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A serious game to motivate children to do homework

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Abstract

In this master thesis the concept Mænage School was created based upon theories about serious games, gamification, and game-based learning as well as the experiences and opinions of 17 pupils and 8 teachers. Some applications targeted towards Norwegian elementary school pupils were also investigated. The intent of this concept was to explore if game design can boost pupils' motivation towards homework, and if such a concept can help the teacher adapt to each individual pupil's skill level more efficiently. Three iterations of user testing resulted in two high-fidelity prototypes being made, one Unity application for the pupils' aspect, and one web application for the teachers'. This thesis concludes that serious games can positively affect pupils' motivation towards homework. A digital concept such as Mænage School can provide a range of utilities compared to what the traditional homework sheet does. However, thorough research must be conducted on this challenging userbase when making such applications, since the technological and cognitive abilities of children differ greatly between school year two through seven. In addition, no teachers are alike and differ in technological skills and preferred teaching approaches.

Sammendrag

I denne masteroppgaven ble konseptet Mænage School laget med grunnlag i teorier om serious games, gamification og spillbasert læring, i tillegg til erfaringer og meninger fra 17 elever og 8 lærere. Noen applikasjoner målrettet til elever i norsk skole ble også utforsket. Hensikten med dette konseptet var å utforske om spilldesign kan øke elevers motivasjon til å gjøre lekser og om et slikt konsept kan hjelpe læreren med å tilpasse seg hver enkelt elevs ferdighetsnivå mer effektivt. Tre iterasjoner med testing endte med to high-fidelity-prototyper, en laget i Unity til elevene og en i web-teknologier til lærerne. Denne oppgaven konkluderer med at serious games kan påvirke elevers motivasjon til å gjøre lekser. Et digitalt konsept, slik som Mænage School, kan tilby mange hjelpemidler sammenlignet med hva den tradisjonelle ukeplanen gjør. Med det sagt, må grundig forskning gjennomføres på denne brukerbasen når man skal lage en slik applikasjon, ettersom de teknologiske og kognitive evnene til elever er veldig forskjellig mellom andre og syvende trinn. I tillegg er lærere forskjellige fra hverandre både med tanke på teknologiske ferdigheter og undervisningsmetoder.

Preface

This thesis project concludes my Master of Science degree at the Department of Computer Science at the Norwegian University of Science and Technology in Trondheim. This project has been supervised by Alf Inge Wang and Ole Andreas Alsos. The foundation for this thesis has been Serious Games AS' Mænage, a serious game that focuses on making chores fun together with the family.

I would like to extend my thanks to Alf Inge and Ole Andreas for their guidance and feedback during the process. My dear friend and professional Unity developer Anders Kvalvaag also deserves thanks. His ability to give me a crash course in Unity saved weeks of my project. All of the teachers, pupils, and parents who were willing to contribute to the thesis also deserves a big thanks for their commitment to see this thesis completed. Thanks to Anders, Andreas H., Andreas K., and Andreas V. for participating in the ideation process in the early stages of the project. And thanks to Andreas F. for editing the video demo of the concept. Finally, to my amazing wife and English teacher Camilla; thank you for being helpful and supporting through the whole process, and especially for every proofreading.

Marius Ingebrigtsen Lundbø
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I. Introduction

Many educational games were introduced in the early 2000s. These games were not necessarily games for the computer, but for other platforms as well, such as Leapfrog with its interactive pen and book (Druin & Druin, 2009). Games that go under the Serious Games umbrella share the property of having their primary focus providing something else than just pure entertainment (Djaouti, Alvarez, & Jessel, 2011), which typically AAA entertainment games focus on.

A steady growth of people have games as a natural part of their everyday life. Scientists have acknowledged this trend and have studied how one can borrow from the power of games to for instance teach skills in an entertaining media. Even though Serious Games primarily focus on something else than entertainment, one can see the pedagogical value of entertainment properties such as fun.

For many parents, it can be a daily struggle to motivate their children to do homework and school assignments. In addition to this it is a challenge for the teacher to provide homework that fits the individual skill level of each pupil. It is not rare that the whole class receives the same homework, even though they have a need for a personalized homework sheet. This thesis aims to harvest the power of Serious Games by creating an innovative concept to meet the need of young pupils of different levels. The goal is to make it easier for the teacher to adapt challenges to the individual child, without taking up more time than making the normal homework sheet itself. The concept, 'Mænage School', was built upon the Serious Game 'Mænage' by Serious Games AS, which has recently seen great results in motivating children and parents doing chores together (Universitetsavisa, 2017).

According to SSB, Norwegian grades in schools are low, with mathematics being the lowest with 3.7 average (where 6.0 is top score) and even lower for boys (Utdanningsdirektoratet, 2017) . According to some (Pham, 2010), pupils can have varying motivation for doing homework based on socio-economical background. There is also a discussion going on based on if homework works for improving grades. For the sake of the thesis and the fact that a big majority of Norwegian schools practice homework, this thesis will not comment on that discussion but rather focus on making the activity of doing homework more fun by itself. According to Thomas Dahl from the Department of Teacher Education at NTNU:

> *"The main problem with homework is that it is not good enough considered what the homework should be and what it should contribute to. Often pupils can get homework that they have no prerequisite for handling, thus resulting in a marginal outcome".*
>
> Translated to English from Dahl (2015)

In the same interview, Dahl states that he is pro homework because he claims that pupils can benefit from practicing at home what they have learned in school. This would mean that the best way for a pupil to learn is by doing homework that is custom-made to the level of the pupil.

This places a great burden on the teacher, as he or she will have to tailor the homework of every pupil in the class. With Mænage School, the goal is to make it easier to adapt homework to every pupil's individual need within reasonable time, so that the pupil gets more out the learning process, and the teacher is able to complete his or her work within a reasonable time.

The Serious Game American Army (Zyda, 2005) saw great potential in teaching skills to people. In Norway 35% of the population plays digital games each day, where 80% of them are boys in the age 9-15 years (Vaage, 2017).Women play just as much as men when it comes to tablets and smartphones. This gives confidence that there is a time and a place for games, and that trying to use games as motivational drive for homework in the desired target group could be possible. How the work gets presented to the user can affect the motivation greatly since we tend to get more motivated if we think we are playing a game (Wang & Lieberoth, 2016). Because of this, the thesis focuses on the users' opinions and experiences throughout the whole process.

Research Goal

Given the challenges above, the research goal of this thesis is to **explore if game design can boost pupils' motivation towards homework, and if such a concept can help the teacher adapt to each individual pupil's skill level more efficiently**.

Limitation of Scope

The scope of this thesis is limited by focusing on one platform for one each of the user groups, which were Android tablets for the pupils, since the application it builds upon is made for tablets, and PCs using Google Chrome for the teachers. The concept is intended for pupils between 2nd and 7th grade of Norwegian elementary school since not all pupils receive homework in 1st grade.

Research Questions

Given the challenges and goal above, the following research questions were created:

(RQ1) How does Mænage School affect pupils' motivation towards homework?

(RQ2) How can a digital tool like Mænage School make it easier for the pupils to do homework?

(RQ3) How can Mænage School help teachers adapt homework to pupils of different skill levels in a school class efficiently?

Research Design

A number of research methods were applied to the conducted research, such as interviews, observations, questionnaires, and document inspections. The research strategy chosen for the thesis was design and creation, where the IT system itself is considered the research. The process throughout was based upon the human-centered design framework in ISO 9241-210 (International Organization for Standardization, 2010), by having multiple iterations over the prototypes and always asking the intended users for feedback on the changes. After each new iteration, the users conducted a scenario test case, evaluated the solutions using System Usability Scale, and gave their thoughts and opinions about the prototype. The first two iterations with prototypes were paper prototypes and the final two in the last iteration were high-fidelity. One was made in the game engine Unity, the other as a web application in Vue.js. For the last test case the users also answered a questionnaire related to the research questions used for discussing and concluding the thesis.

Structure of the Thesis

The thesis is structured in the following manner:

Chapter II presents a literature review and establishes a background with relevant theories and work of serious games, game-based learning, and gamification, as well as presenting applications that either tries enhancing learning or motivation through the use of game design.

Chapter III describes iteration 0, the preliminary study, which consists of defining the research methods and how they were used in the thesis. Data was collected from pupils and teachers in Norwegian elementary schools to determine the use context. Based on this data, personas and scenarios illustrating a wide range of problems were created.

Chapter IV describes iteration 1, the concept generation, where information from Chapter III was used in a bottom up approach to make the first iteration of the "Mænage School" concept, two paper prototypes that were tested on users.

Chapter V adapts to the feedback from the previous Chapter and discusses the changes made to both paper prototypes before they were brought back to users for new feedback.

Chapter VI presents the final requirements and discusses choices made regarding technology. It also describes the software architecture that made up two high-fidelity prototypes: one Unity application for the pupils and one Vue.js application for the teachers. Both prototypes were tested in their intended environments and the users gave feedback that was used to answer the research questions of the thesis.

Chapter VII discusses the results from Chapter VI, evaluates research methods, describes challenges that occurred during the project, and answers the research questions, as well as the future of the concept.

Chapter VIII sums up the research questions and research goal, as well as offers some concluding remarks to the thesis.

II. Background

This Chapter is a literature review conducted with the intention of understanding the state-of-the-art of serious games, game-based learning, gamification, as well as presenting applications that either tries enhancing learning or motivation through the use of game design. After introducing each topic each section explains how the topic relates to this thesis.

1. Serious Games

What is a serious game? All games are serious depending on who you ask, but one of many definitions of the term is: “a game in which education (in its various forms) is the primary goal, rather than pure entertainment” (Michael & Chen, 2005). Another popular definition is Zyda (2005): “a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.” This might sound similar to the term edutainment, but that is mostly thought of as games with obvious education goals often targeted to preschoolers and new readers. In this way, edutainment can be seen as a subset of serious games which aims to target all kinds of education of all ages (Michael & Chen, 2005).

1.1. The G/P/S Model

At this point you might have realized that there are many games that can fit in to the serious games definitions above, so how would you compare two games such as Mænage seen in Figure 1-1 and SPARSim in Figure 1-2? Both have a primary goal rather than pure entertainment but are very different games. One is trying to make chores fun together with the family as a drag-and-drop management application for a whole family, and the other one teaches employees different skills needed in their work such as food safety, correct customer care, and wastage handling through a first-person view (Attensi AS, 2017).

Figure 1-1: Screenshot from Mænage

Figure 1-2: Screenshot from SPARSim (Attensi AS, 2017)

Thankfully, Djaouti et al. (2011) provided a common ground with a model for rapid classifying serious games seen in Figure 1-3. As the figure shows, there are a lot of different fields that fit in to serious games, but they all agree that serious games have a “serious” dimension combined with a “game” dimension. Before this model there were only ways to categorize them after one of the dimensions- the “serious” side or the entertainment side.

Because of serious games' dual nature the G/P/S model encapsulates the "game" dimension in the gameplay section, and the "serious" dimension in the scope and purpose section, which gives a general overview of how a game is played and for what purpose it is designed (Djaouti et al., 2011).

Figure 1-3: A representation of the G/P/S model

Gameplay

In general, games lacking goals will be considered play-based, while video games featuring goals will be considered game-based. For example: A teacher might select a play-based game in order to set own free goals in the classroom. When you get 10 words correct we go out, versus when you have completed the game we can do something.

Purpose

A game can be designed for zero or more purposes. It can be Message-broadcasting, such as Educative (Edugames), Informative (Newsgames) Persuasive (Advergames), and/or Subjective (Art games). It can also be Training, such as physical or cognitive skills through Exergames, or Data exchange- games that collect or encourage players to exchange information.

Scope

A way of stating the domain of the intended target audience.

1.2. Using Serious Games

As seen of the G/P/S model, anyone with something to teach, or information to pass on could tutor this through a serious game. Serious games are used in many different markets and can extend the use of film and books by allowing the user to put their skills to the test (Michael & Chen, 2005). For a player to have fun, games tries to immerse the players, which is a familiar concept even if you do not play games because even when we were young we were playing around. A challenge can be that educators stand for the "serious" part and game-designers stand for the "game" part, and normally one person is not both. Therefore, both roles must share their domain knowledge with each order in order to leverage the full potential of serious games.

1.3. Summary

One of the objectives of this thesis is to come up with a new concept that expands upon the serious game Mænage, which will be explained under subchapter 4 Related Work. This serious game concept has a primary purpose of motivating pupils in Norwegian elementary school to do homework. The scope of the game is therefore the education market for kids attending second through seventh year of school, its purpose is mental training through homework, and would either be designed play-based without goals, or game-based featuring goals.

2. Gamification

Gamification can be defined as “the use of game design elements in non-game contexts” (Deterding, Dixon, Khaled, & Nacke, 2011), or as “using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems” (Kapp, 2012). The term gamification has had a negative vibe to it as the term was often misused by adding points, leaderboards, and badges to an application so that marketing could call it “gamified”, but to be successful it must include game design beyond the game components, as well as having some intrinsic value present to further boost engagement of (Deterding, 2012).

Take Habitica (2018) in Figure 2-1 as an example; Habitica uses lots of elements from games to motivate their users to achieve their goals and stay productive, but at its core Habitica is a habit tracker and to-do list. To further engage with the user, it gives you an avatar presented as a role-playing game character with an iconic class where its resources are fueled by your ability to stay productive. You can also gain experience, do quests, level up, and defeat monsters with your friends. Without the habit and to-do aspect the application would only be a big collection of game mechanics with no intrinsic value to the users.

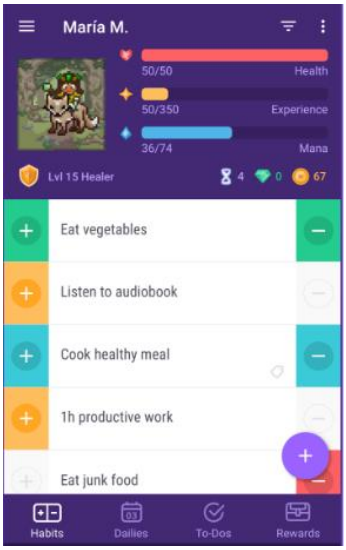

Figure 2-1: Screenshot from Habitica mobile application

Gamification is different from serious games since serious games are full-fledged games with a purpose other than entertainment purposes, whilst gamification only incorporates elements of games.

2.1. Summary

At its core, the concept from this thesis would only be a digital homework sheet. However, in order to motivate the children to do homework it could use game design elements such as mechanics, aesthetics, and game thinking to make it feel more like a game. To know what would be worthwhile to borrow from games, the next subchapter looks into how to keep engagement up with game-based learning.

3. Game-based Learning

To keep a user engaged throughout a game it is important to keep the user experience fun, intrinsically rewarding, and that the difficult is just right. To be aware of what is needed to keep a learner engaged in a game this subchapter delves into what make things fun and engaging.

3.1. What Makes Things Fun to Learn?

To keep children intrigued, it is vital to keep a game fun. But how can we strive to make it so? Malone created a set of heuristics for designing instructional computer games, where all the principles follows: “intrinsic motivation; activity is fun or rewarding by itself, not by an external reward” (Malone, 1980). According to Malone, the categories are challenge, fantasy, and curiosity.

Challenge

For a game to be fun it needs to provide a goal, which is the objective of the game, and the way to achieve this goal is uncertain. Under no circumstance should the player be in doubt of their goal of the game. The game can make the goal obvious or allow the user to come up with appropriate goals by themselves. Good goals are often practical or fantasy, and players should be able to know if they are getting closer to their goal or not.

To keep the outcome uncertain, we can vary the difficulty, either by letting the players set it themselves, or base it on how well they play. We can also have multiple level goals, that is, getting better and better score or doing something as fast as possible. If we hide information and reveal it selectively we can also provoke curiosity and make it more challenging. Lastly, randomness can be used to guarantee a varying outcome. Succeeding on challenging content can boost self-esteem but failing it can have the opposite effect.

Fantasy

Fun can be achieved through the use of fantasy goals as well, hereunder extrinsic fantasy, intrinsic fantasy, and emotional aspects of fantasy. Extrinsic fantasy depends on the user to use a skill correctly. Intrinsic fantasy uses the same as extrinsic, but the user also must reflect of what they know of the fantasy. Emotional aspects of fantasy appeal to different emotions by introducing a strong theme.

Curiosity

Players will try to feed their curiosity, we can keep them curious by having an optimal information complexity, neither too simple or too complicated with what they already know in mind. There are two types of curiosity: sensory and cognitive. Sensory curiosity can be affected by changes in sensory stimuli, such as light and sound. Cognitive curiosity is achieved by rendering current knowledge incomplete, so that players want to make sense of it again. In

addition, a responsive environment can cause curiosity, either by being surprising (randomness), or by being constructive.

3.2. Flow and GameFlow

Probably most people have had an experience of such magnitude that they lost track of time, what they got out of it was no longer important, and it felt like the most rewarding thing to do by itself, we call this experience Flow (Csikszentmihalyi, 1990). However, Flow is not limited to games, you can just as well achieve the Flow experience from Candy Crush as well as rock climbing. It is most common to occur if the activity is goal-oriented and is intrinsically rewarding. There are eight parts to the Flow experience:

- a task that can be completed
- the ability to concentrate on the task
- that concentration is possible because the task has clear goals
- that concentration is possible because the task provides immediate feedback
- the ability to exercise a sense of control over actions
- a deep but effortless involvement that removes awareness of the frustrations of everyday life
- concern for self disappears, but sense of self emerges stronger afterwards and
- the sense of the duration of time is altered

GameFlow is a framework built for understanding enjoyment in games, and is built upon the eight steps of Flow (Sweetser & Wyeth, 2005). It is not used as an evaluation tool, but rather a tool for uncovering issues and how these issues affect player enjoyment. The GameFlow framework can be seen in Appendix A.

3.3. Experiential Gaming Model

Studies have found that there are conditions that help us achieve the Flow experience, and it can provide properties that can aid learning. The experiential gaming model (Kiili, 2005) describes how players can learn as problem solvers and explorers by letting the user creatively think, reflect, and test solutions.

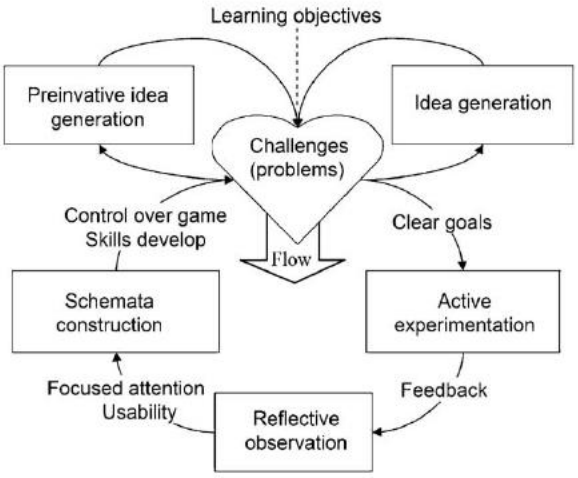

Figure 3-1: Experiential gaming model

First, the user is faced with a set of challenges with the purpose of learning. Ill-structured problems do not have definitive answers, and therefore offers more opportunities for using different problem-solving strategies (Kiili, 2005). The preinvative idea generation phase lets the user generate unstructured and chaotic ideas without any constraints and considerations. From there the ideas are introduced to constraints and resource limitations in the challenges. While the ideas are generated the user actively tests the ideas and receives feedback on them to be able to further iterate on them. The goal is that when enough iterations are completed, the user can control the learning objectives of the challenges.

To keep the Flow experience going throughout this process we need to ensure that the challenge is just right for the user, so as the user gets better at the skill, the difficulty should increase with them, but not too difficult, as shown in Figure 3-2.

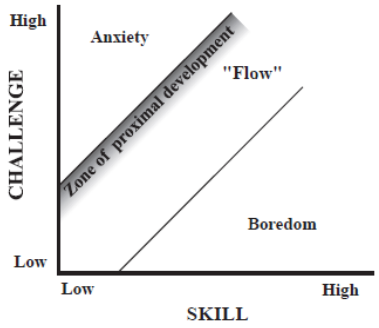

Figure 3-2: Three channel model of flow

The Experiential Gaming Model does not cover means for designing a whole game, and only acts as a link to the educational theory. For instance, it does not cover topics like storytelling, game balance, and optimizing cognitive load, which all are important topics when designing a game.

3.4. Summary

For the new concept to be engaging and achieve a rewarding and engaging experience the pupil would always need to have an appropriate challenge and know what that challenge is. Since the challenge would be set directly by the teacher, a way of achieving this would be to ensure the teacher knew what would be appropriate to each individual pupil. In addition, for allowing the pupil to think creatively, reflect, and test solutions as well as spike their curiosity, the concept would need to allow presenting information in parts. There would also need to be some factor in the game that would create an intrinsic rewarding effect.

4. Related Work

This subchapter briefly describes the predecessors of the ‘Mænage School’ concept, ‘Mænage’ and ‘Mænage Extended’, as well as applications that either tries enhancing learning or motivation through the use of game design intended for the Norwegian school system.

4.1. Mænage

Mænage is a play-based serious game by Serious Games AS that focuses on making chores fun together with the family (Aakervik, 2017; Alsos & Nordahl, 2017). You can divide tasks among each family member by either dragging or shooting a task into the appropriate family member’s container. The container serves as a way to quickly get an overview over what is to be done. When you complete a task, it will fall into a pool containing your other completed tasks. The bar with the icon in the middle of the pool represents a goal for motivational purposes, this can be gaming time, allowance, items, or other activities. Lastly, you get to see all the tasks you have completed at the very bottom. The initial design of Mænage was created by Camilla Dahlstrøm in the summer of 2016 and further by said person in TPD4195 Design Studies (Dahlstrøm, 2016), the final design you see in Figure 4-1 is made by Serious Games AS.

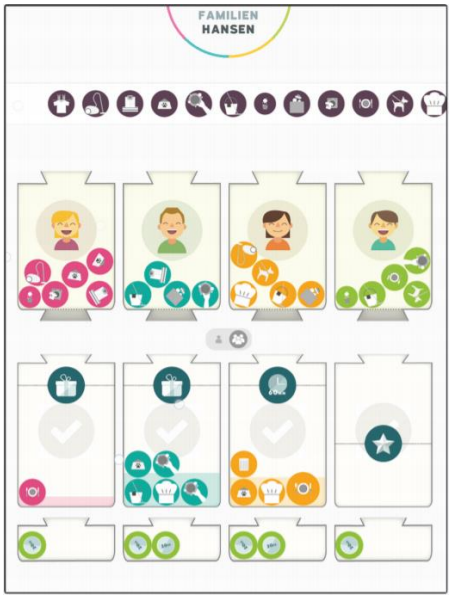

Figure 4-1: Screenshot from Mænage

4.2. Mænage Extended

Mænage Extended is built on top of the Mænage application, and is the final product of Morten Kartevoll's master thesis from the fall of 2017 (Kartevoll, 2017). Mænage Extended proposes a reward model that allows you to sometimes receive medals that reward you additional points. Points are still the measurement for achieving a goal in Mænage. In addition to this it introduces gems as a currency for spending in an in-game store, where you can buy cards. The cards are an alternative way of getting rewards, and parents should be able to customize these cards. Lastly, it features a profile page. This is an overview of all your collected goods, such as gems, bought cards, and medals. Figure 4-2 shows the gem store view, the user's collectibles view, and the medal view. Kartevoll's thesis concluded that a single reward model could not alone make an application intrinsically motivating since it would not necessarily have direct impact on the task's execution (Kartevoll, 2017).

