interest without manually comparing data. To utilise ERA in a classroom setting, it must be easier to find such students. This means making a realtime overview of which students who are not solving assignments, how many they have solved, which type of assignments they are solving, how they score on the assignment, etc. This type of overview is to make it easier for a teacher to identify students of interest at a glance.

Improving the metrics of learning analytics: The redesign of ERA must utilise ERA's learning analytics both inside and outside of the classroom situation, presenting more relevant information which makes it easy for a teacher to track in-game performance of students. By providing more precise performance metrics on an event, teachers could be able to better evaluate a student's performance at a glance. How much time did the student use on this assignment? How many tries has he or she had? Further, teachers must be able to see the contents of an assignments which has been solved by a student. In addition, if the history of what the student answered was represented, it would further benefit the teacher as they could address what the student's actually did wrong.

9.5 Cross-Functional UX

Enki and ERA has shared functionality and the findings indicate that there are design issues which affect the UX of both. This is mainly tied to the following findings:

1. The *deliveries* design is ineffective (8.3.1)
2. The *chat* design is ineffective (8.3.2)
3. A lack of labelling between Enki and ERA (8.3.2)

9.5.1 The Deliveries Design

The current design of Enki and ERA has the deliveries as the only point where a teacher may review what a student has done. This makes this functionality an important aspect of Enki and ERA, but there are design issues which affect both user groups.

There are no constraints in place making students unable to deliver the same assignment multiple times. This can make for a confusing experience for the students, as it does not make much sense that they would keep trying to do the same assignment over and over again without a misunderstanding being at the basis. Students seem to be expecting an instant reward, and when this does not happen they have in certain cases retried multiple times before realising that the delivery is supposed to be corrected by a teacher.

This has been the cause of a frustrating experience for teachers, as they receive multiple deliveries from the same student on the same assignment. This makes for extra work which does not benefit either them or the student, and if these ´´extra" deliveries are left uncorrected, they are kept as a part of the uncorrected pool, which again affects the number of uncorrected deliveries at all times. This can make for a recurring frustration, as it is hard for teachers to keep track on relevant incorrect assignments.

It follows that this makes for an ineffective design, where a teachers job is distracted by irrelevant deliveries, and their feedback is hard to make use of; the time that passes between a student's delivery and a teacher correcting it increases the likelihood of forgetting what they thought while solving, and where to find the assignment they are receiving feedback on.

9.5.2 The Chat Design

ERA and Enki's chat design is comprised of different rulesets and limitations for teachers and students which complicate how effective the chat is in enabling communicating and portraying the correct messages, affecting the UX of both user groups (8.3.2). For a student, Enki provides the following limitations on their chat:

1. Students are unable to see the chat as they solve assignments.
2. Students are unable to see a message history.
3. There is no distinction in the notification between receiving a message from a student and a teacher.

These limitations differ from the ones in ERA, where a teacher can see all messages and the different communication channels clearly (i.e. class chat and private chat), but there is a significant difference here: teachers can not send messages to offline students, but students can send messages to offline teachers.

It follows that this makes for an ineffective design, as students are able to send private messages to teachers which are never to be seen, meaning that teachers are unable to see messages which are sent from students when they were offline. In addition, teachers are unable to send messages which are guaranteed to be seen to their class. Making it a less viable communication tool when they are to make announcements for their class as they play Enki.

9.5.3 Labelling of Assignments Between Enki and ERA

Teachers are currently unable to communicate how a student should go forth to find a specific assignment of their choice. This causes problems, as it is impossible for the teacher to make a student revisit an assignment where they have a less than pleasing score.

9.5.4 Redesigning Cross-Functionality

It follows from this discussion and findings that the cross-functionality between Enki and ERA has significant room for improvement. The following list summarises significant changes that I recommend implemented in a revised design. Further work must be done in order to find quality assured ways of implementing them into the design.

Improving the *deliveries* design: The deliveries design must be improved in both Enki and ERA. For Enki it is important that students are only able to deliver a single assignment, that it is easy for a student to see what they delivered, and to retry the assignment they have received feedback on. For ERA, it would be beneficial to notify the teachers when they have uncorrected deliveries.

Improving the *chat* design: The chat design can be improved in two ways. (a) Teachers and students private communication can be improved by implementing a seen/unseen system for chat messages. This could make Enki's chat a more viable option for teachers, as they could send messages to offline students. In addition, a chat history for chat messages should be implemented on the client, so that a student is able to keep a conversation going, both in private and class chat. (b) To improve the game communication for teachers, their messages must be seen. This can be done by making it possible for teachers to send announcements for their students. This information would be available for students regardless of their choices.