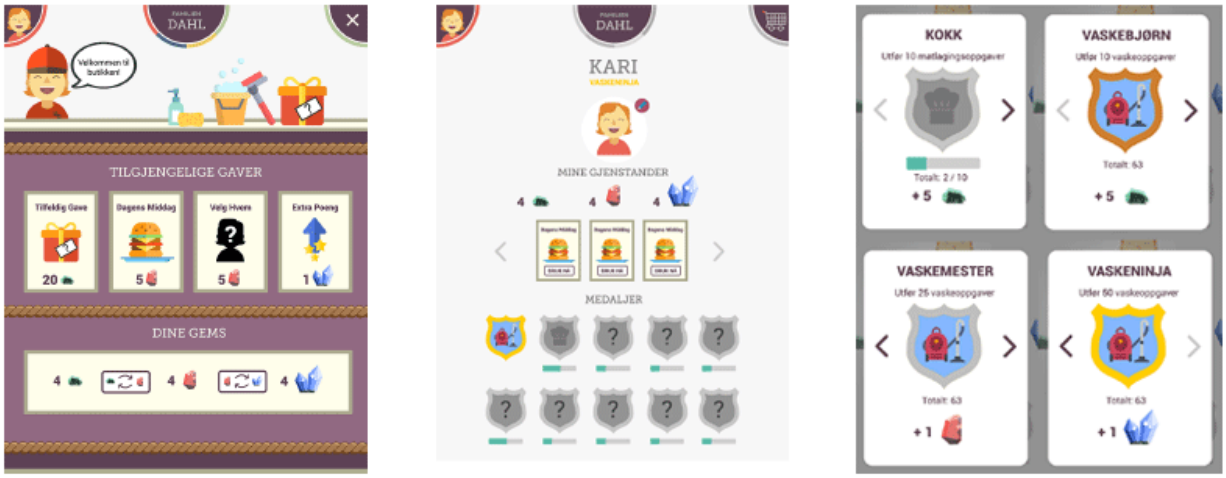

Figure 4-2: Screenshots from Mænage Extended

During the workshops for Mænage Extended it was revealed an interest among the children to include their homework into the application. This is where this thesis steps in and attempts to see if it is possible to achieve this.

4.3. Enki

Enki, seen in Figure 4-3, is a play-full social game for educational purposes focusing on pupils in year four through seven in Norwegian elementary school (Asio, 2018). The pupils customize their own avatars to take on adventuring in different worlds, each representing a subject or topic for example “Kalkulon” for mathematics. The pupils can explore these worlds and complete school tasks in their own tempo based on the official curriculum. After doing tasks pupils get rewarded with stars, and after collecting enough stars pupils can travel to a place with even more difficult tasks. The teacher has her or his own administrative tool and can see statistics on their school class and individual pupils, what all the pupils are doing, give feedback on tasks pupil completes, and toggle the talk functionality of the pupils. The game is available on a wide variety of platforms such as PC, Mac, iPad, and Surface.

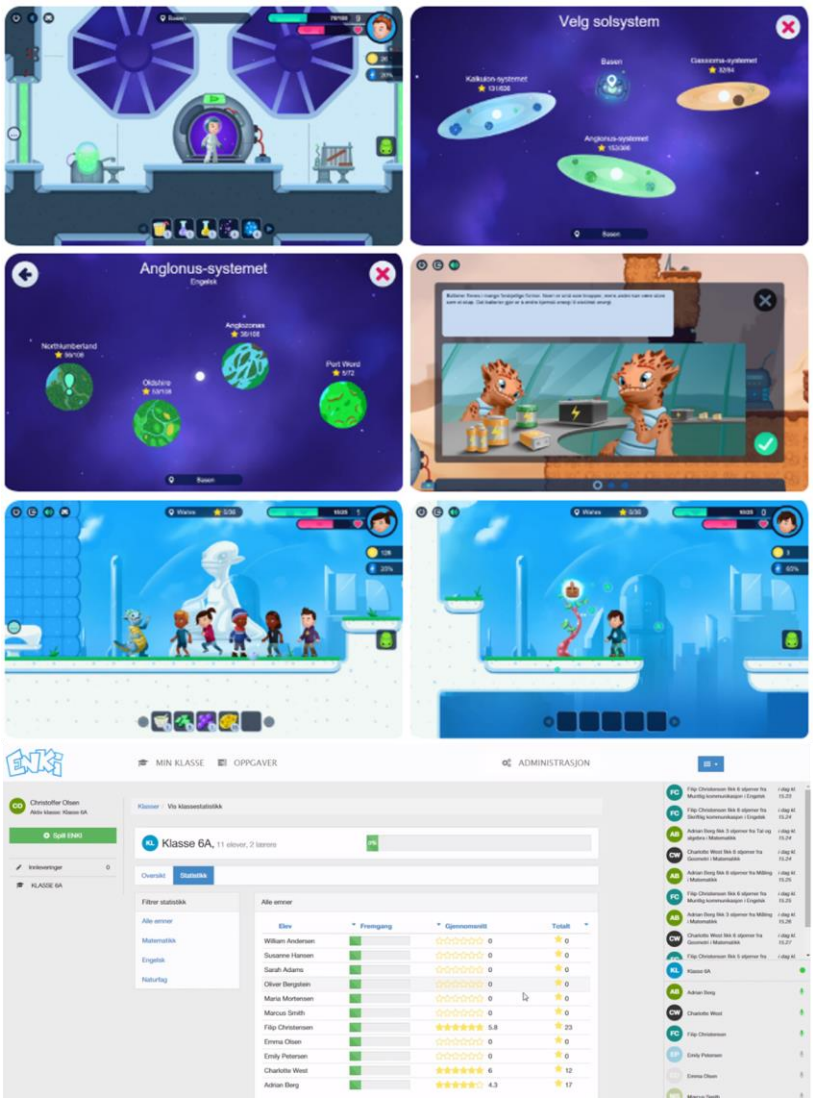

Figure 4-3: Screenshots from Enki (Asio, 2018)

4.4. Campus Increment

Campus Inkrement seen in Figure 4-4 is a learning platform especially made for working with the instructional strategy flipped classroom and provides courses consisting of tasks, evaluations, and videos in mathematics, science, and physics all with the starting point in Capellen Damm's textbooks (Inkrement, 2018). The mathematics courses have curriculum for 5-7th year of Norwegian elementary school, but the teacher can use the author tool to make a course from scratch or from a template. With the version "Campus Skole", the application also provides a homework planner which lets the teacher assign chapters as homework by using a calendar. The teacher can then make their own lectures as well as use the three at-school tools in their lectures; discussion, independent work, and self-evaluation. The teacher can then login and see progress statistics for the whole class or what every pupil has done and what they thought was difficult.

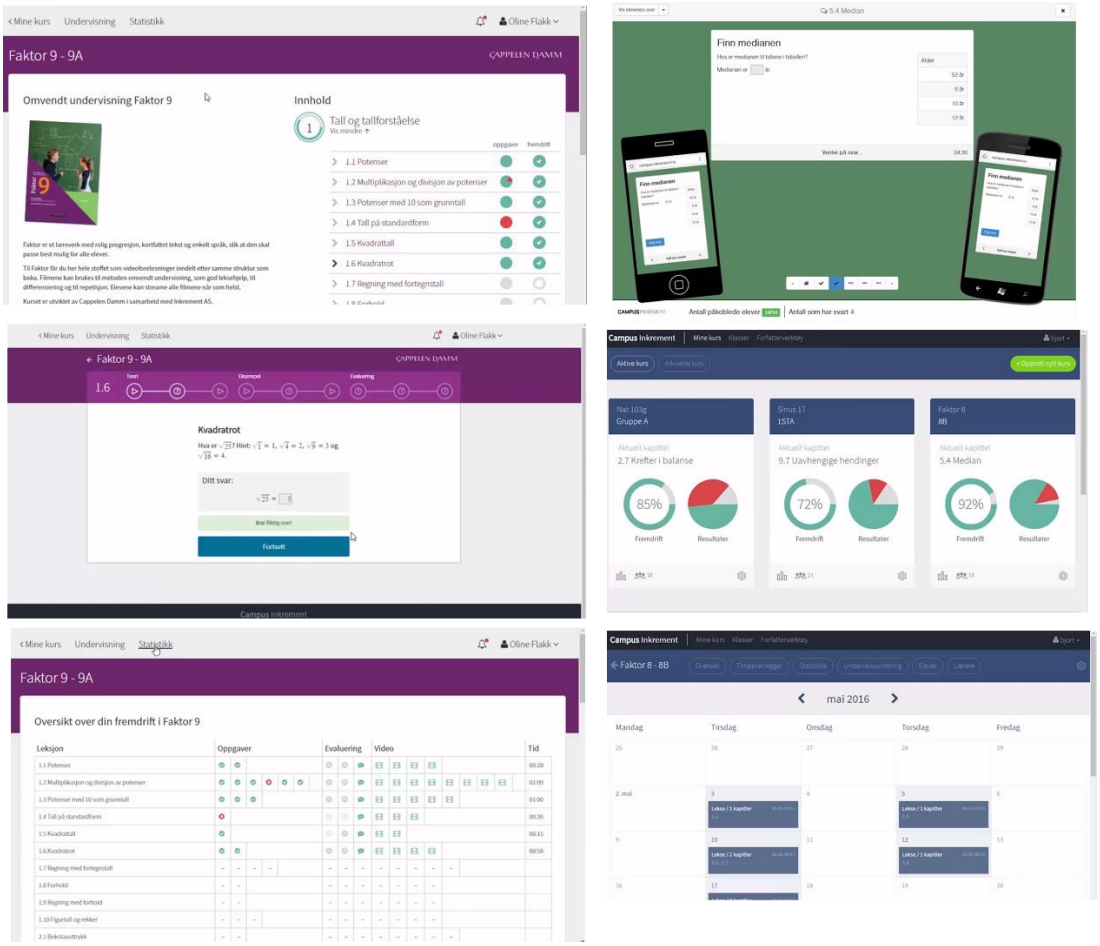

Figure 4-4: Screenshots from Campus Inkrement (Inkrement, 2018)

4.5. Kikora

Kikora, seen in Figure 4-5, is a mathematics program which holds over 30 000 tasks at different levels that supports all school years' curriculums of Norwegian school except the most advanced courses from Upper Secondary school. The platform has various concepts built in, such as GeoGebra, Én Opp, Mattemaraton, Castor, and Kranium (Kikora, 2018). Pupils can work on their own level at their own pace on their preferred device as long as it has a modern web browser available. Tasks is calculated using Kikora's mathematics engine which gives the pupils immediate feedback on their calculations and can even tell the pupil which step in the calculations they did wrong. If they get stuck they can get help through assets such as videos, hints, web links, suggested solutions, and a formula appendix. If the pupil gets the correct answer he or she is rewarded with a trophy. The teacher gets a wide variety of tasks that they can give to the pupils as discussions, assignments, or tests. The teacher gets back the tasks already evaluated which frees up a lot of the teacher's time and can view the tasks as a report for the whole class or inspect every single pupil's calculations if needed.

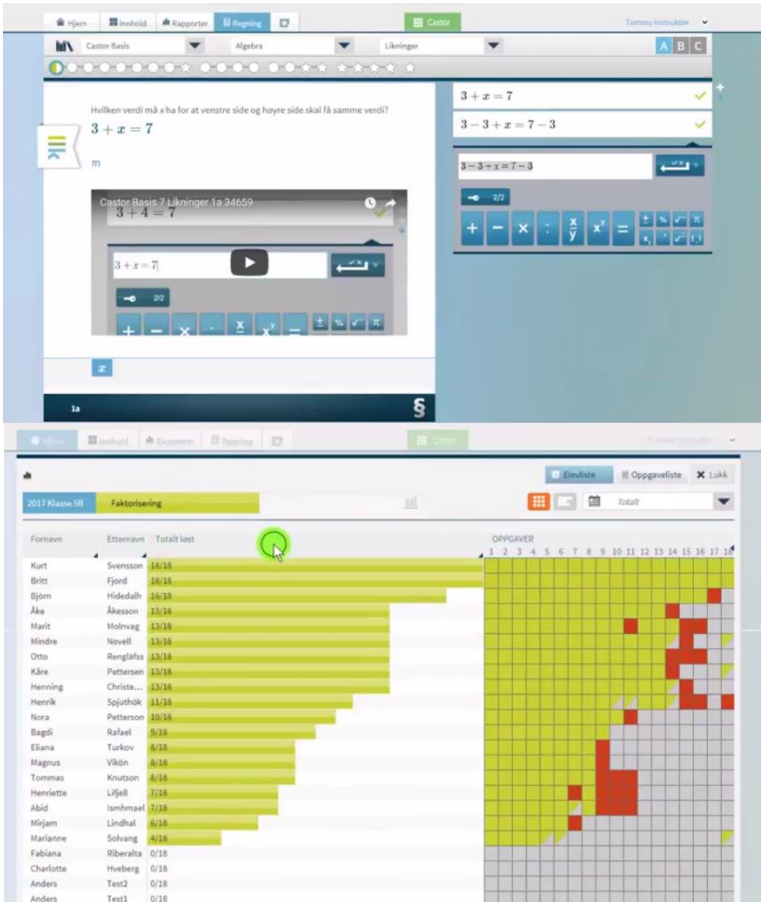

Figure 4-5: Screenshots from Kikora (Kikora, 2018)

III. Iteration 0 – The Preliminary Study

The first iteration of the project, the preliminary study, aimed to identify exactly who the users were and the challenges they had. After understanding the domain, a suitable research methodology was chosen. Through interactions with the users the user groups were refined, and personas were created as an attempt to cover the whole audience's problems.

5. Relevant Research Methods

The goal of this subchapter is to present relevant research methods when researching information systems, and why the chosen methods suits this thesis. It covers the different approaches to cover research questions, means of producing empirical data, and the ways of analyzing data. However, how they were used will be presented in subchapter 6- Research Design.

5.1. Research Strategies

There are many approaches to answering research questions. Below in Table 5-1 follows a brief explanation of a few research strategies suitable for use in information system research according to Oates (2006), and their possibilities and limitations are listed in Appendix C.

Research strategy	**Description**	**Example methods**
Survey	Obtaining similar data from a large amount of people in a standardized and systematic way for identifying patterns.	Questionnaires, polls
Design and creation	Develop a new IT product to contribute knowledge to a domain.	Development
Experiment	Investigate cause and effect relationships, test hypothesis, and prove or disprove links between factor and outcome.	Observation and measurement, proving/disproving relationships between factors
Case study	Obtain deep and detailed insight of a case and its relationships and processes.	Exploratory study, descriptive study, explanatory study
Action research	Plan to apply research in a real-life situation, execute it, reflect upon the results, and start a new iteration with the new research.	Process enhancing
Ethnography	Understanding the culture and way of seeing a group of people by spending time in the field.	Physically staying in the field

Table 5-1: Common research strategies for information system research

5.2. Data Generation Methods

To form a solid understanding of the users' situation and how the prototype was affecting them data was collected. Two types of data were collected: qualitative and quantitative data. Interviews, workshops, observations, and documents are qualitative in this thesis, and questionnaires are quantitative.

5.2.1. Interviews

Interviews can fit in with a lot of different research strategies because it can be used to collect both qualitative and quantitative data. Depending on which type of interview is used the goal might vary.

Structured Interviews

Structured interviews are pre-determined and standardized questions, acting as a verbal questionnaire. You go in to the interview knowing what you want answered and try not to deviate from the plan, although you can ask both open and closed questions. They are typically held in person, over phone, or via chat. By standardizing the questions you can compare and group the data reliably (Wilson, 2014) making them quantitative.

Unstructured Interviews

The unstructured interview is the opposite of the structured one by having an open conversation, though sticking to a general topic and agenda. The goal is to get detailed data about the participant's experiences without putting restrictions on them (Wilson, 2014). Instead of preparing questions you prepare topics, and even then, the agenda might change throughout the interview. This type of interview is good for capturing general themes and giving new insight to how a user might interact with technology making it qualitative data.

Semi-structured Interviews

The semi-structured interview combines the structured on unstructured interviews to introduce a topic as well as asking questions you might have about it when going in to the interview. It usually rounds up with a discussion allowing further exploration of the topic. This is great when there exists some knowledge about the topic, but you still need more details (Wilson, 2014). Semi-structured interviews are good for understanding user's goals and gather data on a topic you think you have identified the problems of, but still allows the users to continue to elaborate issues that might be relevant to your topic. Because it covers takes from both structured and unstructured interviews it can yield both quantitative and qualitative data.

All the types of interviews can be conducted through phone and Internet audio services, such as Skype. It allows people that otherwise would not be able to meet you face-to-face to participate, however, your observations are limited by what you can collect from their voice,

unless you use video calling, and it can be difficult to have an interviewee spend more than twenty to thirty minutes of his or her time (Wilson, 2014).

5.2.2. Workshops

A workshop is a “period of discussion or practical work on a particular subject in which a group of people share their knowledge or experience” ("Collins COBUILD advanced dictionary of English," 2009, p. 1810). There is no set way of arranging a workshop, but it tends to consist of small groups (or many people divided into small groups) where one can educate, discuss, problem solve, or gain hand-on experience by doing work-related tasks either individually and/or as a group.

5.2.3. Observations

The intentions of observations are to unveil what people actually do instead of what they report they do. Observations use one or more senses and can be used in all the research strategies listed in Table 5-1. Observations can be done known or unknown to people being observed, but many people question whether observing without consent is ethical (Oates, 2006). If used systematically one can define events to look out for in advance and be prepared to note them down by timestamp or other variables. One can also be part of the situation, a participant observation, where you select a role in between the two extremes: participation and observer. Even though people let you observe them you should be clear on the frames, since it might be ok that you record what they say in the work environment, but perhaps not when on lunch break.

5.2.4. Questionnaires

A questionnaire is a set of predetermined questions answered in a given order. When one thinks of a questionnaire, one often thinks of it used in the survey strategy. However, it can be used in other strategies too and is used to reveal generalizations and patterns (Oates, 2006). A questionnaire can be administered by the one conducting the questionnaire, or it can be done without the researcher present. The first approach is similar to a structured interview. A challenge with the questionnaire is that the quality of the data collected is strongly dependent on the skill of the one constructing the questionnaire (Peterson, 2000), since they can only answer what they have been asked. The two main types of questions in questionnaires are open questions- leaving a blank space for a respondent to give an answer, and closed questions- force the respondent to choose from a range of options.

5.2.5. Documents

Documents are containers of information and is divided into found documents and research-generated documents. Found documents exist prior to the research and can be anything from homework sheets to work schedules and so on. Research-generated documents are documents that exist only because of the research you are conducting (Oates, 2006). When analyzing documents, you either view them as *vessels* or as *objects*. Vessels mean that they contain data that can be analyzed, while objects mean treating them as entities and looking at how they are used.

5.3. Data Analysis

After generating data you need a way to analyze them, below describes two approaches to look for relationships or themes in you data- quantitative and qualitative data analysis.

5.3.1. Quantitative Data Analysis

Quantitative data analysis means you look at data based on numbers, and is typical associated with surveys, although it can be used in other strategies too. The goal is to look for patterns and draw conclusions, and tools such as tables, charts, and graphs can be used to make this process easier. According to Oates (2006) there are four types of qualitative data- nominal, ordinal, interval, and ratio data.

Nominal data are categories that originally had no numerical value, such as how many participants were male, how many were female etc. The only analyses to make on these categories are frequency.

Ordinal data has numbers assigned to a qualitative scale, which makes them usable for limited arithmetic operations. An example of this could be the use in Likert scale-based questions, where data can be ranked, but we do not know the intervals between a rank. For example, we cannot measure how far “agree” is from “strongly agree”.

Interval data is like ordinal data only made in a quantitative scale where the ranking of the categories is proportionate, making it possible to state the differences between two data values with precision, meaning scales using addition and subtraction can now be used.

Ratio data is close to ordinal, but instead of having relative measurements such as ordinal, but it there can be a true zero to the scale, making all scales using all the arithmetic operations applicable.

There is also a separation between *discrete* and *continuous data*. Where discrete data uses whole numbers, e.g. how many pets you have, and continuous lets number have greater accuracy, e.g. your exact date of birth.

5.3.2. Qualitative Data Analysis

Qualitative data analysis looks at non-numerical data, such as text and images, where it mostly consists of abstracting from the data collected. Even though you can create new data from the data you collect, such a task may seem daunting due to the large data sets you can collect in a relatively short amount of time. One should start off by converting the data collected to a similar format (Oates, 2006). For interview tapes this can mean transcribing, and generally for all qualitative data you want them presented in a way you can categorize them with the research questions in mind.

5.4. Summary

There are a number of research methods used in information system research, where survey, design and creation, experiments, case study, action research, and ethnography are some of the common strategies. For generating data for your project interviews of different structures can be used, as well as workshops, observations, questionnaires, and documents. Finally, there are different approaches to analyze the gathered data. Quantitative data are based on numbers in some form and are used to look for patterns and draw conclusions. Qualitative data typically focuses on abstracting from a typical complex data set.

6. Research Design

Up to this point the goal of the research, motivation for the topic, existing theories of the domain, and the relevant research methods have been defined. From here on it is time to present my own research. The goal of this subchapter is to explain the overall research design and how the research methods defined in the last subchapter were used to fit the thesis.

6.1. Research Strategy: Design and Creation

All the strategies might be viable in some degree, but according to Schell (2015) you can only consider your design finished if it passes the following eight questions:

1. "Does this game feel right?
2. Will the intended audience like this game enough?
3. Is this a well-designed game?
4. Is this game novel enough?
5. Will this game sell?
6. Is it technically possible to build this game?
7. Does this game meet out social and community goals?
8. Do the playtesters enjoy this game enough?"

Schnell also states: "*The Rule of the Loop: The more times you test and improve your design, the better your game will be."* This suggests there should be made an artifact and that said artifact should be tested on the users multiple times. This fits well with the focus of the research strategy *design and creation*.

By definition the thesis falls under *design and creation* because the finished concept is an instantiation- a working system that in this case demonstrates ideas and theories that can be implemented into a computer-based system (Oates, 2006). For an IT system to be considered research it must be using academic qualities- such as analysis, explanation, argument, justification, and critical evaluation. In addition, it must contribute to knowledge either through as being the focus of the research, being a vehicle of something else, or by being a product of a project with the process in focus (Oates, 2006).

Design and creation is a strategy with a problem-solving approach iterating its five steps: awareness of problem, suggestion, development, evaluation, and conclusion (Kuechler & Vaishnavi, 2012). First, one becomes aware of the problem through some context, for example literature review of a topic. Secondly, one comes up with a concept for solving the discovered problems. From there on the solution is developed, evaluated, and the knowledge gained identified (Oates, 2006).

The *awareness of the problem* came from the thesis task text presented that originated in Kartevoll (2017) where children presented with *Mænage Extended* would like their homework alongside their chores at home. The need became even clearer through conversing with pupils

and teacher in Norwegian elementary schools. Based on the data collected from the users and the literature study in Chapter II a concept was made as a *suggestion* to solve the defined problems. During the *development* phase a high-fidelity prototype was made showing the tentative design and how it seemingly would work. Through user testing the solution was *evaluated* and rated. The data was then used to *conclude* the process and summing up what knowledge was gained. The process, as seen in Figure 6-1, was repeated multiple times, once for each iteration throughout the thesis. However, it is important to understand that with this research strategy the analysis and the design are the most important parts, because coding the working solution is considered trivial (Oates, 2006).

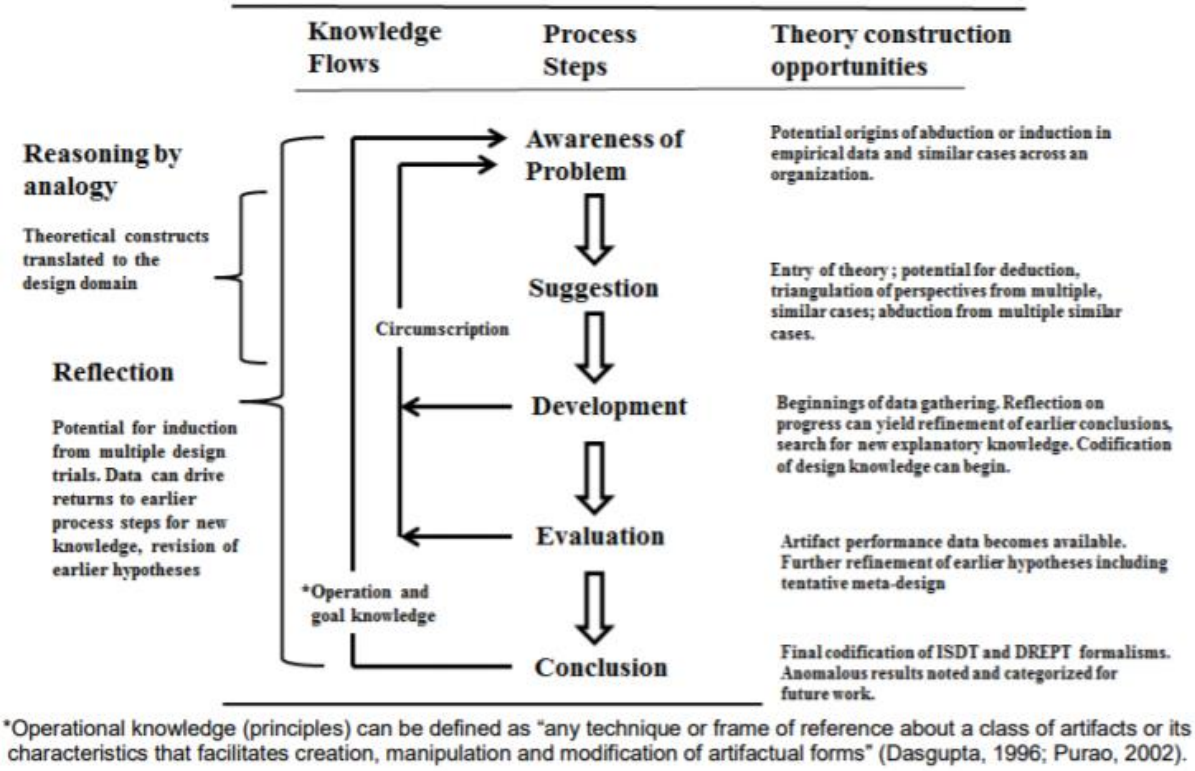

Figure 6-1: Reasoning in the Design Research Cycle (Kuechler & Vaishnavi, 2012)

Prototyping

Requirements that are not known from the beginning may occur at any stage in the software development process. To accommodate these occurring requirements, agile software development was used to work in short intervals and often deliver new versions of the prototype, this should in turn bring better value to the product (Dingsøyr, Nerur, Balijepally, & Moe, 2012). This means collecting data from the users and basing the first iteration of the prototype on it and existing theories. After each iteration the users test it by completing a set of tasks. Because of the rapid prototyping the earlier versions of the concept are low fidelity prototypes and the later stages high-fidelity prototypes. This means that it takes less time to change things in the most uncertain phases and when the major parts are agreed upon, in-depth functionality can be tested in the medium it is intended for.

Low-Fidelity Prototypes

Low fidelity prototypes, or low-fi prototypes, are often used in the initial phases of the software development cycle, and can be as simple as a user interface drawn on paper (Dhillon, Smith-Jackson, & Dhillon, 2012). This makes them very cost efficient and gives you the ability to simply throw them away and draw a new one if it does not meet the users' needs. In this project the paper prototypes were hand-drawn in Adobe Photoshop where all the elements were split into interchangeable layers, which again made it very easy to print different parts to paper. Interactions and changes, either made on the spot or suggested by the users, were done with sticky notes, pen, and paper. This encourages the user to be critical of the prototype since it visually does not look finished (Mastalerz, 2016). The paper prototype was redesigned when no new feedback was collected from the test, then the new design followed the same process.

High-Fidelity Prototype

When the paper prototype seemed to satisfy the users' needs, indicated by the users' feedback, a high-fidelity prototype, or hi-fi prototype, was made. The hi-fi prototype are supposed to be very close to the actual product in both feels and looks, which means it provides actual interactions and functionality (Dhillon et al., 2012). Since the pupil aspect of 'Mænage School' builds upon the 'Mænage' application for tablets, the prototype was made with the same technology, namely Unity (Unity Technologies, 2018). The teachers had different needs and a different context of use than the pupils, their part was therefore made with web technologies and the JavaScript framework Vue.js (You, 2018b). The final products of the thesis were a high-fidelity prototype for the pupils' concept and another one for the teachers' concept.

6.2. Primary Data Generation Method: Interviews

Interviews was selected as the primary data generation method because there was existing knowledge about the topic prior to the thesis, but more in-depth knowledge about the specifics of this problem was needed. Therefore, semi-structured interviews were conducted with both the pupils and teachers. The sessions with the pupils followed a workshop format where groups of 2-3 pupils from elementary school sat down and shared and discussed their experiences, then they tried Mænage together and further discussed how their homework could be implemented in the application.

Because few teachers were able to make the time to meet up and be interviewed a decision was made to cut the workshop part and rather offer them to talk over the phone, which got more teachers to join in. The phone interviews were semi-structured as well. First, a predetermined set of questions was asked, then later there was an open part with room for more discussion and adding things they felt had not been mentioned yet. This structure was selected because after every interview new information came up, which further augmented the starting questions, giving the interviewing process an iterative approach.

6.3. Secondary Data Generation Methods

In addition to interviews, observations, questionnaires, and documents were used as well to get more data and strengthening the validity of the data of each method.

6.3.1. Observations

Observations were used to determine shortcomings and what was good in the prototypes while the users were testing them. Users were encouraged to think aloud, but supporting their commentary with observations might unveil things they did not express. Saying out loud what you are thinking while at the same time using a system you have never used before might cause a big cognitive load. The observations were done with consent of the users involved.

6.3.2. Questionnaires

Questionnaires were used in the form of the System Usability Scale (SUS) after they had tried an iteration of the system, and a five-point Likert scale with questions for the high-fidelity prototypes in the last iteration of the project relating to the research goal and questions. The SUS is a questionnaire consisting of a ten question Likert scale that aims to give a subjective assessment of the system's usability (J. Brooke, 1996), in Appendix B follows an augmented version of the SUS. It is a summative form of evaluation since you get a score between 0-100. Each question is worth 1-5 points and run through the formula where the variables x_1 though x_{10} are user input for questions 1-10:

$$[(x_1 - 1) + (5 - x_2) + (x_3 - 1) + (5 - x_4) + (x_5 - 1) + (5 - x_6) + (x_7 - 1) + (5 - x_8) + (x_9 - 1) + (5 - x_{10})] \times 2.5$$

The reason why the formula alternates the subtrahend and minuend is because the questions alternate between being positively and negatively loaded, meaning the best score of question one would be a user input of 5, while the best user input of question two would be 1. This yields a score between 0 and 100 where a higher score than 68 is considered above average (John Brooke, 2013). To be able to categorize the results, the score brackets in Table 6-1 which is based upon Bangor, Kortum, and Miller (2009), was used:

Acceptable	80 – 100
Should be reimplemented	60 – 80
Should be discarded or reimplemented	40 – 60
Not acceptable, discard	0 – 40

Table 6-1: SUS score brackets.

This gives a quick and easy way of checking if a change made it easier or worse for the usability of the user. However, many children may find it difficult to give a Likert response when the format is based upon numbers, and an easier format would therefore be based on words that reflects frequency of thought (Mellor & Moore, 2014). The children therefore answered either

strongly disagree, disagree, neither nor, agree, or strongly agree, and their answer was translated in to 1-5 for SUS calculations.

6.3.3. Documents

Homework sheets were collected from teachers, pupils, and parents. Teachers were asked if they wanted to contribute to the project by providing homework sheets that they felt benefited the pupils the most. These are *found documents*, which are documents that exist prior to the research (Oates, 2006), which together with being randomly collected makes them non-bias to the research. The motivation behind this form of data generation was that the threshold for contributing is lower than interviews, workshops, and interviews, since they require scheduling and the teachers or pupils to commit their time to the cause.

6.4. Testing

Testing is needed in different parts of the software developing process. This part explains the importance of testing with the end users to ensure that the correct requirements are met, as well as how the software in the high-fidelity prototype was tested.

6.4.1. User Testing

13.1% of software projects are cancelled due to incomplete requirements, 12.4% due to lack of user involvement, and 8.7% due to changing requirements (Omoronyia, Stålhane, & Sørensen, 2015). This is a big motivation towards ensuring the users' needs are understood and met in Mænage School. During the project the users were involved in every iteration of the project, from the data collection in the preliminary study to the scenario testing in the high-fidelity prototype. All testing based with user involvement were built upon Svanæs (2008) ten points on executing usability testing:

1. Introduce yourself.

2. Describe the intention of the test.

3. Explain to the participants that they can end the test at any time.

4. Describe the equipment in the room and the limitations in the prototype.

5. Teach the users how to think out load.

6. Explain that you cannot offer any help during the test.

7. Describe the task at hand and introduce the product.

8. Ask if there are any questions and run the test.

9. End the test with letting the user comment on the prototype before optionally wrapping up loose ends.

10. Use the results.

Scenario Testing

Some of the benefits of scenario testing are: the tester learns the product, you connect testing to documented requirements, you can expose failures to deliver desired benefits, explore expert use of the program, make a bug report more motivational, and bring requirements-related issues to the surface such as reopening old requirements discussions with new data (Stålhane, 2015c). There were in total six user test cases using scenarios, both for the four paper prototypes as well as the two high-fidelity prototypes. The first tests were conducted on paper prototypes with interchangeable paper sheets, but the high-fidelity tests were completed on an Android tablet for the pupils' application and a laptop using Google Chrome for the teachers' application. Below follow the final scenario test cases for the two prototypes, the previous tests are variations of these and can be seen under an iteration's result subchapter.

Pupils' High-Fidelity Test Case

The scenario test case below is the final version of the test case executed by pupils in Norwegian elementary school. The scenarios were read out loud one by one after a pupil meant they had completed the previous scenario.

1. Complete your homework assignment in mathematics.
2. Complete your Norwegian homework.
3. Check if you have any messages from your teachers.
4. What does your class get to do when you have collected enough points, and how far have you come towards your goal?
5. Who have collected the most points in your class?
6. How can you get more homework for earning extra points?

Teachers' High-Fidelity Test Case

The test case below is the final version of the scenario tests the teachers executed. As with the pupil a statement was read out loud one by one after a pupil meant they had completed the task. However, there are two different parts of the week that are interesting to test, namely before the week starts when the teacher creates the homework and at the end of the week when pupils have given feedback. Because of this the teachers were asked to imagine that scenarios 1-5 took place at Sunday, and 6-7 at the end of the next week.

"Pretend it is Sunday in week 45, you need to prepare the homework sheets for your pupils, so they receive it Monday."

1. Add a new sub goal in task group "B" in Mathematics.
2. Add a new task group in Norwegian that is extra homework for those who want to do it, and add two sub goals where at least one of them have a link.
3. Delete the task group in Norwegian that is missing a name.
4. Based on what the pupils had former week, assign them new homework.

5. Give class 5C a message that reminds them to get their parents to sign their note about the school milk offer, the deadline is approaching.

"Pretend it is now the end of the week, and the pupils have completed their homework assignments."

6. Check if the task group "A" had a sufficient difficulty.
7. The pupils want to eat pizza rather than playing soccer, but you think the required points for such a goal is too low. Change the reward to please the pupils and adjust the required points to 6000 to give them a fair challenge.

6.4.2. Software Development Testing

Based how much of the source code the tester has available there are different ways of testing a software application. The different kinds of software tests can be put into three categories- white box testing, black box testing, and gray box testing. However, testing is not limited to executing a test where we give input, observe, and check input, we can also run experiments and inspect code and other artifacts to check if we have achieved our goals (Stålhane, 2015b).

White Box Testing

White box tests use information from the code itself to generate tests and are naturally a part of a software development project since debugging is one of the ways of getting coverage. In addition to debugging parts of the applications that had more conditionals, such as the homework GUI in the Unity application, a truth table was used to achieve full path coverage. These methods are dynamic in nature opposed to code inspection and code walkthrough which are static (Stålhane, 2015d), which also were used. The good thing about white box testing is that you get very detailed testing, but the downside is that it takes a long time to execute.

Black Box Testing

White box testing can be viewed as a way of understanding the implementing code, checking the implementation, and debugging, while its contrast, black box testing, can be seen as a way of understanding the algorithm used and checking the solution- functional testing (Stålhane, 2015d). Black box tests do not expect having the source code available and is carried out by defining initial component state, input and expected output for the test, setting the component in that state, giving it the input, and observing the output against the expected output. After testing the happy path of the test, we can try with edge cases to make the test fail.

Gray Box Testing

Gray box testing (or grey box testing), is when the test is based on limited knowledge about the system such as design documents beyond requirements documentations (Stålhane, 2015a). Round-trip path tree testing was used to test the routing of the Vue.js application and all

states of the graphical user interfaces in the Unity application. The test is used to find all state control faults, sneak paths, and corrupt states. It does so by building a tree structure from a state machine where one test runs all the way down one tree branch (Stålhane, 2015a).

6.5. Privacy

All data collected in this project follows NSDs guidelines for collecting data anonymously (NSD - Norsk senter for forskningsdata, 2017). This means that all processed information was anonymous throughout the whole process, and no sensitive data was being linked to identifiable data directly or indirectly. This means that the interviews were designed in such a way that at no point was background information about the informant combined with voice, or other means of identification.

6.6. Validity & Reliability

There is a problem with using observations as data generation method with only one person as observer and that is that you cannot guarantee that another person would remember and notice the same as you (Oates, 2006). To enhance the findings method triangulation is being used by having more than one data generation method. Quotations are written down but translated as true to the original statement as possible, and findings were constantly reflected upon considering how I might have affected the environment it took place in to try keeping me as non-bias as possible. Considering questionnaires, according to Mills, Durepos, and Wiebe (2010) if used in a case study context it might be better to collect incomplete information and check it against another supplementary approaches, since you must assume the participants are aware of the topic you research and can express their thoughts and ideas of it well.

When it comes to reliability, it is important to be aware of the fact that the participants of this thesis make up a very small part of the 633 029 pupils and 38 948 tutors in school year 1-10 in Norwegian school (Utdanningsforbundet, 2017). This means that the results of this thesis is the result of the opinions of the participants rather than the general opinion of all the possible users of the application. The documents collected were homework sheets from all years of Norwegian elementary school and were given from pupils, parents, and teachers. This means that determining the origin of the documents are solely based on the provider, and its content within the homework sheet is studied, it is not treated as data by itself.

6.7. Data Analysis

Both qualitative and quantitative data analysis were conducted, although the qualitative approach was most dominant. First, the data had to be in a similar format so that it could be compared. The interviews were transcribed in to digital sticky-notes where opinions and experiences were categorized. The observations were noted in observation schemas where a problem or discovery was mapped to a task and test scenario. The documents were viewed as vessels of data. Then all the data was read through identifying key themes in the data, as suggested by Oates (2006) I looked for:

- Parts that had no relevance to the research goals.
- Parts of descriptive information needed to describe context.
- Parts that seemed relevant for the research questions.

How information was categorized was adjusted throughout the project since new insight was made gradually. Then I looked for connections between the different parts and categories, and tried to see patterns and come up with theories to explain why things were as they were and test my theories in the next iteration to see if they were on to something.

Quantitative data analysis was used on the qualitative data for determining common patterns. Such as averaging how long time a typical teacher in elementary school has available to make a homework sheet per week, determining when most of the children thought homework became boring and so on.

6.8. Summary

The research called for design and creation as research strategy, where the system itself is considered the research. The primary data generation method was semi-structured interviews with observations, questionnaires, and documents as secondary methods. As described above different kinds of testing were conducted both on the systems created and on the users. Privacy of the participants was an important factor, as well as the validity and reliability of the data collected from them. Finally, both qualitative and quantitative data analysis were performed.

7. Data Collection

To create a useful product for the teachers and pupils in Norwegian elementary school, data was collected from plausible end users. The data was used to create personas, identify problems to be solved, and different ways of resolving them. The methods used were interviews, workshops, and document collecting.

7.1. Pupil Interviews and Workshops

The data gathering from the pupils were done in groups of 2-3 pupils from elementary school. They were interviewed together and the meeting had a workshop format consisting of them answering questions, drawing and telling me what they thought about the topic, and letting them try out Mænage for themselves using a tablet. Throughout the meetings there were discussion on the different subjects. In total 16 pupils were part of the meetings, the distribution can be seen in Table 7-1.

Grade	Participants
1st grade	3
2nd grade	2
3rd grade	4
4th grade	0
5th grade	4
6th grade	3
7th grade	0
Total	16

Table 7-1: Pupil participation distribution

The most prominent opinions were that homework was boring if it took too much time and was too repetitive. The paper homework sheets were okay if done in a simple and structured way, although they were boring if not printed in colors. Most of the pupils from 2nd grade and up had at some point used different web solutions and would like to have more homework digitally. Everyone from 3rd grade and up had 2-3 difficulty levels in mathematics, but some also in English and Norwegian. The most motivated pupils seemed to be fine with doing the intermediate and hard levels because they felt they learned more, while the less motivated wanted the easiest because they took less time. Mathematics stood out as the most engaging subject, and when asked why they replied that it was the most varied one opposed to Norwegian where you often had to read the same text multiple times. Their main motivation for going digital was less books to carry around and less paper and separate task sheets to keep track of. Some of the features suggested for Mænage School by the pupils can be seen in Table 7-2.

Id	Description
P1	Would like to play a game when they have finished their homework.
P2	When you click a chore ball with homework you should be able to click “go to homework”, if it is in the books it should display task and page number.
P3	When you do your homework, you should have a timer that tells the teacher how long time you spent on your homework, so that he can make the homework easier if it is too difficult.
P4	When you have completed homework, you can click complete and get rewards.
P5	You can ask your classmates for help if you are stuck on a task.
P6	The teacher can provide you with motivational messages.
P7	Homework points- a currency you can buy special rewards with.
P8	There should be video explanations of topics and homework that they can replay whenever they want to.
P9	The homework should be properly integrated in Mænage and not just scanned and uploaded.
P10	The homework sheet should not be multiple pages, but rather scrollable.
P11	Should be able to mark a task as done.
P12	Want to see if others are done with the homework so that they can go out and play.
P13	Should be able to click a button to get hints on homework if stuck.
P14	Should be able to unlock things in the Mænage by doing homework.
P15	Instead of having to write long links they should be able to click an icon or getting a short URL.
P16	Should be able to change the looks of their own homework sheet.
P17	Should have different ways of learning in the app. For example, you should be able to have quizzes and flash cards.
P18	There should be a “what do I need to do today” button.
P19	Should be a way to ask the teacher for help.
P20	If there is a game in the game, there should be a high score list.
P21	Should be able to play with other pupils in the same class.
P22	If you click at your class, you can view the current and former homework sheets.
P23	There should be weekly goals, so they can understand why they are doing different tasks.

Table 7-2: Pupils' feature suggestions

7.2. Teacher Interviews

The teachers were interviewed through face-to-face meetings or on the phone, depending on how much spare time they had. During the meeting, homework and homework sheets were discussed as well as what would be important for a tool that aims to do homework more engaging. The interviews were loosely structured with a set of questions that needed answering and from there on the rest was discussion, which was the major part of the interview. Table 7-3 shows which grades the different teachers interviewed had taught during their career so far. Since there were few teachers available for interviewing there was made a decision that the interviewees’ experiences had to at least cover two teachers per grade, so that all the data from on grade was not solely based on one teacher’s experience.

Teacher #	1st grade	2nd grade	3rd grade	4th grade	5th grade	6th grade	7th grade
Teacher 1	X	X	X	X	X	X	X
Teacher 2		X	X	X	X	X	
Teacher 3					X	X	X
Teacher 4	X		X		X	X	X

Table 7-3: Teachers' experiences by grade

Below follows the results from the interview with the teachers. The information is split into categories which are based on the question asked and additional categories that got created during the interviewing phase. The categories below are summaries of the opinions and experiences they have made themselves during their career so far.

When to do homework

It should be possible to do all homework early if needed, if pupils at many activities during the week. Especially older pupils were entrusted more responsibilities such as having to have finished the homework to Friday without binding it to specific days. However, dividing the homework throughout the week is strongly recommended, and even better, working with the homework the same day they talked about the topic at school.

Checking homework

Most of the teachers claimed it was difficult to always check the homework unless they were more than one pedagogue in the classroom at the time. Alone it could take the whole period to check everyone's homework. The parents are encouraged to check their children's homework, but this cannot be taken for granted by the teacher. Often, parents bring a note with their child if they were not able to complete their homework for some reason, then they get prolonged time to complete the homework.

Varying difficulties

All the teachers thought dividing into different difficulty levels was a good idea, because pupils in the same grades could be on vastly different levels of understanding in different subjects. Most often the difficulties were coded in some manner, from easiest to most difficult here are some examples:

Green, blue, black	Step 1, step 2, step 3
Green, purple, blue	A, B, C

When only splitting into two difficulties the third option was cut. The often most common subject to differentiate was mathematics, since the differences in skill seemed to vary the most there. Also, it seems to be the funniest subject for the pupils because it varies itself naturally. In general mathematics, English, and Norwegian were the subjects that most often had difficulty levels because here the teachers saw the biggest differences in skill. Often there were tasks that everyone was to do before selecting a difficulty. Some of the pupils would not select the more challenging homework if an extended explanation on the homework sheet was given, because it looked like more work than it was, but cutting it affects the ones that needs a detailed explanation. Most of the textbooks that the schools use nowadays encourages splitting into difficulties. However, if they do not have such textbooks the teacher must by him-/herself create and test the homework giving them less time to do other things. The difficulty was selected with the pupil, or with both the pupil and the parents. How much time they wanted each pupil to spend on their homework varied, but all agreed that they should not spend more than an hour a day. Most of the teachers also strived for mapping learning objectives to individual homework, so that the pupil understood why they were doing something.

Messages

When asked what they thought was important besides the homework on the homework sheets they answered information to the pupils and parents. This also includes what happens that specific week. Everyone included messages on the homework sheets, but would like to be able to separate messages to the pupils from the messages to the parents.

General challenges

They all liked the thought of having everything digital, but that it also would be nice to be able to export it to a printable version if a child did not have the necessary equipment to use it. For example, some children did not own a mobile phone, computer, tablet, or even have access to the Internet at home, and if the pupils should be able to talk to each other all the conversations had to be logged because of the possibilities of bullying.

Applications used

Only some of the teachers had used teaching applications in the classes. The applications were: Microsoft Office (based for students) and companion websites for the textbooks. Although they were more than happy to try out new applications if it could benefit the pupils and help the teacher spend their time more efficiently, so that they for example could get more time to prepare for classes and less time making homework sheets. The time spent on making homework sheets varied from a total of two hours to one hour every workday. Also, one of the teachers even made three separate versions of the entire homework sheet every week, resulting in a lot more time going into the homework sheet creation process. In Table 7-4 the specific feature suggestions from the teachers are listed.

Id	Description
T1	Should be able to vary the type of homework.

T2	Should be able to support flipped classroom with video.
T3	Should be able to unlock more homework task for pupils that want to do more.
T4	Should be able to give messages home.
T5	Would be practical if you were able to deliver homework through the app.
T6	Should be able to get an overview of who have done homework.
T7	Should be able to see how much time was spent doing homework, efficient time would be nice to see.
T8	Should be able to give comments to pupils on done homework (if delivered though app).
T9	Should be able to co-write homework sheet with other teachers, since one teacher probably will not cover all subjects.
T10	Pupils should be able to reflect on what they have had learned this week, check off weekly goals.
T11	Data should be presented to the teacher in a useful way, do not show each individual task book.
T12	There could be unlockable content for avatars for completed homework.
T13	Reading weeks could provide bonus rewards (read ten pages and give the class more points).
T14	Rewards should be class-wise, get 100 points and there will be dodgeball.
T15	Should be able to give homework of different difficulty to pupils, but there should be a way of giving class-wise tasks that everyone gets too without having to add them to each difficulty level.
T16	There should be both messages to the pupil and messages to the parents at home.
T17	There should be a learning goal accompanied with homework, so that the pupil can understand the purpose of the task.
T18	If there is a chat function there must be a way of turning it off for the entire class, and the chat must be logged.
T19	The pupil should be able to navigate the app alone, without the parents, and with few but intuitive clicks.
T20	Should be able to click URLs or icons instead of manually writing the URL.
T21	Must be able to write longer texts in case of giving tasks not in the books.
T22	The app could give the pupil the homework, without telling the pupil the level it belongs to.
T23	The teacher should be able to assign pupils to difficulty levels for each subject once, then adjust this later as the pupil needs.
T24	There should be a shortened and extended task description to avoid that pupils think it is more than what it actually is when including a more detailed description (more like additional hints).
T25	Pupils should be able to rate the homework and give feedback through the app, shy pupils rarely speak up in class.
T26	Bind a learning objective to each homework, so that the teacher can see how well the entire class does it on for example addition, subtraction, multiplication, etc.
T27	Should be able to move homework to the next day if the pupil failed to complete it.
T28	Should be a print option so you can get a printed copy of the homework sheet if the pupil does not have a tablet.