Improving traceability of assignments between Enki and ERA: Enki and ERA's design can be improved by adding traceability between the assignments in Enki and how they are portrayed in ERA. Unique identifiers for assignments and the corresponding NPCs can be put into pluch such that it provides a way for teachers to communicate which NPCs have which assignments.

9.6 Technical Aspects

When technical malfunctions create significant errors, a challenging and frustrating UX for both teachers and students ensues. In such a situation where an entire class is struggling with getting the game to work, the teacher is expected to be able to help or resolve the situation. However, neither Enki's website, the game, or ERA provide any information about the possible presence of a technical error (8.4.3). Therefore, a teacher's technical competence is put to the test without any help from Enki, making a challenging and frustrating UX for teachers.

It follows that a severe technical malfunction makes for a bad UX, and when experienced multiple times, it may lead to that teachers stop using the game altogether. But as these technical malfunctions differ in severity: they affect the UX in a variety of ways (8.4.1). When only a few students are affected, these errors often go unreported (8.4.2). This includes when the game malfunctions by flashing (8.4.4), being unable to load (8.4.5), or crashing (8.4.6). In addition, when errors are present in the in-game assignments teachers or students have no way of reporting them (8.1.6). Altogether, this makes for a frustrating and annoying UX for the students and teachers.

In addition to the game having technical difficulties from time to time, teachers experience technical malfunctions with ERA aswell. The reports indicate that ERA's real-time connection layer (i.e. what enables a teacher to keep watch on what their students are doing in-game) malfunctions and gives no message to the teacher of what is going on (8.4.7).

9.6.1 Redesigning Technical Aspects

It follows from the findings and this discussion that the UX of both user groups is affected by the technical aspects. To ensure a better UX, I recommend the following:

Minimise the number of errors: Rigid test routines can be put into place to ensure that the different devices and browsers which Enki and ERA is to work in does not create unexpected problems for the users.

Empower users by notifying them of what is wrong When known errors occur in Enki and ERA, providing error messages, notifications, and practical information of what is going on can empower a user to resolve their problems. This can be done through Enki and ERA and through the webpage by which they are accessed.

9.7 Discussing the Research Questions

In this section I will provide an answer to the research questions, which follows from the discussion up to this point and may be considered as a summary of what has been presented thus far.

9.7.1 How is Enki and ERA Experienced by Teachers and Students in the Classroom?

Enki and ERA are in most cases experienced by teachers and students as a positive and enjoyable classroom activity. Although this study has found that Enki and ERA's design has room for improvement, it does not mean that it is unable to provide an enjoyable and motivating classroom experience for teachers and students. It helps to create a *flipped classroom* for teachers and gives the students autonomy to work with assignments at their own pace. Teachers experience that their students are motivated to progress in-game as long they are able to receive help when needed.

9.7.2 Why are Teachers Using Enki and ERA in their Classroom?

Teachers use Enki and ERA as it provides a learning environment adapted for the classroom which is suited for the Norwegian curriculum in upper primary school. In most cases it engages students to do problem-solving assignments as a part of a motivating game experience. Teachers use Enki mainly for mathematics during school hours, as it seems to provide assignments which are well-adapted to the upper primary school within this subject. The combination of Enki and ERA makes for an easy-to-use management and learning analytics tool, which helps teachers to manage and keep track of students in-game behaviour. Although teachers experience that neither Enki or ERA is supporting them and their students learning as well as it could, it makes for a viable alternative for a classroom activity.

9.7.3 How is Enki and ERA Supporting the Teacher?

To answer if Enki and ERA are supporting the teacher, one must see the question in relation to a teacher's daily activities. On the one hand, Enki and ERA are providing the proper support for a teacher to run a classroom game adapted to the Norwegian curriculum without running into problems. On the other hand, Enki and ERA does not provide a learning experience which can support a teacher in their everyday goals as teacher. This again can be seen in relation to teachers usage patterns with Enki, as it is today, the game is merely used as a classroom activity, which in some cases supplement the teachers learning activities. If Enki and ERA were to be used by teachers as an activity which supported their day to day teaching activities, it would fail as it is not designed to provide the teachers with the necessary information for this purpose.