T29	Pupils should be able to complete the homework for the entire week if they so desire, some have more activities than others.
T30	Should be a way of getting one pupil unique homework if needed, in case that pupil require special attention.
T31	Should encourage doing some homework every day. If everything is done then repeating the glossary can be beneficial.
T32	Pupils should be able to record themselves reading their homework for the subjects Norwegian and English.

Table 7-4: Teachers' feature suggestions

7.3. Homework Sheets

Homework sheets were collected from the teachers interviewed. Also, parents showed great enthusiasm in the project by donating old homework sheets they had laying around at home. 30 homework sheets were collected, and some of them were from the same school class, but from different weeks, in total there were homework sheets from 10 different school classes.

Structure

The homework sheets mostly had the same structuring. All of them were organized in tables, but what was different was if the homework was sorted by subject or by day, although some had both at the same time.

Homework

The only difficulty levels found in the set were “green, blue, black” and step 1, 2, 3, for easy, intermediate, and hard respectively. Some had guidelines on how long time to maximum spend on each subject per day, e.g. 15 minutes on mathematics. Most of them had in some form the learning objectives or competence aims included, but some had augmented them in a manner that seemed to be addressed the children and not only the parents, and some had just copied and pasted the competence aims into the homework sheet. In addition to learning objectives weekly themes were seen, for example “Mathematics – Time”. Homework was assigned weekly for Friday, to specific days in the week, and some had daily homework tasks, such as “read 15 minutes in the textbook each day”. When the pupils had tasks on websites the full URLs were included, and some had an extra table column with extra homework if they needed more.

Besides Homework

In addition to homework all the homework sheets included “messages” in some form or another. Mostly they were addressed to the parents, but some seemed to be for the pupils, although they were mixed together in the same square. Mostly, the backside of the sheet contained the pupil’s time schedule, some even provided monthly overviews of special events at school. At the bottom the teacher’s contact information was included and could contain the teacher’s name, private and office phone number, email address, and contact hours. Images seem to be used a lot in different places in the homework sheet, some related to homework themes,

some to events at school, and some just positively themes, such as smileys and hearts. The most unique features were custom pupil names, recap of last week, riddles, and weekly social goals.

7.4. Summary

The subchapter presented an overview of the data collected from interviews and workshops with pupils and teachers in Norwegian elementary school, as well as data collected from a set of homework sheets. Some of the general categories of data collected were about when it was expected for pupils to do homework, how was homework checked, how teachers organized different difficulties, how messages were given to the pupils and parents, general challenges, and applications used. Based on the data collected the next subchapter identifies the user groups for the project.

8. User Groups

From the data collected it was revealed that children in 1st grade would not fit the scope of the project since neither of the interviewees of that age used computers, tablets, or smartphones. In addition, motivation did not seem to be an issue at this early stage since they at this time only had gone to school for three months.

8.1. Pupils

The most common opinions from the pupils from 2nd to 7th grade was that homework in general was boring or that it was fun and rewarding given they provided sufficient challenge, so they could learn more. Some would select the more difficult levels for the challenge, others would select the easiest because it took the least time. When asked if they wanted a digital version of their homework 87.5% said they would enjoy this, the remaining pupils were worried it would take too much time to use and enjoyed their table-styled homework sheet as it was. When it comes to devices they have available it seems that 3rd grade and earlier use mostly a tablet, and from 5th grade and later the computer becomes more dominant, although the smartphone was present with almost all the interviewees after and including 3rd grade.

8.2. Teachers

All the teachers interviewed either had pupils of different ages now or at an earlier stage (see Table 7-3: Teachers' experiences by grade), so they all had experience in different grades. What seemed to be more of a difference between them is the different amount of technologies they utilize in their teaching, and the fact that some had pupils with special needs and needed to customize their homework sheets more than the rest of the class. This ranged everything from learning disabilities to not having a strong enough understanding of the language used for the rest of the class' homework sheet.

It differs from school to school how much time a teacher has to create the homework sheets, but some claimed to spend a maximum of one hour, since the same time pool goes to preparing for the classes themselves.

9. Personas

From the data collected and observations made a set of fictive characters were created. Personas are fictional characters based on user research to represent users that might use your product (Dam & Siang, 2018). In this case the personas are made extreme users, these are users that represents the extremes in the userbase (Mortensen, 2017). One does not specifically create the solution for these, their goal is the identify problems the average user might not consider. Below follows five personas- three pupils and two teachers. Marcus (8) has problems with concentrating on his homework, Sebastian (10) is not motivated to do homework, Jessica (11) wants to learn more but is starving for content, Eva (26) is up-to-date on everything technological and wants to make homework as tailored to the specific pupil as possible, and Lars (55) is old-fashioned with a limited technology-related skillset.

Marcus (8) – Pupil

- Third grade
- Parents are often at work, and cannot help him with homework
- He has a lot of activities when not at school
- He is an only child

Marcus is eight years old and attends third grade at Rainbow Elementary School. Marcus likes many things and has a lot of friends in all his spare time activities. He plays soccer, swims, and plays the trumpet in the school band. He does not understand why he has to do the difficult homework in order to do well in school.

Marcus is an average clever kid and his teacher, Ms. Smith, thinks he does great in school, especially at mathematics. However, when she asks him how long time he spends on homework he answers one hour. This results in Marcus selecting the easiest route (out of three) when doing his homework. Little does Ms. Smith and his parents know that during the homework session the television is always on, as well as the iPad with Clash of Clans. Marcus gets jealous of the smart kids at school and wishes he could manage the same as them. After all, he thinks mathematics is fun.

CC0 Image 1: Pupil

"Homework takes up a lot of my time. I will rather take the easiest path to get it done quickly, so that I can do things I enjoy."

Core values

- Playing is fun
- Dessert can make great dinner too
- I like spending time with my family

Sebastian (10) – Pupil

- Fifth grade
- Does not do his homework
- Plays a lot of games

Sebastian is ten years old and attends Rainbow Elementary School. He does not have a lot of friends, but he appreciates the one he has. To him homework is boring and just another chore he needs to do, and does not understand why he will need Norwegian and mathematics if he is going to be an eSport competitor.

When Sebastian comes home from school he goes straight to the computer and start playing games. Because most of the games are English he thinks he is proficient enough and does not have to pay attention at school. However, at the national tests he has lower scores than anyone else in his class. His teachers are starting to get worried that he will not be able to catch up to his classmates, and might have to take a year all over again if something does not change for the better and that fast.

CC0 Image 2: Pupil

"Why should I care about doing my homework? It is boring, I want to play all my video games and have fun!"

Core values

- Fun
- Achievement
- Engagement

Jessica (11) - Pupil

CC0 Image 3: Pupil

- Sixth grade
- Plays soccer twice a week
- Her father is always home when she does her homework
- She is the youngest of three children

Jessica is eleven years old and attends sixth grade at Clearsky Elementary School. Jessica loves to read and learn about new things all the time. When she attended kindergarten she always kept on asking the staff to teach her to read and write. From there on she has always wanted to learn and figure out how things work.

Jessica is considered the smartest kid in her class by her fellow classmates. When she gets home from school she reviews what she is supposed to learn this week and starts on her homework. Jessica always chooses the most challenging homework if she has the choice. Sometimes she even does the easier ones just for the fun, although she thinks the easier ones can get boring quite fast because they do not challenge her as much. Reading is interesting too, but she thinks it can get tedious in the long run if she has to read it multiple times. She likes it nice and quiet when she does her homework and she sometimes does it in the backyard as well. If she gets curious about something she learns she will Google it on her father's computer in the living room.

"School and homework makes me smarter so that I can become a veterinarian one day and save animals and tend to stray dogs."

Core values

- Never postpone until tomorrow what can be done today
- Friends and family
- Knowledge is important to do important things

Eva (26) - Teacher

- Teaches third grade
- Uses social media and keeps up to date on new technology
- Is up to date on pedagogical theories and likes to test new scientific breakthroughs in her classes

Eva is 26 years old and teaches mathematics, Norwegian, and English for a class of 20 pupils at Rainbow Elementary School. Technology is a big part of her life during her workday and private life. In her lunch break she like to enjoy a cup of tea while browsing the Internet for any news on the educational front.

In Eva's classroom, every pupil has an Ipad they have gotten through the school, and instead of a blackboard they use a smartboard. The pupils use the Ipad for book resource web pages and use Google Drive in order to keep all documents digitally available for both pupil and parents alike.

Although she uses technology a lot she has to use different applications in order to track and keep everything digital. She might use a Google Sheets for tracking attendance and homework completion, but keeps a Google Docs document for tracking each individual pupil's skill level in different subjects

CC0 Image 4: Teacher

so she can attempt to create homework for pupils at different levels. Eva feels this is important because when only providing a single choice of homework some thought it was difficult and got annoyed, others got bored because it was too trivial.

"Technology is a big part of life and I would love to reap the benefits it brings to education in order to bring out every pupil's true potential."

Core values

- Always stay up to date
- My pupils are my second family
- Everyone is special in their own way

Lars (55) - Teacher

- Teaches sixth grade
- Does not see the point in changing his approach, what he has been doing for 20 years seems to work
- He has a Facebook account, but only because his daughter made one for him

Lars is 55 years old and teaches mathematics, Norwegian, English, and social studies at Clearsky Elementary School. He prefers the blackboard and book versions of homework because he cannot see how the time he puts into technology benefits the pupils.

Lars' colleagues have multiple times tried to make him use more technology and other methods of teaching, but he thinks there is too much of an entry barrier and do not want the hassle since he will retire when he is 62. Although he is reluctant to technology, he is willing to give it a try if it offered clear benefit to the pupils, saved him time, and had a low learning curve. He is proficient enough with the computer to use Word, log into his email, and use the basic functionality of Fronter. Lars provides multiple challenge choices in his homework schedule, but keeps getting feedback from the parents that it does not fit all children. From this he has gathered that the quiet pupils do not speak up if they do not understand something.

CC0 Image 5: Teacher

"Why should I change my methods of teaching if they have been working for 20 years?"

Core values

- Stick to what works
- Things were better before
- Like the simple things

10. Scenarios

A scenario is a "story" which shows a concrete example of situations and needs connected to the design you are trying to make (Shneiderman, Plaisant, Cohen, & Jacobs, 2014). Scenarios are often written or drawn, and can be useful since a description of a design often can be abstract and difficult to explain and understand.

In this subchapter I have created situations that unveils problems and needs the personas in the previous subchapter might have in different situations that needs to be addressed in the Mænage School application. Each of the five personas have one scenario linked to their character, and the stories are written and illustrated. The scenarios are based on information discovered during the interviews in the data collection phase.

10.1. Scenario 1

In Figure 10-1, Marcus is often home alone, so it becomes his own responsibility to get the homework done. He sits at the kitchen table when he does homework. After a while he turns on the television to play in the background because he feels bored with the tasks. After an hour has passed he has just completes the homework for English, but still has Norwegian and Mathematics left as his mother enter the door ready to drive him to soccer practice.

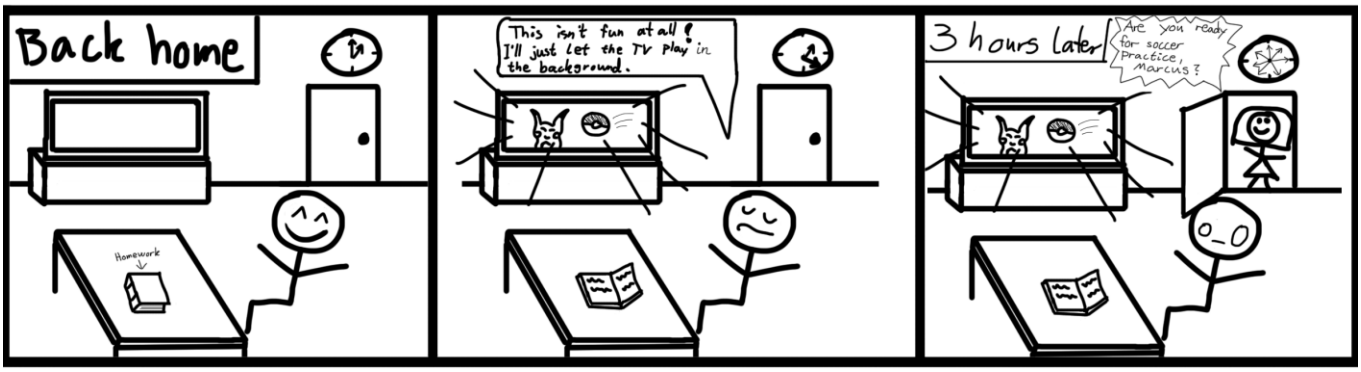

Figure 10-1: Scenario 1- Marcus cannot concentrate

10.2. Scenario 2

In Figure 10-2 Sebastian comes home from school at 2 pm. He goes to his room, closes the door and opens the mathematics textbook. As he looks at the different tasks he is supposed to do he keeps asking himself the same question- "why should I do this?" After scanning the pages up and down with his eyes he dumps the books on the floor and turns on his computer, it is time to accomplish something great! Back at school the next day the teacher gives the pupils problems about multiplication. All of Sebastian's friends finishes up within 10 minutes, but Sebastian has no idea what to do.

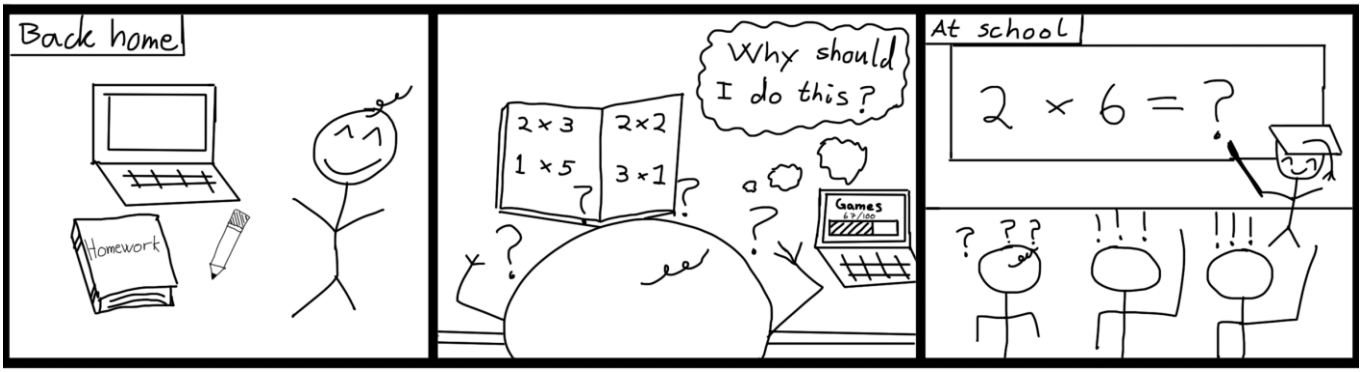

Figure 10-2: Scenario 2- Sebastian does not see the point of homework

10.3. Scenario 3

In Figure 10-3 Jessica gets home at 4 PM at Monday after being at SFO doing homework. After twenty minutes she has now completed all the homework for the entire week on the most difficult level and has nothing more to do. Jessica looks up other tasks on her homework sheets, but quickly finds out that they are trivial, and it does not feel like she accomplishes anything by doing them. She finds her older brother's mathematics books and tries to understand algebra, to no success. If only she had something closer to her curriculum to do…

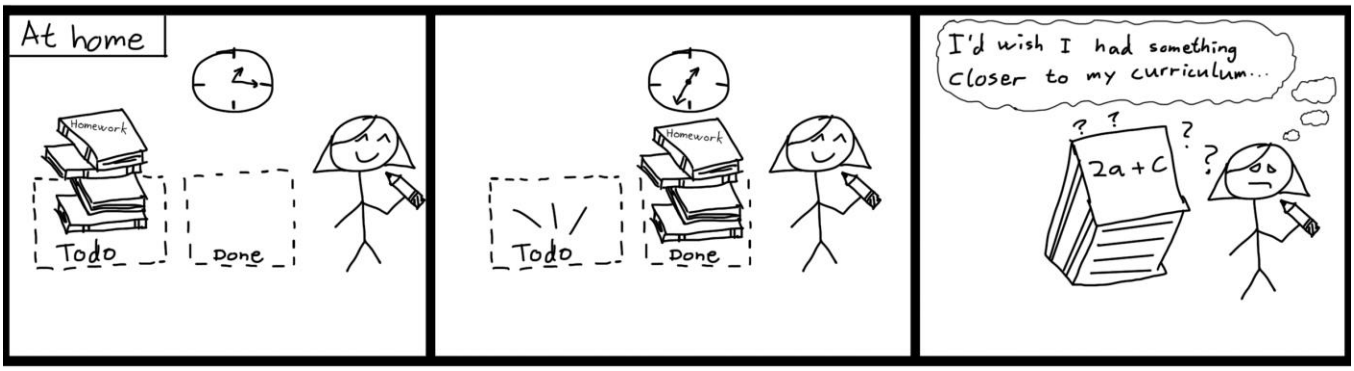

Figure 10-3: Scenario 3- Jessica needs more homework that fits her skill level

10.4. Scenario 4

In Figure 10-4 Eva spends most of her flexible school time and time at home to adapt the homework to every pupil she has. She makes 20 homework sheets every week that contain different tasks and combinations of difficulty tasks to give her pupils the best odds possible. She also tries to find fun learning games and intriguing informational videos they can watch. This results in homework sheets with several extensive URLs and the process takes up most of her spare time, something that is starting to annoy her husband.

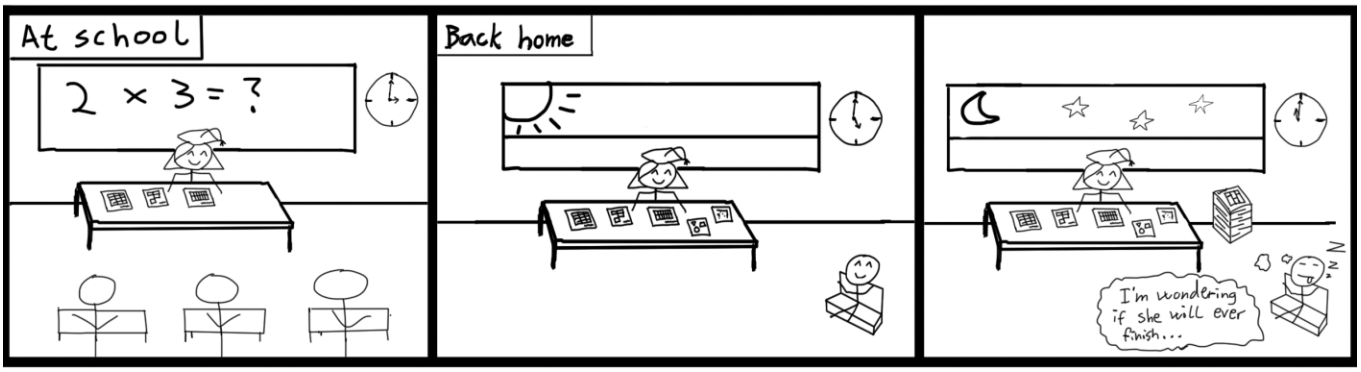

Figure 10-4: Scenario 4- Eva needs a way to spend her time more efficiently

10.5. Scenario 5

In Figure 10-5 Lars explains everything once at the blackboard at school and gives out a bunch of homework tasks from a book he found back in 1999. He tends to stay away from splitting up his homework sheet into different paths because the only data he has to figure out what his class can is paper versions of national tests. Lately, he has taken over a new class and the pupils and parents have started to complain that the children do not understand all the tasks, if they do they are often far too easy. To make the problem even worse he is starting to run out of space to keep old test results organized.

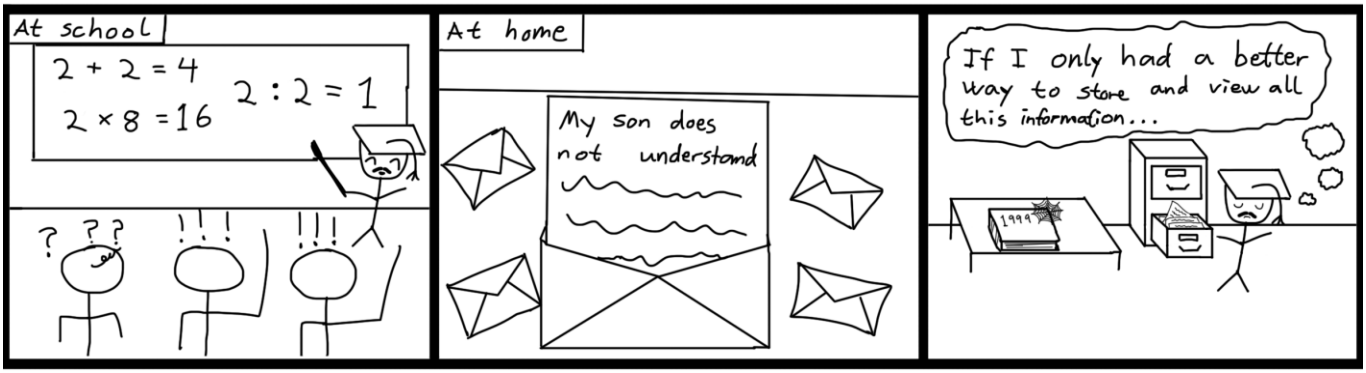

Figure 10-5: Scenario 5- Lars needs a better way to get feedback and store information

IV. Iteration 1 – Concept Generation

In the first iteration knowledge from the preliminary study was used to create the concept for Mænage School, which should solve one or many of the scenarios from iteration 0. The concept that seemed to fulfill the users' needs was chosen and elaborated upon. Next, paper prototypes were created of the concept and tested with multiple user tests. Finally, the prototypes were evaluated by using SUS and analyzed before being used in the next iteration of the project.

11. Possible Concepts

Since the personas and their problems were mostly very different from each other it was decided to use a bottom-up approach to come up with the concept for ‘Mænage School’ to focus on the problems individually. Then the concepts were combined into one, which became ‘Mænage School’. Since I was doing this project alone four students were invited to take part of the ideation process. The students were presented with the personas and their problems and got to try the ‘Mænage’ application. The brainstorming process followed brainstorming guidelines suggested by Schell (2015). A whiteboard was split into seven categories, one for each persona and one general for pupils and teachers as seen in Figure 11-1.

Figure 11-1: Ideation during first concept workshop

11.1. Quiz-bobler

‘Quiz-bobler’, or Quiz Bubbles in Figure 11-2, is a game within ‘Mænage’ that turns quiz questions into a game aimed at solving Marcus’s problems. Bubbles sink towards the ground containing a question. The pupil is presented with three alternatives where one if the correct answer to the closest bubble. If a bubble stays airborne too long, a new bubble starts sinking towards the ground. If a bubble hits the ground, the pupil misses out on the point, but if the correct answer is pressed before it hits the ground a point is given. Giving the wrong answer increases the speed in which the balloons fall. At the end, all the questions with the correct answers are presented so that the pupil can see what was correct. The focus here is to engage the pupil and switch up the conventional way of doing homework. This concept tries to solve one of the most boring aspects of homework- repetition.

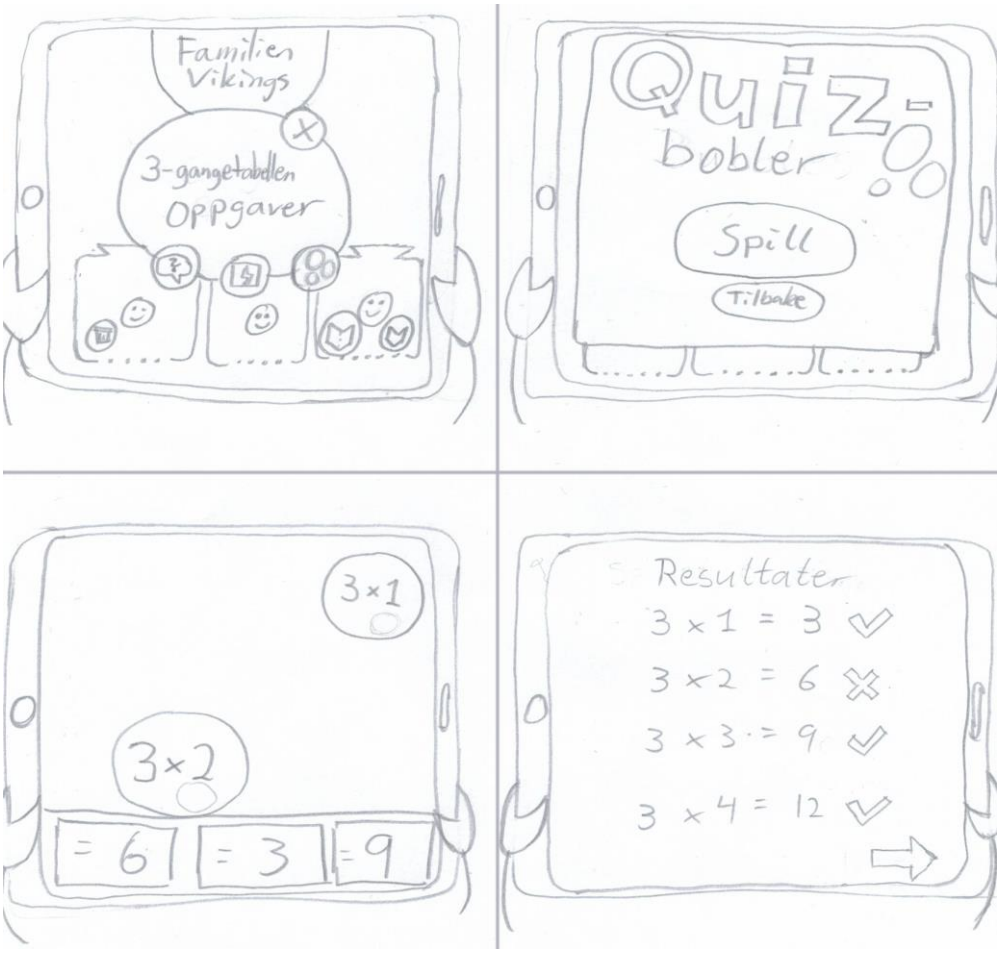

Figure 11-2: Quiz-bobler concept

11.2. Ugleklassen

‘Ugleklassen, or The Owl Class in Figure 11-3, lets each pupil mark homework in ‘Mænage’ as complete, which results in an animation that breaks up the homework ball and fills up the class owl reward bar. This is intended to solve Sebastian’s problems and give him a reason to do his homework. When the owl bar is full, the whole class gets to do an activity, which they have decided upon together with the teacher. If a pupil clicks the owl icon for her/his class, they are taken to the class’ page. Here they see the top three contributors as well as their own score of homework points. Homework points can be spent on ‘Mænage Experience Points’. You can get more points if you complete the Homework ‘dailies’ and ‘weeklies’ tasks. When you reach a certain ‘Mænage level’ you can select cool custom hats for your avatar.

Figure 11-3: Ugleklassen concept

11.3. Oppgavepåfyll

Oppgavepåfyll, or Supplementary Task in Figure 11-4, lets a pupil ask for more tasks if they want to. The teacher can add extra tasks they can ask for by clicking the ‘get more homework button’. When a pupil is finished with his/her homework the pupil can tell the teacher

what they think about the homework so that the teacher can adapt the difficulty and content in general for next week. The pupil could also state how much time they spent on the homework to give the teacher further insight. Requested tasks will appear in the 'What to do today' area where all the homework that should be done for the day appear automatically. The goal of this concept is to provide tasks that fit the pupil as much as possible and aims to solve Jessica's problems.

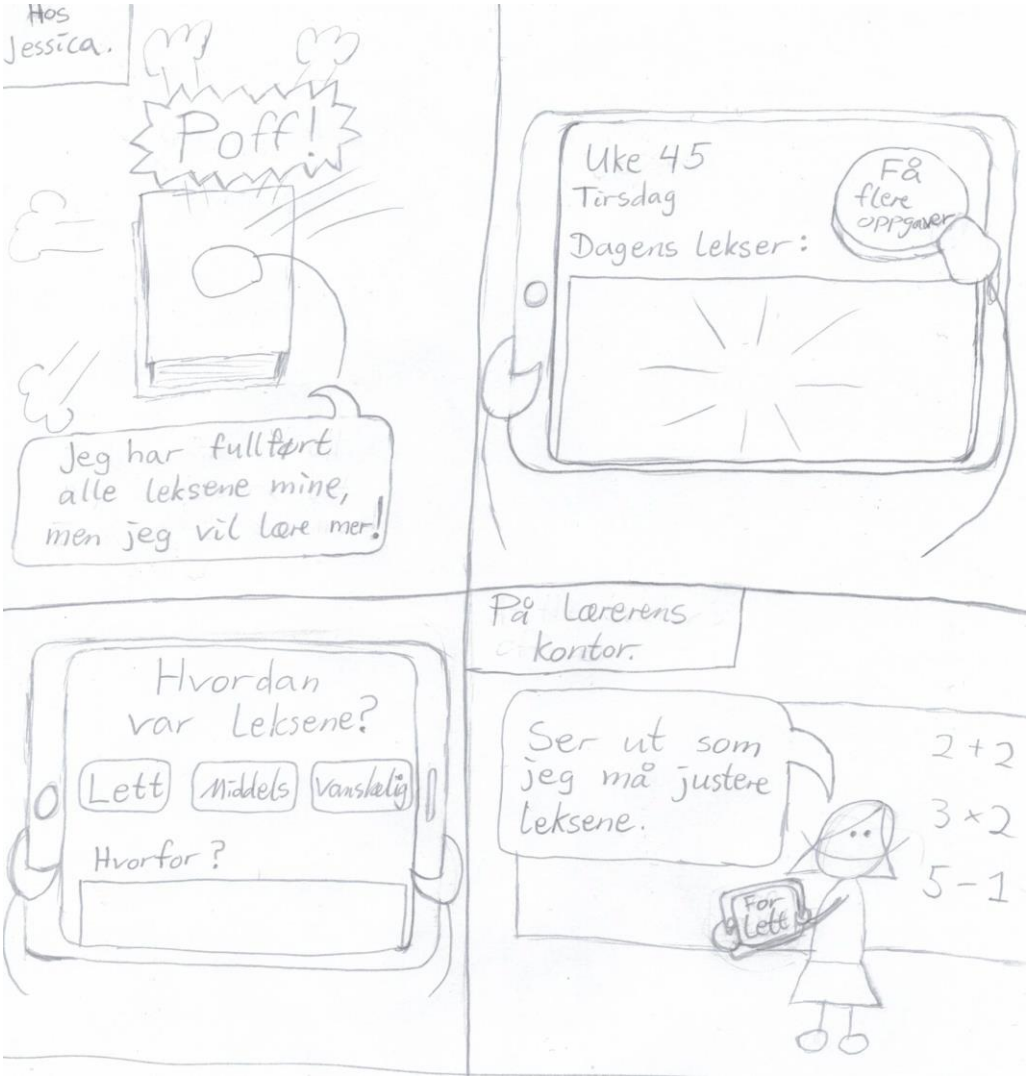

Figure 11-4: Oppgavepåfyll concept

11.4. Ukeplanleggeren

The goal of Ukeplanleggeren, or The Week Planner, is to solve Eva's problem: to adapt to every pupil as much as possible without spending all her day working to achieve it. The teacher can sign in and be the teacher of multiple classes and multiple subjects where the system administrator grants the appropriate accesses. Each week has its own homework sheet divided into four categories- tasks, task distribution, messages, and feedback. The tasks then appear in the pupil's 'Mænage' application presented as a task bubble.

The tasks category further divides into the subjects the teacher has access to. In Figure 11-5 we see how tasks in a subject can be divided into difficulty levels. The teacher can name the paths whatever they like, and can add, edit, and remove at will. When filling in the tasks they can add sub-goals so that pupils can check off the parts they have completed, the teacher can also provide a description and hints to the different tasks. The decision to provide the functionality for infinite amounts of difficulty levels was made based on the fact that in Norway each pupil has the right on adapted teaching and varied work methods (Utdanningsdirektoratet, 2011). This means that making a fixed amount of difficulty levels and put each pupil in them would make it illegal unless you have a way of further adapting to the ones not fitting into any of the groups, like the edge cases. This means a pupil that in Figure 11-5 would not fit in either path A, B, or C.

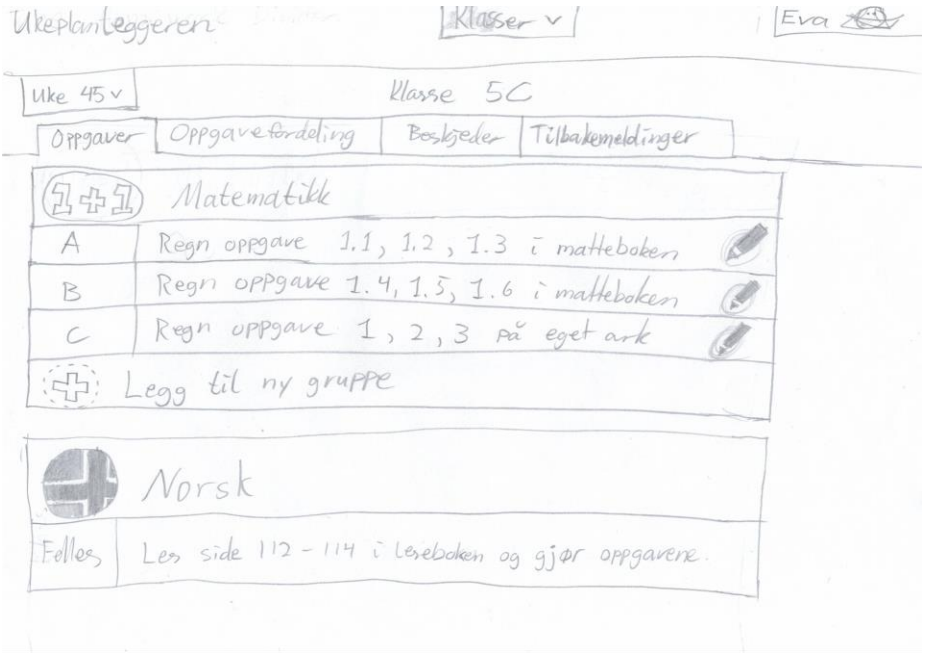

Figure 11-5: Ukeplanleggeren concept part 1

The task distribution category in Figure 11-6 shows how the application provides a list of all the pupils in the class where the teacher can allocate which path a pupil should have. The category can be changed based upon the feedback from the homework and the observations the teacher makes.

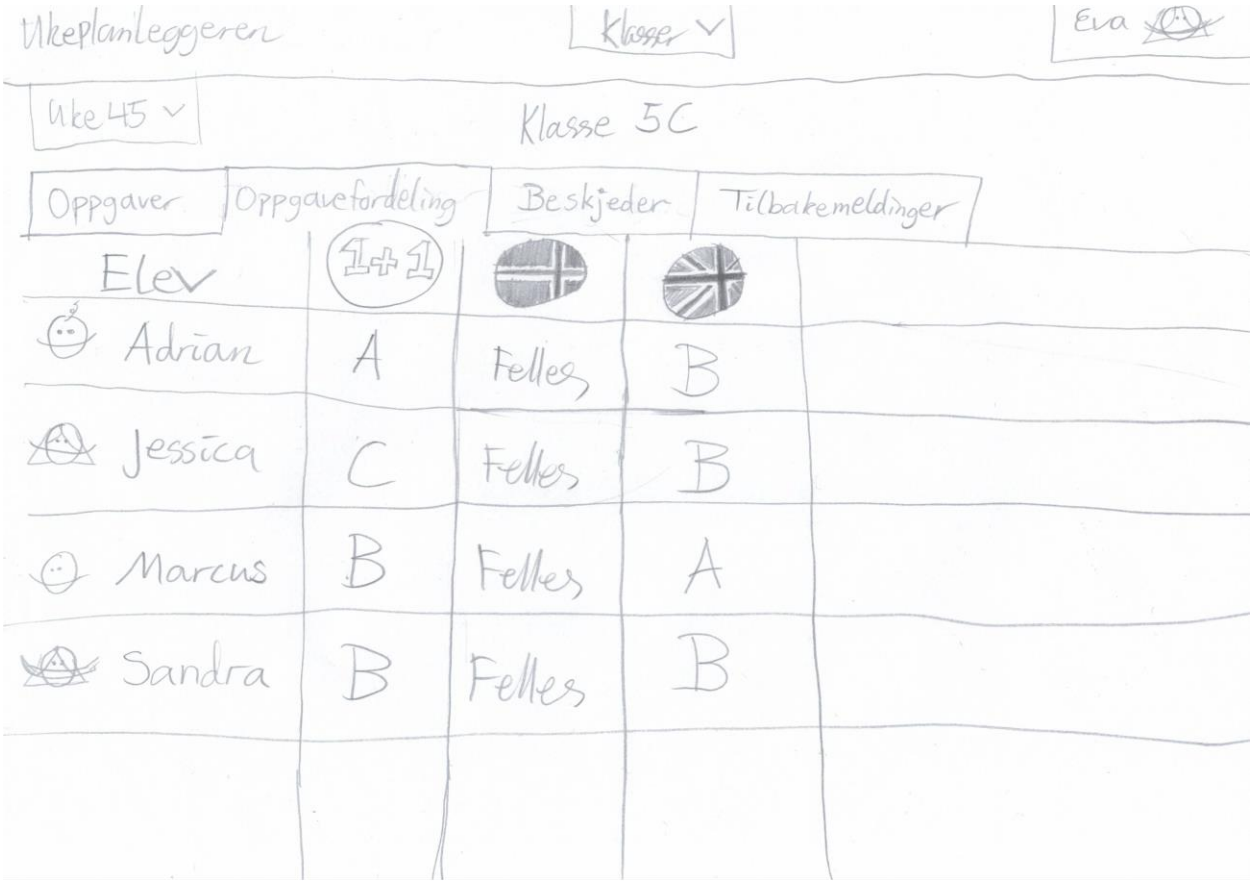

Figure 11-6: Ukeplanleggeren concept part 2

The messages category, seen in Figure 11-7, gives the teacher an easy way of sending information to the pupil that in turn can show messages to the parents. When the teacher adds a message, it appears on the pupil's 'Mænage' application in their overview. Messages can easily be added, edited, or removed, all in the same view.

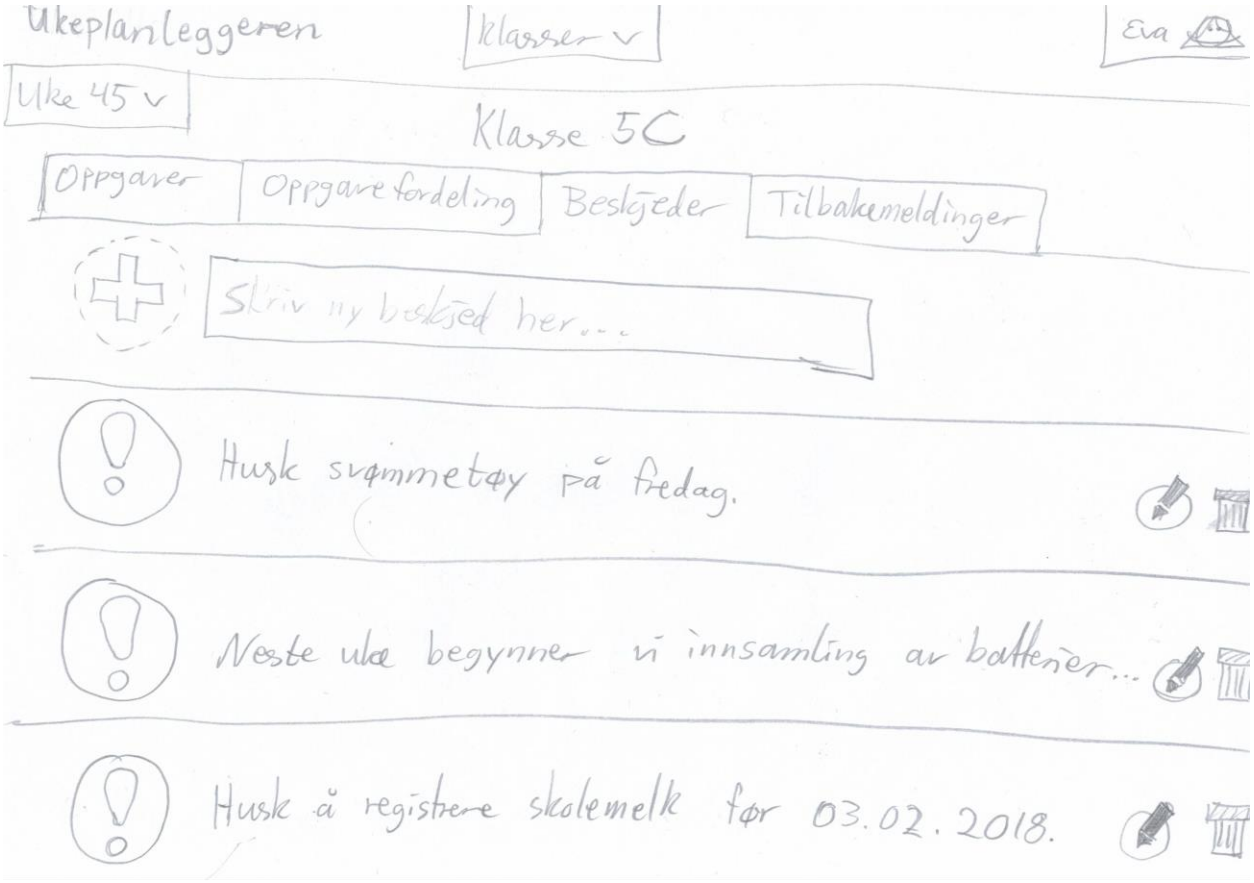

Figure 11-7: Ukeplanleggeren concept part 3

When a pupil has finished a homework bubble, he or she can tell the teacher how it felt doing it- whether it was easy, appropriate, or hard. They can also leave a textual description to help the teacher understand the problem. Figure 11-8 shows how a teacher can select a subject and see how the feedback is averaged across the different difficulty paths, and then see what every pupil answered and view their textual description if they provided one.

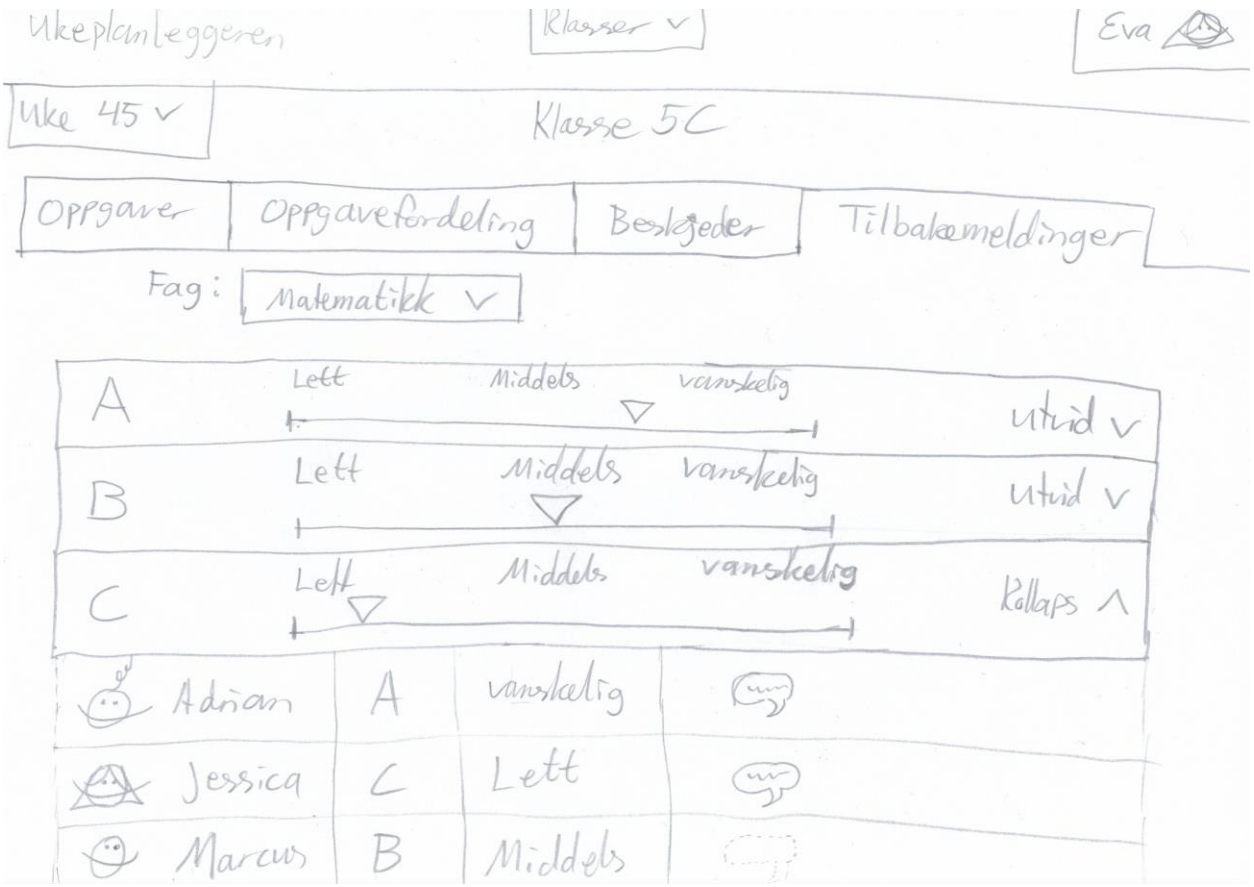

Figure 11-8: Ukeplanleggeren concept part 4

11.5. Klasseinformasjonsentralen

Klasseinformasjonsentralen, or The Class Information Central, aims to solve Lars' problems with organizing. It shares a similar layout with The Week Planner but has a focus on tracking evaluations and to track messages between the teacher and parents. The application sorts this information by year rather than weeks so that all information about the pupil can be viewed at the same time. Similarly, The Class Information Central lets the teacher have multiple classes and have your own login profile so that teachers can have access to what they need. Figure 11-9 shows the evaluation panel, which also could be used for notes about the pupil, and Figure 11-10 shows how the messages could be arranged in the inbox.