Enki seems to provide a low learning value for students when they use it by themselves, but in a classroom setting with a teacher available it motivates for a supportive and collaborative learning environment. Therefore it supports the teacher in providing a motivating learning environment for their students, but it fails to support their students' learning experience within it. It requires a teacher to be available for the student during the gameplay, and when many of the students are in need of help at the same time, it makes for a challenging situation for the teacher.

Consequently, Enki and ERA does not give teachers a comprehensive overview of what the students are struggling with in-game — what an assignment involves, where they answered incorrectly, and so on — it does not support the teachers' need of making use of the data collected from the in-game activities. ERA does not support a teacher's need for an overview of their students' achievements in a classroom situation, and the learning analytics are imprecise and provide little information about how their students perform outside of a single rating on an assignment. However, the current learning analytics that are provided by ERA are important for the teachers experience as it gives a sense of control of what their students are doing in-game.

9.7.4 How Can Enki and ERA be Redesigned to Better Support the Teacher?

Redesigning Enki and ERA to better support the teacher should provide better support for learning within Enki, and provide better learning analytics within ERA for use both inside and outside of the classroom. I have suggested how this can be done through a redesign consisting of 4 parts:

1. Redesigning Enki
   (a) Scaffolding the gameplay
   (b) Supporting adaptive learning
   (c) Instructional support
   (d) Improving the reward system
   (e) Improving the assessment model
   (f) Improving the formative evaluation
2. Redesigning ERA
   (a) Giving an overview of the assignments in Enki
   (b) Giving a statistical overview of the class and students based on assignments
   (c) Constraining statistics based on time
   (d) Enabling a realtime overview of class activity
   (e) Improving the metric for learning analytics
3. Redesigning Cross-Functionality
   (a) Improving the *deliveries* design
   (b) Improving the *chat* design
   (c) Designing a way to label assignments in Enki from ERA and the other way around
4. Redesigning Technical Aspects
   (a) Minimise the number of errors
   (b) Empower the users by notifying them of what is wrong

To properly quality assure these designs, further research must be done on how to create the design solutions for these issues within Enki and ERA.

Chapter 10

Conclusion

In this chapter I will summarise the research done throughout this thesis, and provide some reflections on what I have learned during this work.

10.1 A Summary of the Thesis

In this thesis I have presented the making of educational games for the classroom as a "Wicked Problem", and made the case that edtech such as educational games may be a medium where one can introduce the newest findings within research on learning into the formal educational system for students, and support teachers through sophisticated learning analytics which make it easier for a teacher to keep a detailed overview of how his or her students are progressing in a digitally modelled curriculum.

Then, I introduced a project which is led by a teacher trying to make such a educational game which can easily be adopted into the Norwegian school and explained how the game is designed. I then presented my contribution to Enki which took place in February 2014 until December 2014 and involved the making of an Educational Resource Application (ERA). A collective case study followed, which evaluated the use of Enki and ERA in a classroom context. Here I investigated how well Enki and ERA supports teachers in this environment, and went into the hows and whys of the UX for teachers and students.

The results from the case study ensued, where the participants and findings were presented. These were split up into four distinct parts: Enki, ERA, cross-functional matters, and technical aspects, which touch upon different aspects of the UX of Enki and ERA. The following chapter discussed these parts in seperation. The findings were interpreted and shown in light of the literature analysis introduced in Chapter 3. The primary goal was to inform the next version of the design for both Enki and ERA. I concluded the discussion chapter with answering the following research questions:

1. How is Enki and ERA experienced by teachers and students in the classroom?
2. Why are teachers using Enki and ERA in their classroom?

3. How is Enki and ERA supporting the teacher?
4. How can Enki and ERA be redesigned to better support the teacher?

10.2 Notes on the Design Process

Before this research project, neither Enki or ERA had undergone a systematical evaluation. The implemented design can be seen as subject to a perspective bias, where the needs and understanding of the teachers' role has been driven by the project lead. During the design-process, the main stakeholders which informed the design was the project team, and the project lead acted as a decision-maker with numerous important roles within the project. This meant that main design decisions were informed by the perspective of the project lead, leaving out the perspective of other important stakeholders such as external teachers and students. In retrospect, it is easy to point out that many of the decisions made at the beginning of the project were subject to a harmony perspective. As a designer I failed to recognise that there were potential conflicts between the project team, the project leader, and the perspectives of other stakeholders which would in turn affect how the design performed in its use-context.