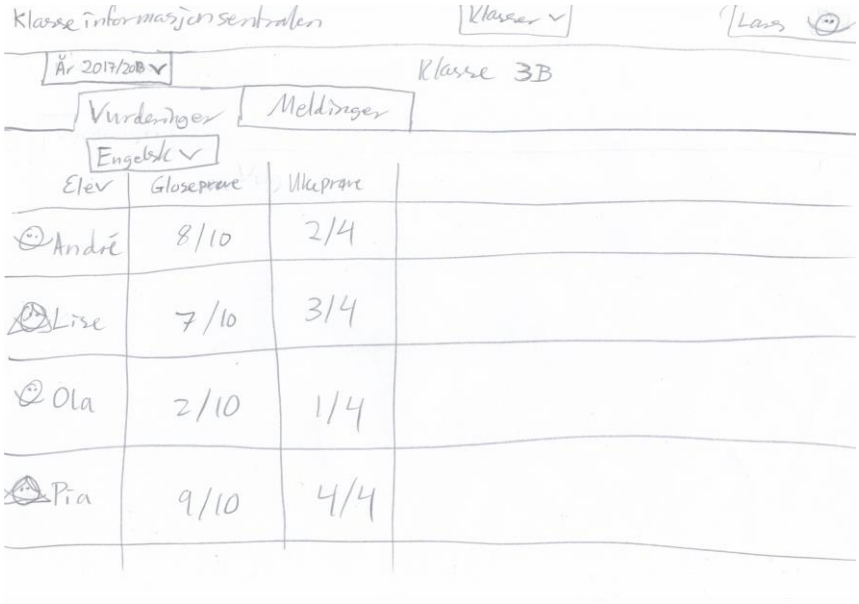

Figure 11-9: Klasseinformasjonsentralen concept part 1

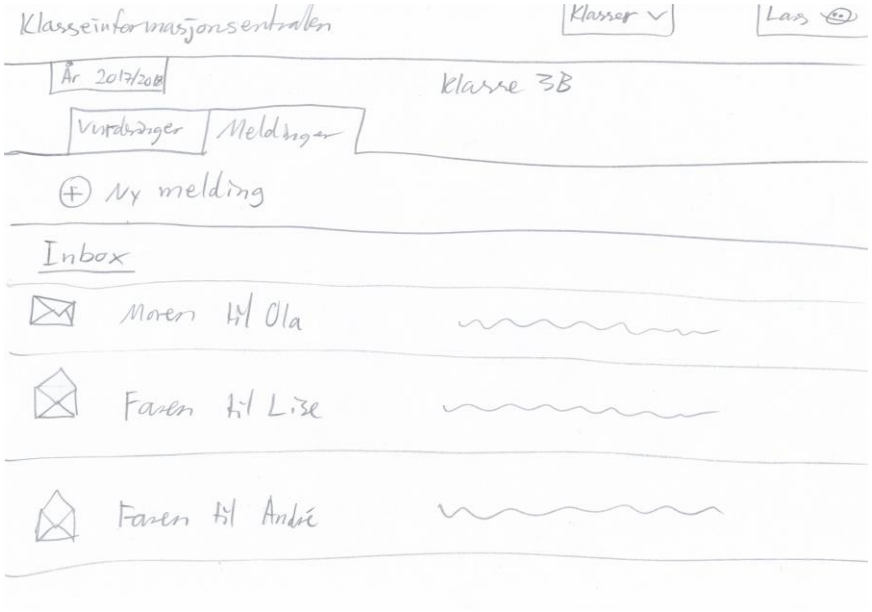

Figure 11-10: Klasseinformasjonsentralen concept part 2

12. Mænage School

This subchapter presents the different views for the first iteration of the ‘Mænage School’ concept. The subchapter is split into two sections where the pupils’ and teachers’ side of the application is explained respectively. The prototype is the result of merging the five individual concepts from subchapter 11. However, as you can see the concept revolving Marcus is not present. This is because a decision was made to test if Eva’s need of integrated Internet links could be used to solve both personas’ problem. This means not making the gameplay aspect a part of ‘Mænage School’ itself, but to rather solving his problems by using Internet resources such as Quizlet (Quizlet, 2018), which already does what that part of the concept tries to achieve- giving alternative ways of learning without requiring any setup from the pupil. This gives the teachers more flexibility to help the pupils improve their learning, after all the teachers are trained pedagogues. The general design considers aspects of the GameFlow evaluation framework found in Appendix A. The concept does not implement experiential learning as explained in section 3.3, but should provide the toolset for the teacher to do so. Minor interactions such as displaying dropdown menus, are done using sticky notes in the tests and therefore does not show in the exports in this subchapter.

12.1. Pupils’ Application

The pupils’ part of the ‘Mænage School’ application was intended for tablets since the application it builds upon, ‘Mænage’, was made for tablets. The prototype consists of three screen views: the augmented ‘Mænage’ main screen, the homework screen, and the school class screen.

Below in Figure 12-1 you can see the augmented ‘Mænage’ main screen. What is new from the core application is the owls in the top right corner and the task bubbles represented with books with different images on, here with ‘1+1’ and the Norwegian flag for mathematics and Norwegian respectively. Each child in the family will have their own owl with a progress bar in the top. When they complete a homework-related task an animation will play that tells the child that the homework contributed to the progress. The bar represents a school class reward and fills up as the pupils in the class complete homework. The owl works both for telling the user that this has to do with the school part of the application, and to use the emotional aspect of fantasy by introducing theme (Malone, 1980). The owl was chosen as the icon because it can represent wisdom, and is often used in school context, such as in the logo for NTNU’s student organization for teacher education, Erudio (Erudio, 2018). The number and letter below the progress bar indicates the pupil’s school class where the number represents which grade they are in, and the letter indicates the partition, which was the format all pupils and teachers interviewed were used to. The interactions to test in this view are clicking an owl which takes the user to the school class view and clicking the homework which takes the user to the homework task view.

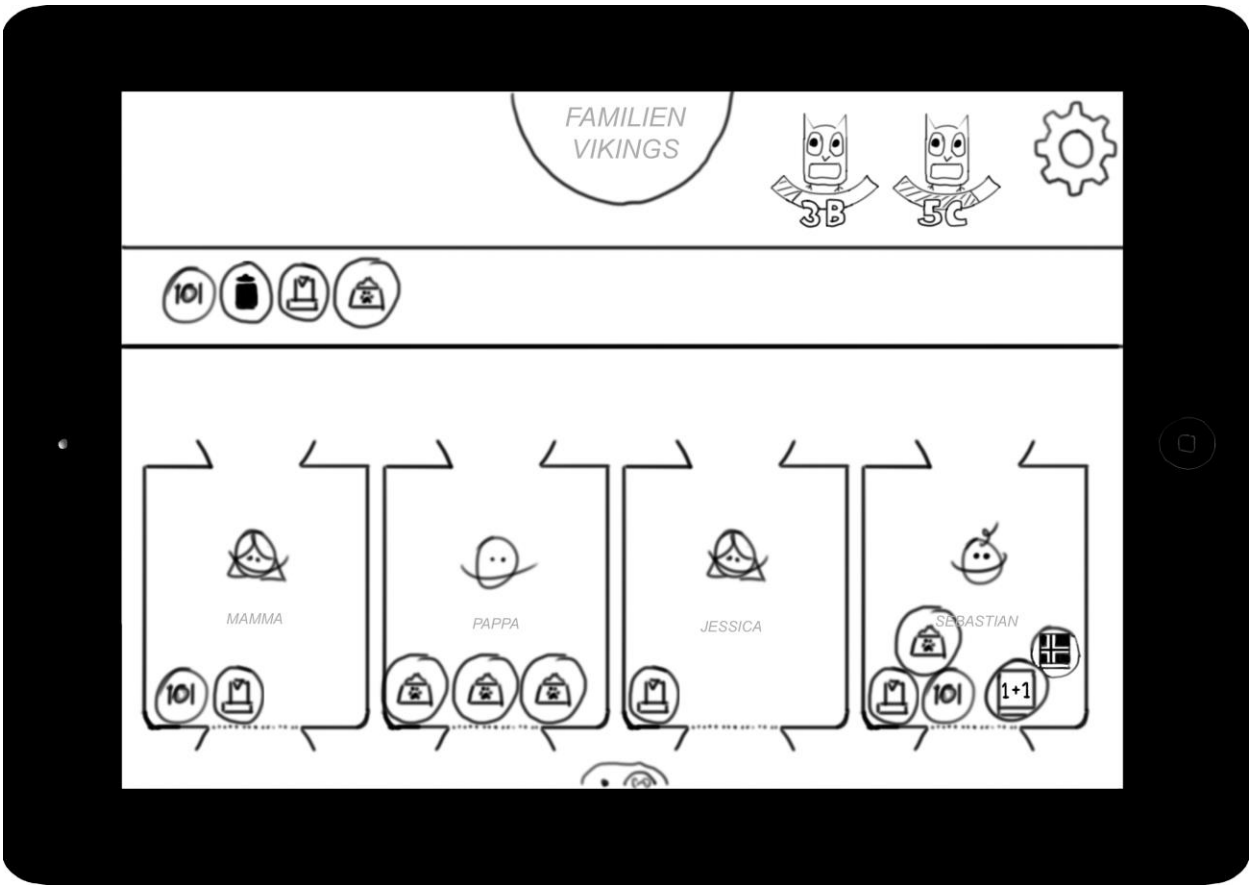

Figure 12-1: Prototype 1- augmented 'Mænage' main screen

By clicking a bubble with a book, the user is taken to the homework task view seen in Figure 12-2. By overlapping the homework task with the main view one keeps the consistency of data display (Smith, Mosier, & Mitre Corp Bedford, 1986) as established by 'Mænage', and tells the users that they are still doing something that has to do with what is in the background. If sub goals are provided by the teacher, they are listed on the left side as square boxes as an indication that multiple boxes can be checked. This makes sure the pupil always has a clear goal in mind as well as letting them know they are getting closer to the end goal, which is to turn in the homework, which enforces the challenge aspect of fantasy (Malone, 1980). The 'X' is kept in the top right corner in all views to keep efficient information assimilation by the user (Smith et al., 1986). Also, by keeping the name and avatar on the task itself the memory load is reduced, since they do not have to remember whose homework it is in the case of multiple pupils using 'Mænage School' in one household. To indicate that the check button cannot be clicked before all tasks are complete the button will stay grayed out until all checkboxes are filled as a user constraint to make the pupil complete the correct actions first (Norman, 2013). If the teacher includes links in the homework they get listed on the right-hand side along with their title, so that they do not get mixed up with the checkboxes on the left. If the pupil checks all the boxes and unlocks the check button, for then to click it, the task view closes, the user is taken back to the main view, and the task bubble dissolves and fills up the correct owl's progress bar.

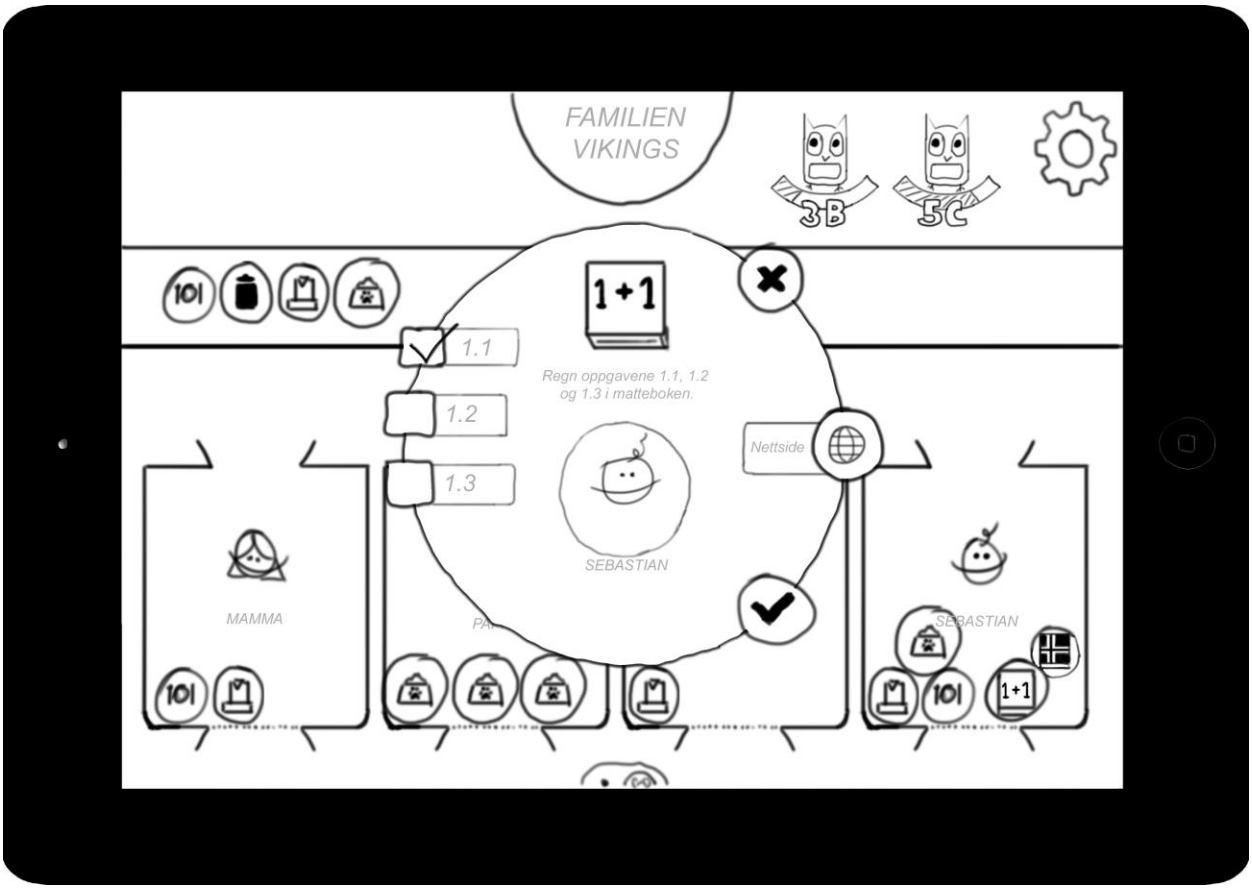

Figure 12-2: Prototype 1- Homework task screen

When the user clicks an owl the school class view, as shown in Figure 12-3, opens as a new overlay window. On the top the name of the school class is displayed so that the user can be certain they are looking at the correct class' page. On the left side the pupil can click the button to get more homework tasks. If the teacher has added extra homework they will appear, if not they will receive tasks from the other difficulties similar to their own difficulty path. The button is shaped as it is to give the button affordance (Norman, 2013) that invites the user to click it. In the center the progress bar is displayed with the reward embedded, the goal here is to indicate that the reward written inside is what is going to happen when it is filled. On the right-hand side there is a podium with the three pupils who have earned the most school points, so that they can compete within the class. However, there is not a complete list of everyone's score to avoid pupils who struggles with their homework to become less motivated. At the bottom, messages from the teacher are listed. These take up a lot of space, are made big, and use an exclamation mark to catch the pupil's attention, since the nature of these messages are often things they should tell their parents.

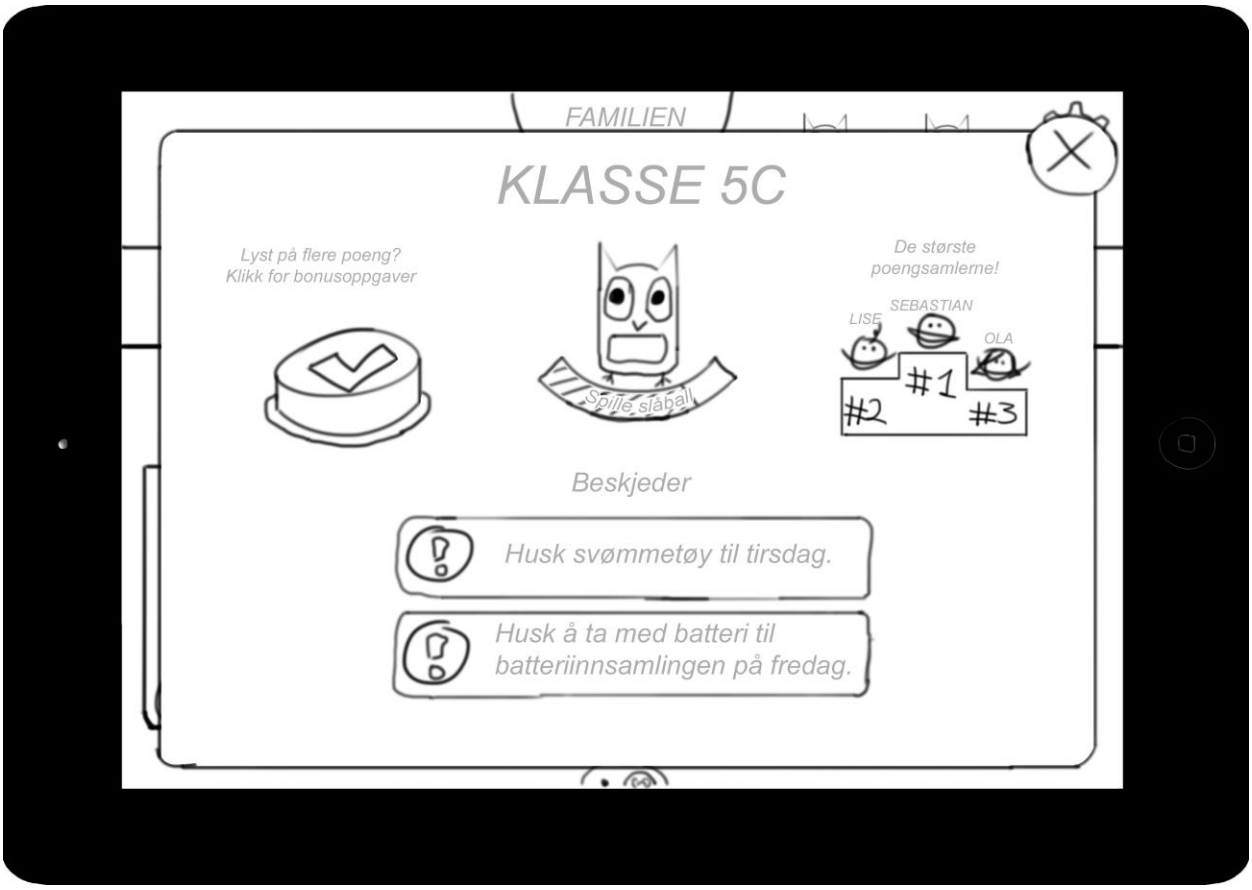

Figure 12-3: Prototype 1- School class view

12.2. Teachers' Application

The teachers' part of the 'Mænage School' application was intended for use in web browsers on computers, this was based upon what the teachers interviewed were used to work with. This concept attempts to merge the suggested solutions for the personas Eva and Lars into one web application. The prototype consists of seven screen views: the task view, the task view with unfolded path editing, the task distribution view, the information view, the feedback view, the evaluation view, and the message archive.

Figure 12-4 is a representation of the task view. The teacher can change which week to edit by using the dropdown menu at the left below the main navigation bar and change which class' homework sheet to edit in the dropdown menu to the right of it. All the views related to the homework sheets follow a 'hanging file folder' metaphor relating to Lars' file cabinet. Metaphors are used in the design to make it easier for the users to relate to the graphical user interface and more effectively communicate the conceptual model to them (Shneiderman et al., 2014). From left to right the main navigation bar consists of the application logo, a table representing the homework sheet, a folder for archive, an envelope for messages, and an indication of which user is logged in. Which of the three main views are active is indicated by a colored background on the currently active one. Clicking the username area displays a dropdown that lets the teacher administer their account and set the school class goal seen in Figure 12-3: Prototype 1- School class view.

The task view should present the teacher with all the subjects they are in charge of related to a school class. Since the most common way of dividing into different levels was by separate paths the concept carries over to the application. The created paths are listed below each subject and contains the written description and can be edited or deleted by using the pencil or trash can. By clicking the button under the path named "Legg til" the teacher can add another difficulty path.

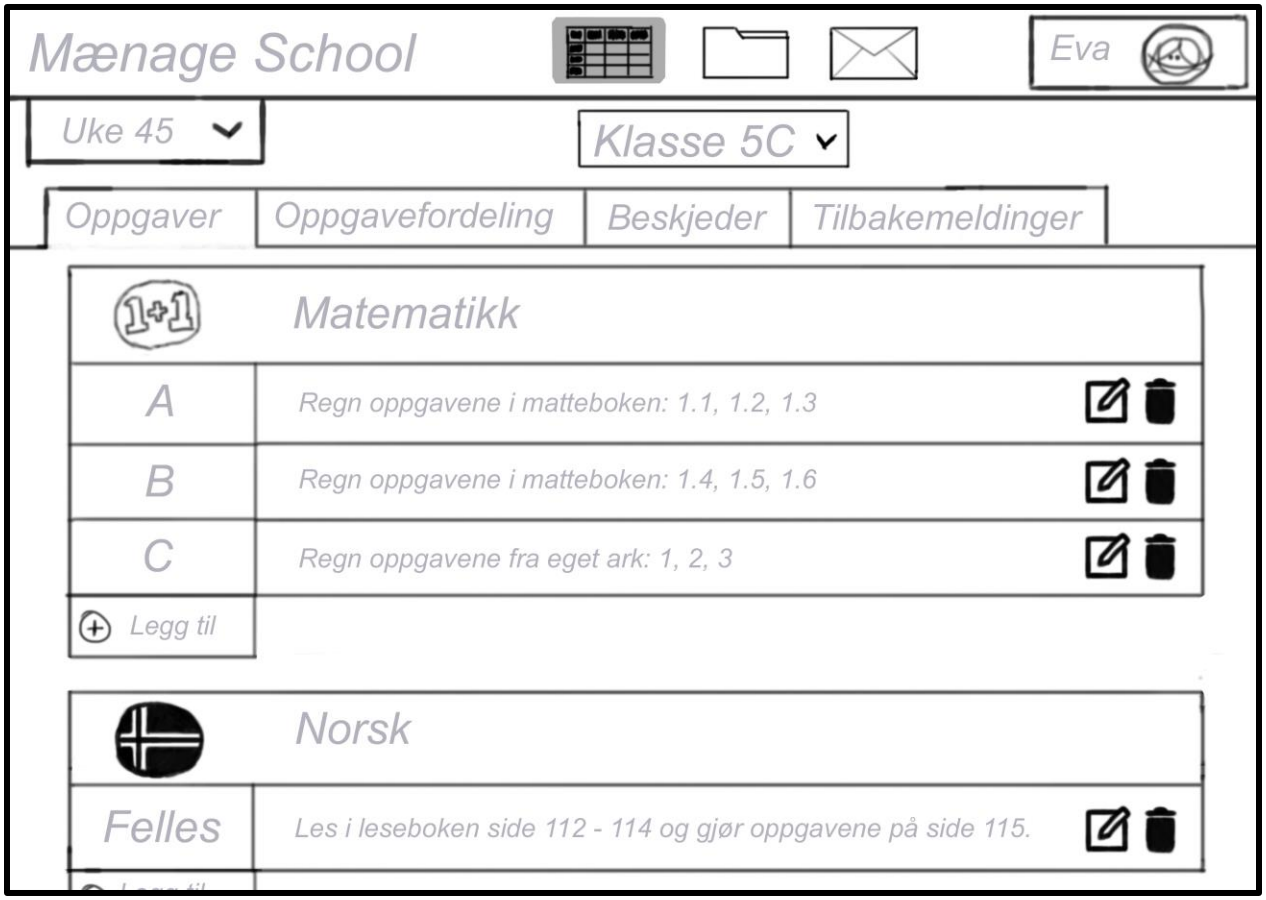

Figure 12-4: Prototype 1- Task view

When the teacher clicks the pencil on a difficulty path, it unfolds as seen in Figure 12-5. The text area is for a description- here the teacher can write whatever they want. Under "Delmål" they can add sub goals by clicking "+" and remove sub goals by clicking "X". Sub goals are goals pupils can check off when doing homework so that they can get a sense of progression throughout, they are represented as a checklist in Figure 12-2: Prototype 1- Homework task screen. Internet links can be added by following the same conventions as in sub goals only under "Lenketittel" and "URL", which represents the display name of the link, and the full URL. There are three radio buttons to the right: "Felles" means the difficulty path will be given to all pupils in addition to the assigned difficulty path, this means the teacher does not have to write shared tasks in all the paths and keeps the homework modular. "Extra" means they are granted if the pupil clicks the 'get more tasks' button as seen in Figure 12-3: Prototype 1- School class view. "Vanlig" means you can assign it under the task distribution view. Clicking the check icon next to the trash can saves the changes and closes the expanded information about the current difficulty path.

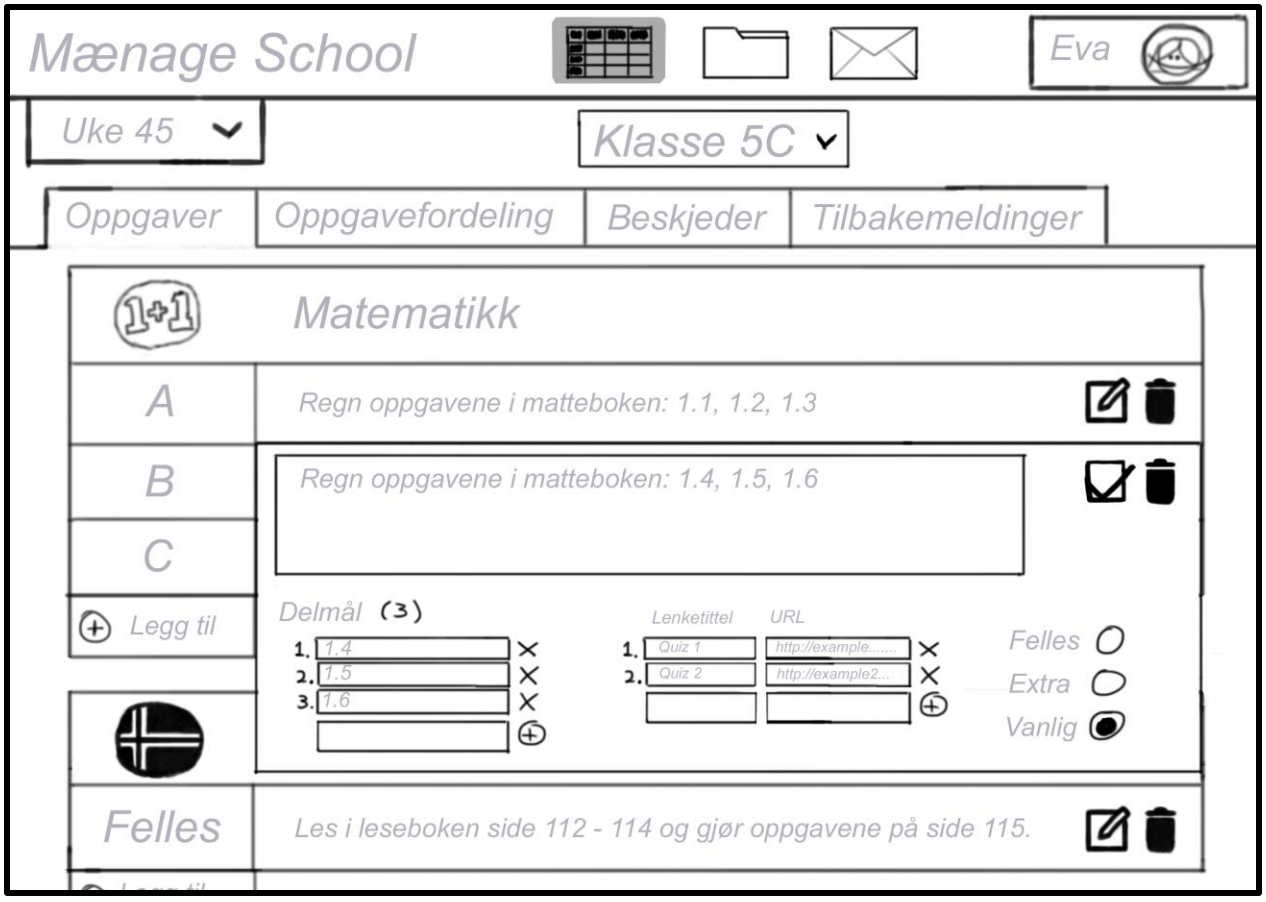

Figure 12-5: Prototype 1- Task view with unfolded path editing

The task distribution panel, in Figure 12-6, displays a table with all the pupils in the selected class. When the difficulty path is clicked, a dropdown menu is displayed with all the available difficulty paths for that subject. This means that in this case clicking A under "Matematikk" in Adrian's row will display the options "A", "B", and "C". For each subject available to the teacher a new row appears, but this functionality is intended for an administration user and does not have to be the teacher's concern. The table metaphor is used because it is easy to add more subjects by adding another column, and as seen from all the collected homework sheets, all the teachers organize them in tables.

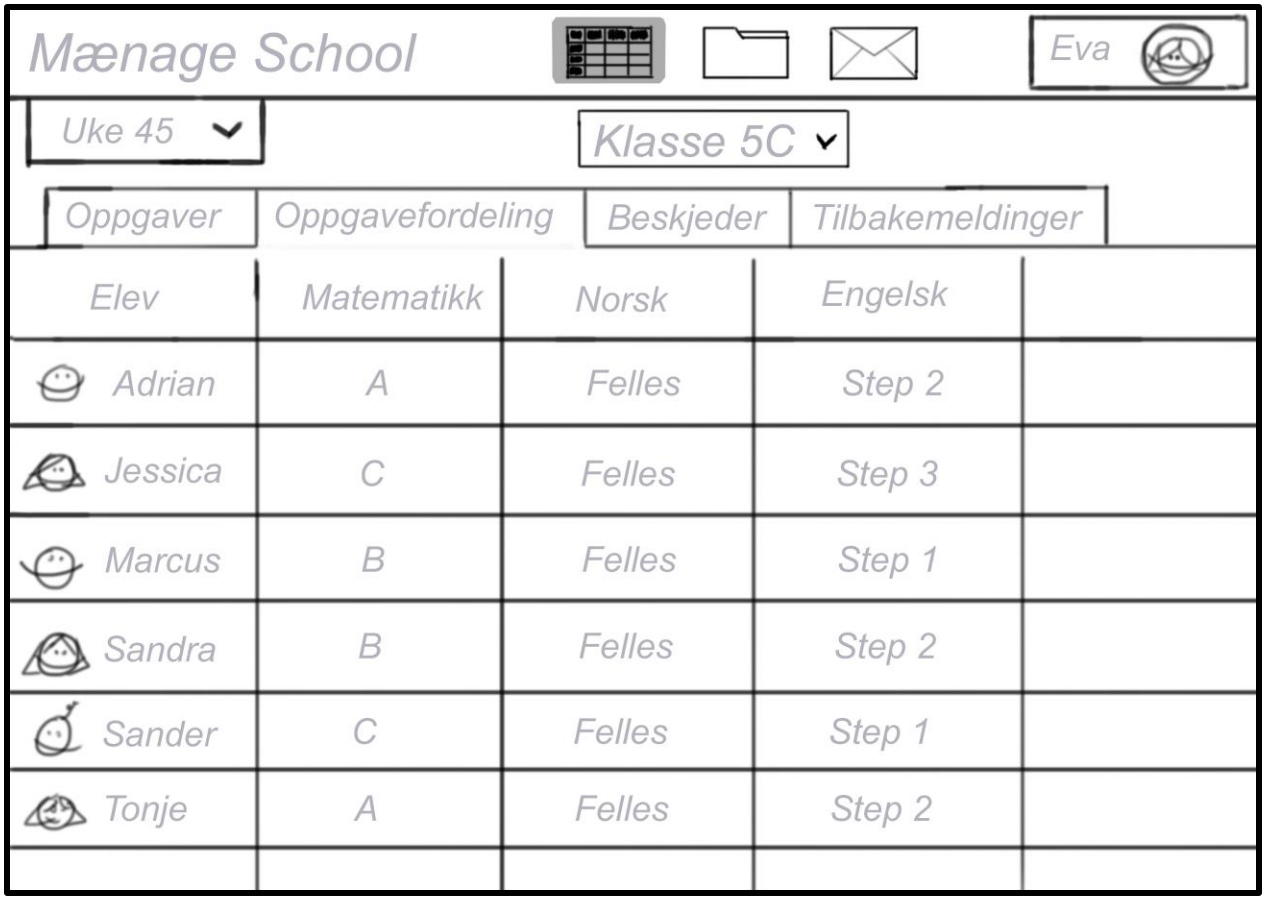

Figure 12-6: Prototype 1- Task distribution view

Figure 12-7: Prototype 1- Information view gives the teacher the ability to add messages for the pupils to bring to their parents at home. A message is given an exclamation mark to signal that it is important. The messages are listed from top to bottom and by writing in the top most field, the teacher can add additional messages. Figure 12-3: Prototype 1- School class view shows how the information is displayed to the pupils in their application. The pencil and trash can share similar functionality as in the task view for concurrency.

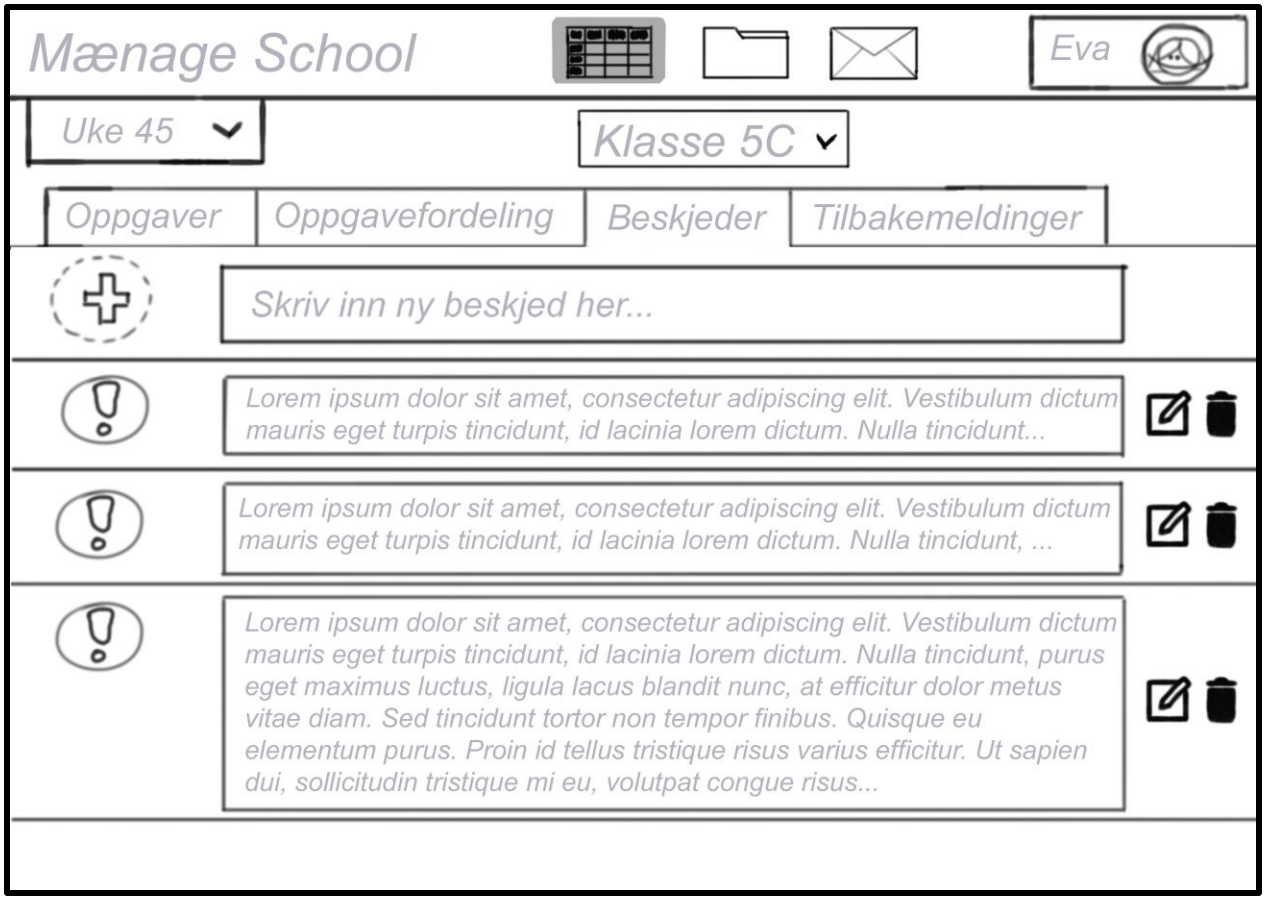

Figure 12-7: Prototype 1- Information view

When the pupil has finished a homework bubble they can give feedback to the teacher. The teacher gets the feedback summarized and can view more detailed feedback by expanding a difficulty path as seen in Figure 12-8. When expanding the difficulty path, each pupil who is assigned that path is listed together with her or his discrete feedback answer and their continual feedback in the word balloon, if any is provided. Clicking the caret toggles the extended information, and for switching between the subjects one uses the subject dropdown menu.

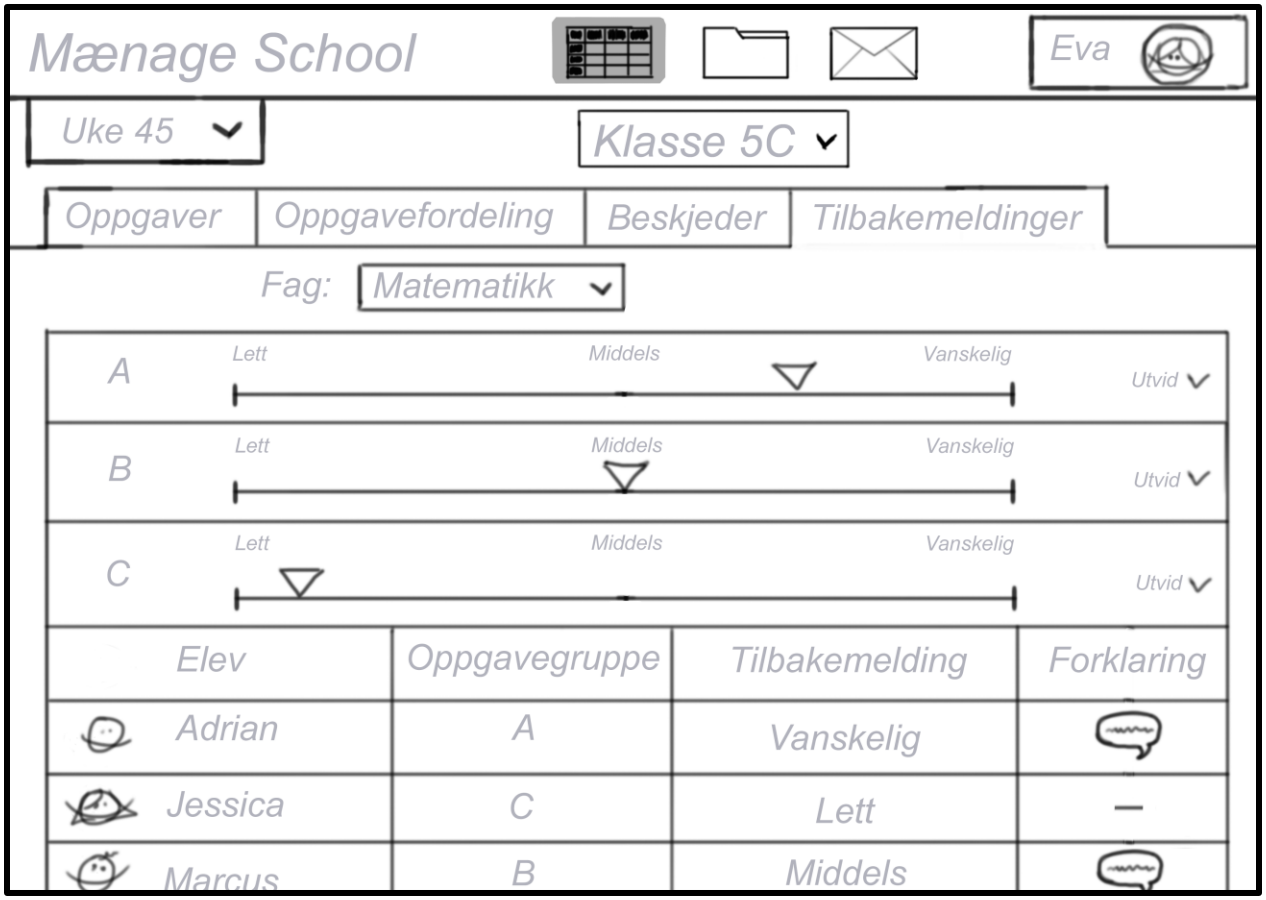

Figure 12-8: Prototype 1- Feedback view

If the teacher clicks the file folder in the main navigation bar they are taken to the evaluation view shown in Figure 12-9. The teacher can switch between subjects using the subject dropdown and can add a new evaluation to each pupil by clicking the "+" next to the right-most table column.

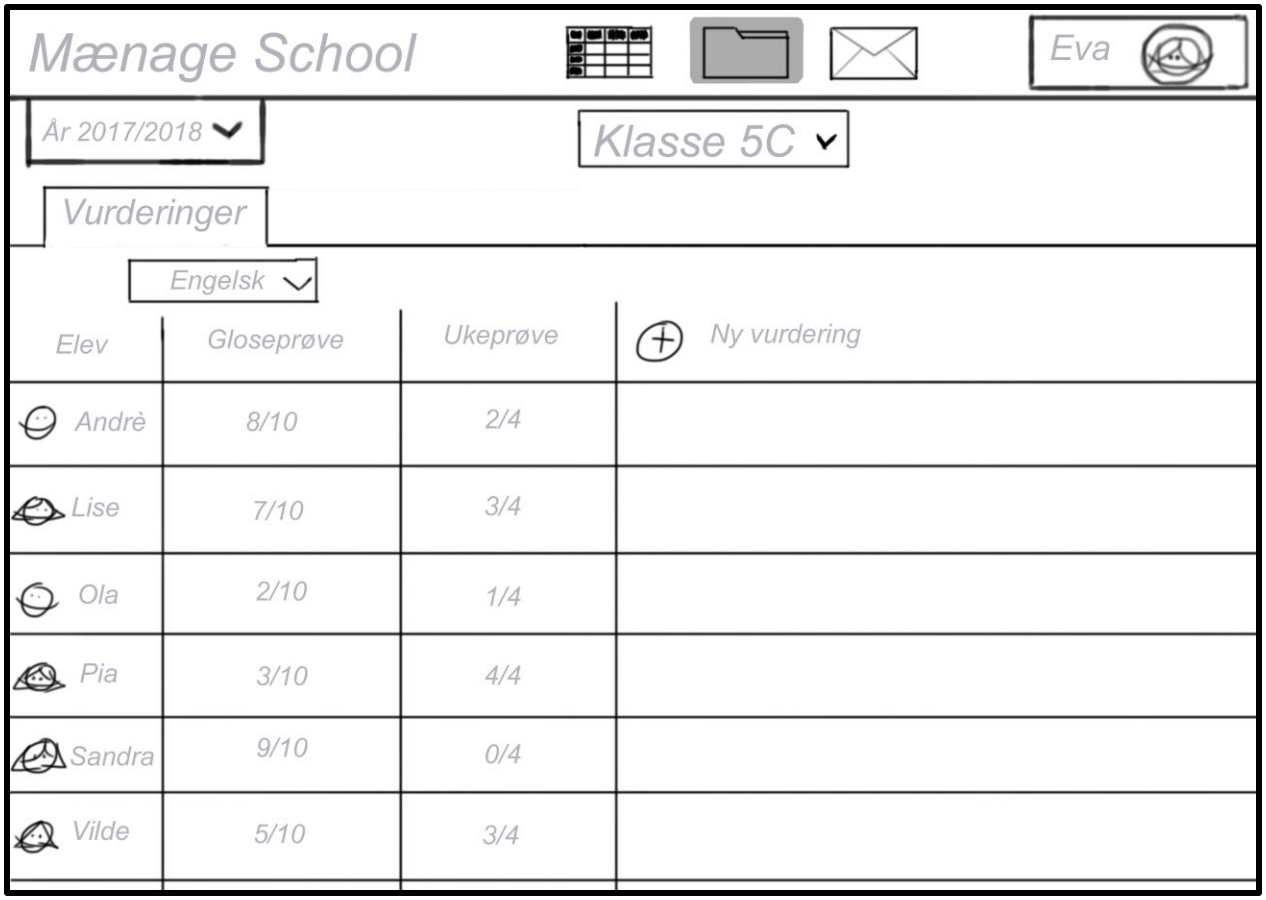

Figure 12-9: Prototype 1- Evaluation view

If the teacher wants to write down or copy and paste messages between themselves and the parents, they can click the envelope in the main navigation bar. This takes them to the message archive view shown in Figure 12-10. The teachers who were interviewed reported that their preferred way of contacting parents was by paper notes, typically by a message book or single piece of paper, by SMS, or email. The perfect scenario would be to cut these three medias and have a dedicated messaging service in the application, but as Lie and Sørensen (1996) explain in the process of domesticating technology into everyday life it is an extensive process to incorporate new technology into our everyday life and identify ourselves with them. Therefore, this is provided as a timeless alternative across all three mediums. Four fields are provided in each message section- title, from, to, and the message itself. By clicking the floppy disk icon, the message gets saved in the archive.

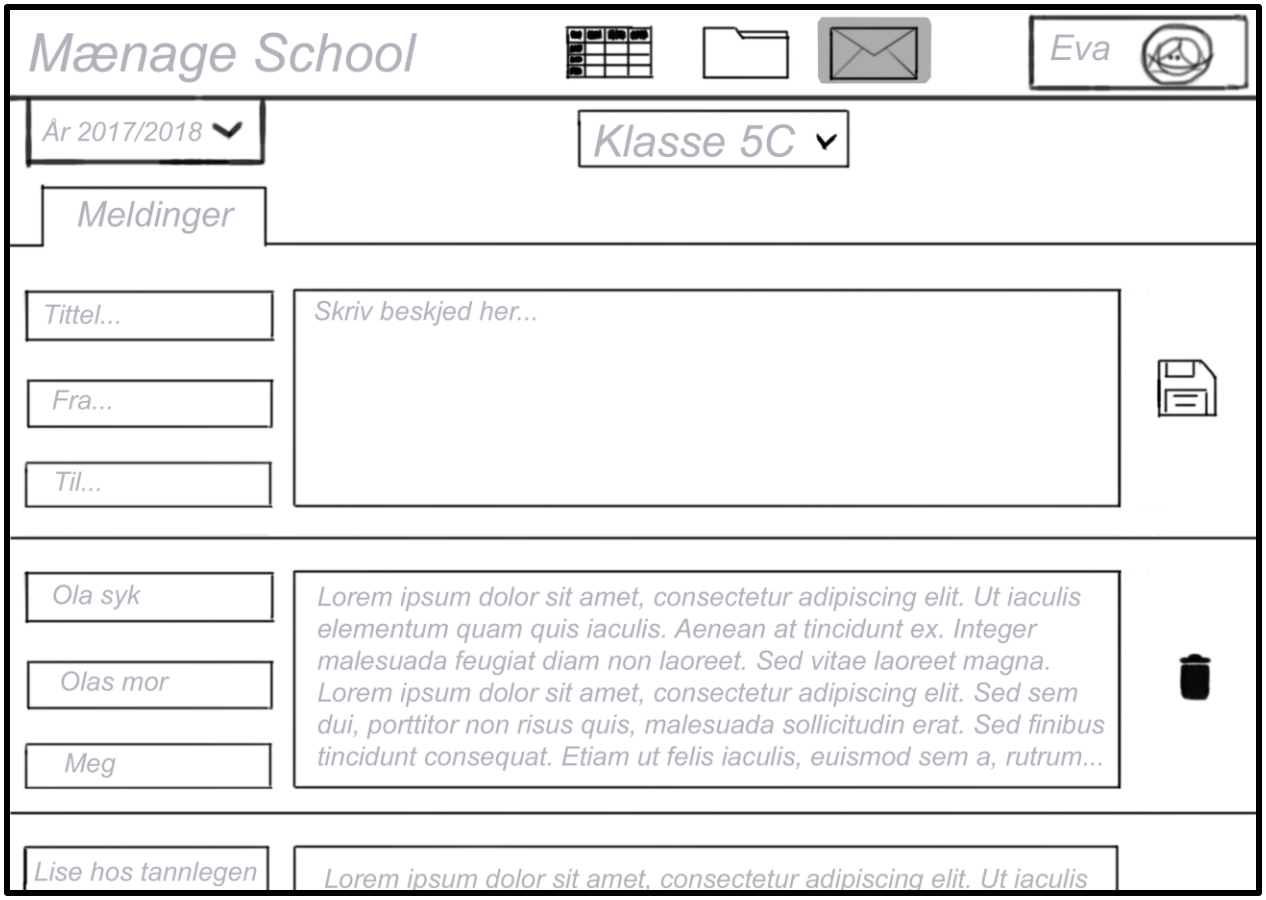

Figure 12-10: Prototype 1- Message archive

13. Results and Analysis – Iteration 1

This subchapter presents the results from the testing of the first iteration of the paper prototypes. Each prototype was tested by both people inside the targeted audience as well as outside, which was the case for the teacher concept. This is because of in addition to testing if it carries the functionality they require, testing on more people would give a better idea if the interactions were working as intended, as well as revealing unforeseen problems. When a tester had completed the scenarios without assistance they answered a SUS form and gave their comments on the prototype.