It follows from this that when one is to perform research through design, one must accept that there is a significant difference between performing research and making a product with a deadline. If I had acknowledged this before planning the project, it might had become clear that there were scarce resources and unrealistic deadlines for this to be a successful research through design project where the original ambitions of supporting a teacher's role in the classroom could be maintained. The research project was affected by this, and it is not optimal that the designs themselves were not thoroughly tested on end users before the case study: the pressure was put on making what Zimmerman, Forlizzi and Evenson (2007) term as a *design practice artefact* (i.e. a commercially viable product) instead of making a *research artefact* (i.e the *right thing*).

The clear separation between the goals of a research project and a commercial project created a challenging situation, where negotiating for a more time-demanding design process would be in direct conflict with the project leader's interests. However, by accepting and recognising these conflicting goals, I could have chosen to take on a conflict perspective, which follows from Nygaard and Sørgaard (1985) whom state that this is only possible through conscious choice; accepting that there may be basic and potentially unresolvable conflicts between the stakeholders interests in a project.

As the design was informed by my document analysis and communication with the project team in the initial design process, it later became clear that the project team was just one of many stakeholders, and by excluding other significant stakeholders such as teachers and students it meant that the design was biased towards a specific perspective. Important information and feedback would be "filtered" through the project team perspective before being communicated to me and making its way into the design. It was up to this group of stakeholders and their interests to choose what information I had access to, and it made them the interpreter of what could be important information to include for the design, and through my subsequent observations and interviews it was discovered that many views were left out duringng that stage.

To make a successful design, it can be seen as the designers job to recognise, confront, negotiate, and compromise on the conflicting interests between stakeholders (ibid.). In this case it would have meant to adopt a conflict perspective at an early stage and reflect on what it meant to use the project team as the main design informants, along with a single teacher which may have been too heavily involved in the project to inform a design which were to be representative for a wide range of teachers. Involving end users at an earlier stage of the design-process could have been done to ensure that the *right thing* was in the making, and perhaps it may have made the end result an even more viable option for teachers in and outside a classroom situation.

With this in mind, the end result of the design-process did provide a starting point for making the *right thing*. The design-process did enable an evaluation of Enki and ERA at a stable version in a classroom setting, and this without running into usability errors which affected teachers and students in such a way that it affected the results in a major way. I was able to extract information about how the design affected teachers and students in a classroom setting where they expected it to work properly. This made me get a better understanding of the needs of teachers and students regarding educational games which are to be beneficial for both user groups both inside and outside of the classroom situation, and makes a statement from Winograd and Flores (1986) come to mind:

> "[It is through] the emergence of new tools, we come to a changing awareness of human nature and human action, which in turn leads to new technological development. The designing process is part of this "dance" in which our structure of possibilities is generated." (ibid., p.163)

The structure of possibilities within Enki and ERA could be thoroughly seen through actual use in a classroom setting, and a more solid understanding of what teachers expect and need from such a a classroom application was discovered through an evaluation which originated from actual user-experiences.

10.3 Notes on Research Through Design

Performing *research through design* makes for a challenging situation for a single designer without a team. It requires a versatile designer with a wide collection of hats. During this project I have had to combine the real, how, and true knowledge to design and create a working application. I have had to function as, among others, a researcher, a user-experience designer, a programmer, an information architect, a project manager, and a software architect. Changing between these different roles has been challenging, and transitioning from a developer and designer for the last version of ERA into a researcher conducting field studies was particularly tough.

During the observations there were several occasions where I struggled to keep the researcher's role: as they struggled with getting Enki to work on browsers which were unsupported, as students asked me if I came from the game company whom made Enki, as teachers used ERA in peculiar ways, as students struggled with gameplay. If I was to interfere, provide user support, or help with the gameplay, it would bias the results through affecting teachers and students actual UX.

Performing research on the use of Enki and ERA when having a strong affiliation with the company, the products, the project team, and the design of ERA made for a tough experience when coming to terms with the product's limitations. It was hard to accept what the interviews and observations had uncovered in reality, and to write about how these limitations were affecting the UX of the product as a whole.

The lesson to be learned was that it must be considered an exercise to distance oneself from the work that has been done as a designer. I am not a representable end user for what I have designed, and it is unfair practice toward the end users to believe that I am able to adopt the perspective of someone with a completely different background without performing rigorous research on their perspective. Even though multiple users may provide conflicting opinions, a designer must stay curious, investigate, negotiate between stakeholders, keep an open mind, and create solutions and designs which empower the end users.

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