13.1. Pupils' Concept Feedback

In Table 13-1 follow the results of the first test with the pupils and is the results of feedback (F) from the tester and the observations (O) made during the testing of the first paper prototype for the pupils' concept.

Scenario 1: Complete your mathematics homework.	
F1.1	Why is the check button grayed out and not just gone or has a "X" over it?
F1.2	The English subject should be the Great Britain Flag or the American one.
F1.3	Expected the task to show up in the application when the checkbox was clicked.
F1.4	Why can I uncheck a box again? Cannot people cheat then?
F1.5	The text is to light, it is difficult to notice.
F1.6	Since my bar is not full, do I not get to play, while the other get to play?
F1.7	The exclamation mark should be yellow and the 'Get more Tasks' button should be green.
F1.8	I would like to spend my own school points on something.
F1.9	Why are the checkboxes on the left and the complete button on the right?
O1.1	Thinks the website link is connected to a specific sub goal.
O1.2	Understands that the "1+1" is mathematics subject and the Norwegian flag is the Norwegian subject.
O1.3	Expects the first check button to uncheck when clicking the second one.
O1.4	Did not notice the description text before after clicking all the buttons.
O1.5	Difficult to separate the foreground from the background in the paper prototype.
O1.6	Thinks the owl points are only their own, not the school class total.
O1.7	Managed all the interactions that had to do with the school class view.
O1.8	Understood the feedback form without any problems.
O1.9	Clicks the checkboxes before they do the task and expects a new task to show up when they click it.
Scenario 2: Check if there are any messages from your teacher.	
F2.1	It does not matter to me if I am on top of the podium or not.
F2.2	"Hah! I have collected the most points in my class!"
O2.1	Was able to use all the functionality and find all the information.
Additional feedback	
F	The text should be easier to see.

F	The “X”s that closes things should be red.

Table 13-1: Feedback for pupils’ low-fi prototype iteration 1

The pupils filled out the SUS schema in Appendix B, in Table 13-2 are the results and the calculated SUS scores. The SUS translation is from Bangor et al. (2009).

System Usability Scale	T_1	T_2	T_3
1. I think that I would like to use this product frequently.	5	4	4
2. I found the product unnecessarily complex.	4	3	2
3. I thought the product was easy to use.	3	4	4
4. I think that I would need the support of a technical person to be able to use this product.	4	5	3
5. I found the various functions in the product were well integrated.	5	3	4
6. I thought there was too much inconsistency in this product.	1	3	2
7. I would imagine that most people would learn to use this product very quickly.	5	4	4
8. I found the product very awkward to use.	3	5	1
9. I felt very confident using the product.	5	5	4
10. I needed to learn a lot of things before I could get going with this product.	4	3	3
SUS score	67.5	52.5	72.5
Average SUS score	64.2		

Table 13-2: SUS scores for pupils' low-fi prototype iteration 1

An average score of 64.2 is too low and should be re-implemented with the feedback gathered from the testers.

13.2. Teachers' Concept Feedback

In Table 13-3 follows a summary of the feedback (F) from the tester and the observations (O) made during the testing of the first paper prototype for the teachers' concept.

Scenario 1: Add task 1.7 as sub goal for difficulty path B under mathematics for class 5C.	
F1.1	What is the checkbox for, if it is saving- should it not be saved as you edit?
F1.2	I would like it to save on the go, I would not like to lose work if I click another group.
F1.3	I would be more intuitive to not show the input fields and just the "+" on the links and sub goals, so I not have to wonder if my pupils got a blank sub goal.
F1.4	If there is to be a save button that close to the delete button there should be a "are you sure you want to delete" prompt box.
F1.5	Having the "(3)" next to sub goals is reassuring, but it should be consistent with the number of input fields.
F1.6	There the input field should appear when you click the "+" button so that the number of fields corresponds to the counter above it.
F1.7	It steps of adding a sub goal was unintuitive.
F1.8	Where do you save?
F1.9	What is the checkbox next to the trash can for?
F1.10	"Vanlig" should be renamed to "Fordelbar" and the order should be "Fordelbar", "Felles", and "Ekstra" from the top down.
F1.11	There should be "?"s with circles around them next to some of the less intuitive functionality that you can hover for info, especially for "Vanlig", "Felles", "Extra", and the sub goals.
Scenario 2: Change Marcus' mathematics difficulty to A.	
F2.1	If you save automatically after selecting a difficulty path from the dropdown menu, it should do so in the task view too for consistency.
F2.2	Should be clearer that you can click the table cells.
F2.3	If there was a log of what the pupil had former weeks when I was to set the new difficulty I would not have to browse every homework sheet to get an idea of what level the child is at, and therefore save a lot of time.
Scenario 3: Remind the pupils to bring gym clothes for Friday.	
F3.1	Should not save when clicking return, wants to be able to span messages over multiple lines, the floppy disc was intuitive as save button.
F3.2	What is the "+" for?
F3.3	There should be a button for saving.
O3.1	Thinks the "+" is a button for adding the entry.
Scenario 4: Check if the mathematics difficulty path C was too hard.	
F4.1	Make clickable things more apparent, such as putting a square around the expand text etc.
F4.2	It could be useful having a log of all former difficulty paths of the pupils.
Scenario 5: Add a new evaluation in English called national test.	
F5.1	I thought the folder icon meant uploads.
F5.2	The folder did not stand out as the evaluation icon at once and I clicked it because the other alternatives did not make sense to have evaluations in.

O5.1	Use a strong color to indicate the active icon in the top, they have a hard time noticing it as gray.
Scenario 6: Write a message in to the message archive.	
F6.1	It is intuitive but not that useful. It would be better if reworked to a 'Reminders' thing. Let there be a title, a reminder date, and date written, that way there can be a badge on the reminders icon that show how many things there are to remember today.
F6.2	Why is there a from and to field? What are they for?
F6.3	This functionality might not be necessary if they use another LMS such as Fronter.
O6.1	Thinks it is a messaging service between everyone that have the application.
Additional feedback	
F7.1	There should be a more visible reward panel, but it should come configured out of the box with a total amount needed for reward and how much each of the three group types are worth, but you should be able to configure the values as needed.
F7.2	If you click your name in the top right, there should be a tutorial. That would be very useful when using the application for the first time.
F7.3	Use the same icons for saving, either check icon (not checkbox) or the floppy disk.

Table 13-3: Feedback for teachers' low-fi prototype iteration 1

The teachers filled out the SUS schema in Appendix B, in Table 13-4 are the results and the calculated SUS scores. The SUS translation is from Bangor et al. (2009).

System Usability Scale	T_1	T_2	T_3	T_4
1. I think that I would like to use this product frequently.	5	5	4	4
2. I found the product unnecessarily complex.	4	4	1	1
3. I thought the product was easy to use.	3	4	5	5
4. I think that I would need the support of a technical person to be able to use this product.	4	5	4	1
5. I found the various functions in the product were well integrated.	5	5	4	4
6. I thought there was too much inconsistency in this product.	1	4	2	1
7. I would imagine that most people would learn to use this product very quickly.	5	5	5	4
8. I found the product very awkward to use.	3	1	1	1
9. I felt very confident using the product.	5	2	4	5
10. I needed to learn a lot of things before I could get going with this product.	4	1	1	1
SUS score	67.5	65.0	82.5	92.5
Average SUS score	76.9			

Table 13-4: SUS scores teachers' low-fi prototype iteration 1

An average score of 76.9 is too low and should be re-implemented with the feedback gathered from the testers.

13.3. Analysis

After the testing was finished the results were reflected upon to identify what worked and what could have been done differently.

Pupils

According to the test of the low-fi prototype of the first iteration of the pupil part of the concept, the problem was the task view. The icons used to indicate the homework was intuitive, but they struggle with the interactions within the task itself. They expected that only one box was checked at a time, and that new content should be displayed when they clicked one of the boxes, just like you expect content to change when you click a tab in a menu. They all managed to finish the tasks, but only after clicking all the buttons and some multiple times in another order. It was also pointed out of one of the supervisors that there could be a potential space problem if the teacher decides to include many sub goals. This was a clear indication that the task view needed reworking, but the pupils already had some opinions of how it should have behaved which could be tested in the next iteration.

The school class view itself was intuitive, but it should be clearer that the points were the total of the whole class. Also, the value of the podium of the three greatest point contributors varied from pupil to pupil whether they cared about it or not. However, it did not contribute negatively to the ones that did not care, which means it will still be included in the next iteration. A suggestion was to have each pupil spend their own points on some rewards, but this falls under reward models that are already covered by Kartevoll (2017), and will not be covered by further iterations.

The general feedback was that the text was too difficult to see, especially in the task view. In addition, they expected the icons like the “X” to be red to indicate it closed something. The next iteration will therefore make the text easier to read by giving the text more contrast and colorize the icons where it serves a purpose, like the “X”. It was a little distracting that the background was the same colors as the foreground, which can be tried solved by darkening it. Text seems to be a challenge for the youngest pupils, so the next iteration will continue to use icons instead of text where it is possible.

Teachers

The biggest part of the feedback had to do with consistency, both in behavior and icon usage. The task view and task distribution panel were closely related but operated in different ways. The task view with a save button, and the task distribution panel saved as you made changes. This made some testers insecure when they were testing because they did not know if they had saved or not before proceeding. Another interaction that had a mixed response was the “+” and the input fields in the edit view for the different groups. An argument for hiding the input fields was that they started wondering if they had given out a blank sub goal or not, which was the same case for the links. This might be mitigated by removing the input field until the “+”

is clicked. Some also wondered what the different types of task groups were for and defaulted to the already selected one. A suggestion was to include a "?" with a circle around it so that if they needed to know the difference they could hover it once and be informed instantly, to prevent it from becoming unnecessary clutter in consecutive uses. It was suggested that "Vanlig" (normal) should be renamed to "Fordelbar" (assignable), and to rearrange the types to "Fordelbar", "Felles" (common), and "Ekstra" (Extra). This way the three task types each had their main property in the name itself.

The cells in the task distribution panel were not that obviously clickable, and if a teacher wanted to know which difficulty path the pupil had former weeks they would have to change week back and forth to check what the individual pupil was assigned. In general, the lower SUS scores belonged to people who used technology sparingly as opposed to the ones that flew through all the scenarios without any problems. A further challenge for the teacher prototype could therefore be to appeal more to the ones that use less technology in their everyday life, but without making it less enjoyable to use for the technology experienced ones.

To sum up, this meant that the task view in the pupils' prototype was to be reworked to use the functionality the pupils expected and enhancing its distinction between foreground and background, as well as enhancing the meaning of icons by using color. This would lead to a redesign in the editing window in the teachers' prototype's task view to accompany the changes. The teachers' prototype also needs to be more user-friendly to people who have less experience with technology.

V. Iteration 2 – Concept Refining

In the second iteration the feedback from iteration 1 was used to make another low-fi prototype that tried to fix the issues that emerged in the first user tests. The main focus of the second prototype was the interactions in the task view of the pupils' prototype, which the teachers' part had to accommodate. The results from this iteration were further used to make the high-fidelity prototypes with Unity and web technologies.

14. New Requirements

The second iteration of the project continued the work on the low-fi prototypes based on the feedback from the user testing. Together with my supervisor, Alf Inge Wang, it was decided to not focus on features that would fall under learning management systems (LMS) due to the scope of the task description and the limited timeframe of the task. This meant that from here on the prototype was not going to accommodate the feedback related to the evaluation and message parts of the concept. The goal of the second iteration was:

- Make it easier for the pupils to understand how to complete their homework
- Rework the teachers prototype to accommodate the changes in the pupils' prototype
- Make the functionality related to the pupils' concept more user friendly independent of former technology experience in the teachers' prototype

Tabs instead of checkboxes

The task view was in the pupils' prototype was restructured into using tabs instead of checkboxes. This meant that a sub goal had its own tab with content and allowed individual sub goals to have their own links, a description textbox, and a single box to check when they finished that part of the homework. At the end of second grade in Norwegian School pupils are supposed to be able to count to 100 (Utdanningsdirektoratet, 2004). With that in mind this prototype has tabs where the first one is labeled "1" and increments the label of each additional sub goal. This change required a change in the view for editing a task group in the teachers' prototype, since before they could add sub goals and a description independently from each other, now the description was part of a sub goal.

Consistency

The second iteration of the teachers' concept was suffering from inconsistencies between how the users saved their changes. In this iteration both the task view and task distribution panel updated when you finished editing something. The link input fields in each sub goal appeared after you clicked the "+" and the number of displayed input fields would correspond to a counter as used for the sub goals in iteration 1. Since the rest of the prototype used "+" icons to add, the new information icon was changed from a "+" to an exclamation point and got a button with a "+" instead.

Tooltips & tutorial

There were two main types of users demanding information - the ones that only needed to know what the difference between the task group types was, and the ones that needed a thorough introduction to the system. The latter would be able to take a tutorial that ran them through all the functionality that could be accessed through the dropdown that appeared when clicked the user's name. However, this was not shown in the prototype as it did not contribute to the concept itself. If the user wanted a reminder of the meaning of the different types of homework groups,

they could hover the “?” for a brief explanation. This way it kept the visual clutter to a minimum and let the users view it if they needed to. To increase the affordance of the table cells in the task distribution panel an edit icon showed up when a cell was hovered by the cursor.

15. Refined Concept

This subchapter presents the changes done to the different views in both the pupil and teacher version of the ‘Mænage School’ prototype. The changes done to the prototypes were based on the feedback from the user testing at the end of iteration 1. The biggest change in this iteration was the restructuring of the task view in the pupils’ prototype, which resulted in a change in the teachers’ prototype for handling the new format as well. The pupils’ prototype introduced use of colors to help visually group and separate different components from one another, and the teachers’ prototype tried to achieve consistent use of icon and consistency of saving the work done. The teachers’ prototype also got a new view for adjusting the school points rewarding mechanic. Colors were used sparingly in the pupils’ prototype but this did not mean that the hi-fi prototype would look as blank, only that the colors were used only where they served a purpose.

15.1. Pupils' Application

The changes made in the school class view, seen in Figure 15-1, for iteration 2 were coloring some of the parts to keep them separate from one another as well as making it less messy. The section displaying the messages from the teacher was given a yellow color to indicate that the headline belonged to the exclamations points below it. The extra tasks button and reward progress bar was mainly colored for not drowning in one another, and the fonts have a greater contrast if it was important, rather than supplementary information. Some of the texts were also moved into the object they belonged to for making the mapping easier, as done in the button and the podium. Lastly, the point score was added below the reward progress bar and labeled with "total" indicating that this is the whole class' points. Red "X"s were used throughout the redesign since the pupils stated they related better to it.

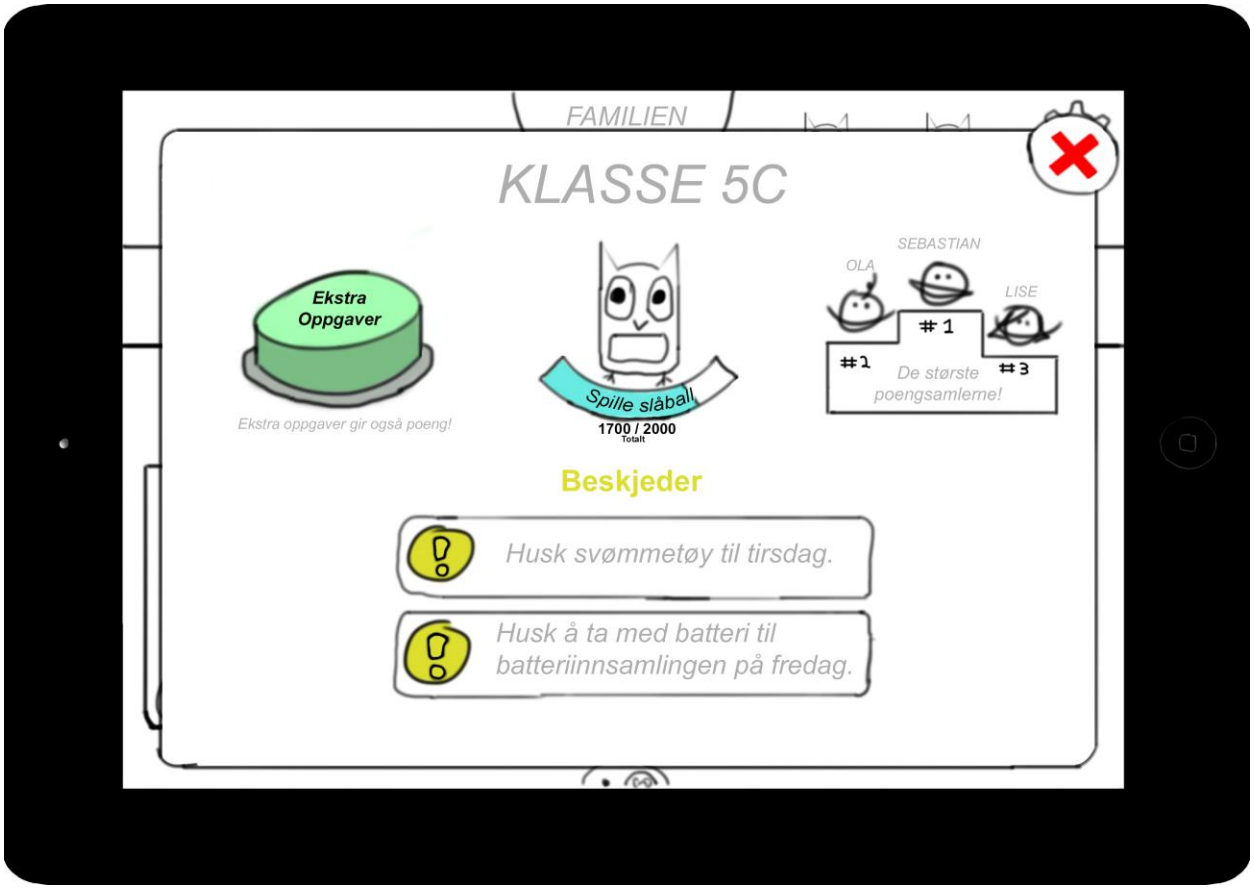

Figure 15-1: Prototype 2- School class view

The task view shown in Figure 15-2 presents the new design for the task view. The pupils did not understand how the rows of checkboxes worked in the last iteration so this time they are only presented one checkbox at the time. The information was split up into tabs and only showed them one set of information at the time. Each tab represented one sub goal and was labeled with a number matching the order it was laid out by the teacher. The Internet links was now bound to an individual sub goal, as seen in Figure 15-2, where the blue number 2 tab is the only one with a visible link button. To keep the tabs separate from one another, no tab had the same color, much like you would expect from ring binder dividers. When the pupil has checked off all the boxes and completed her/his homework, a new tab would appear, which they are automatically taken to, where they answer the feedback form from the teacher. When they answer the discrete feedback (easy, ok, hard) the check button appeared and could be clicked, and if they wanted to provide the teacher with continuous feedback they could provide it in the input field. Same as in iteration 1 the bubble should disappear when it was completed and play an animation that filled up the school class progress bar. The pupil could at any time close the task view and be taken to where they left off when clicking the appropriate homework bubble again.

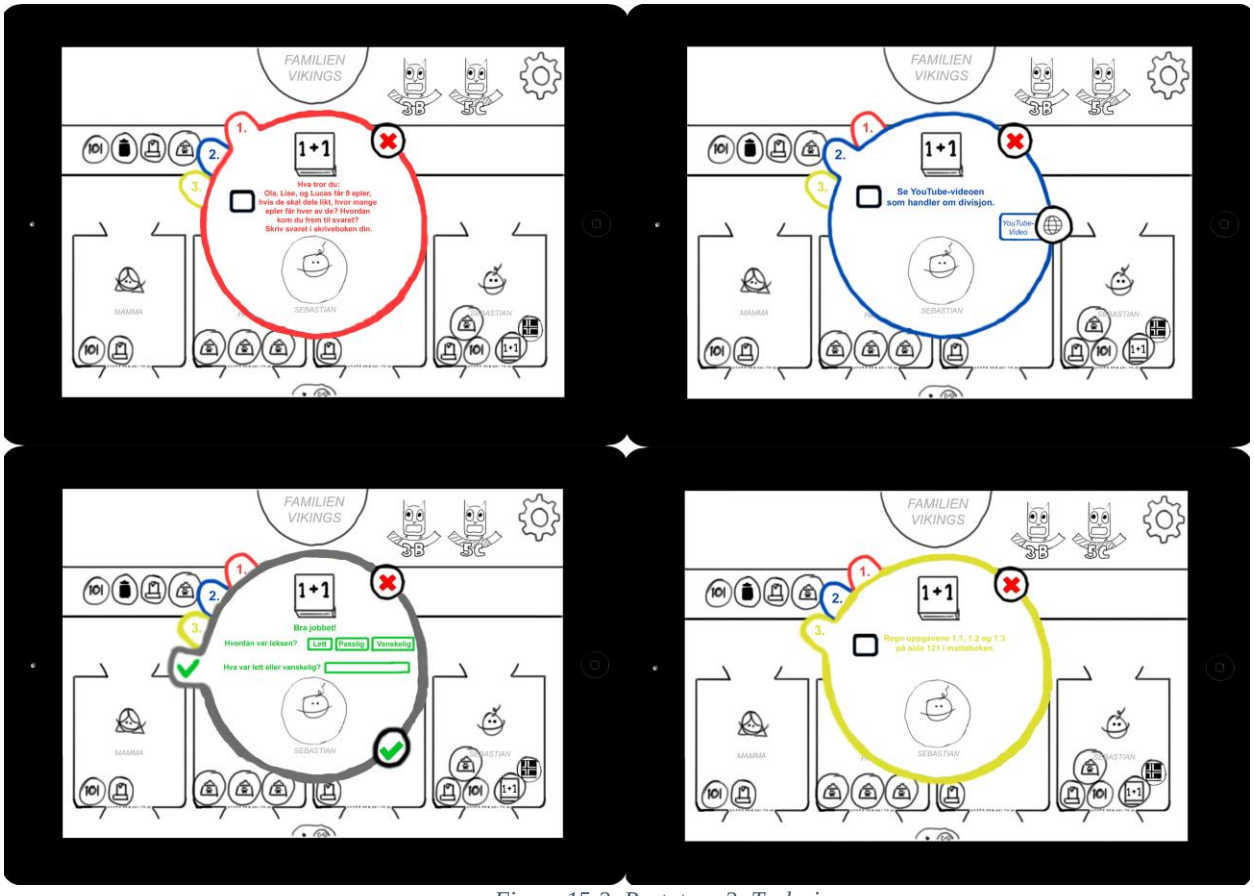

Figure 15-2: Prototype 2- Task views

15.2. Teachers' Application

To accommodate the redesign of the task view in the pupils' prototype, the view for editing a task group got more complexity than what it had, as seen in Figure 15-3. Borders around text was used to represent text input fields as well as indicating functionality that belonged together, such as the edit view itself and the list of sub goals contained within it. The upper input field let the teacher enter a description for themselves to easier remember what the group was for. Below, they could select if the task group was assignable, common to all pupils, or extra, which then the pupils could request in the school view. The trash can was used alongside the "X" for indicating the impact of the action, where the "X" just removed the fillable link entry while the trash can deleted a sub goal or task group. The "?" would explain the difference between the group types if hovered. When the user clicked the button to add a new sub goal or link, the appropriate counter would increment to indicate that it was a new entity, even though it was empty.

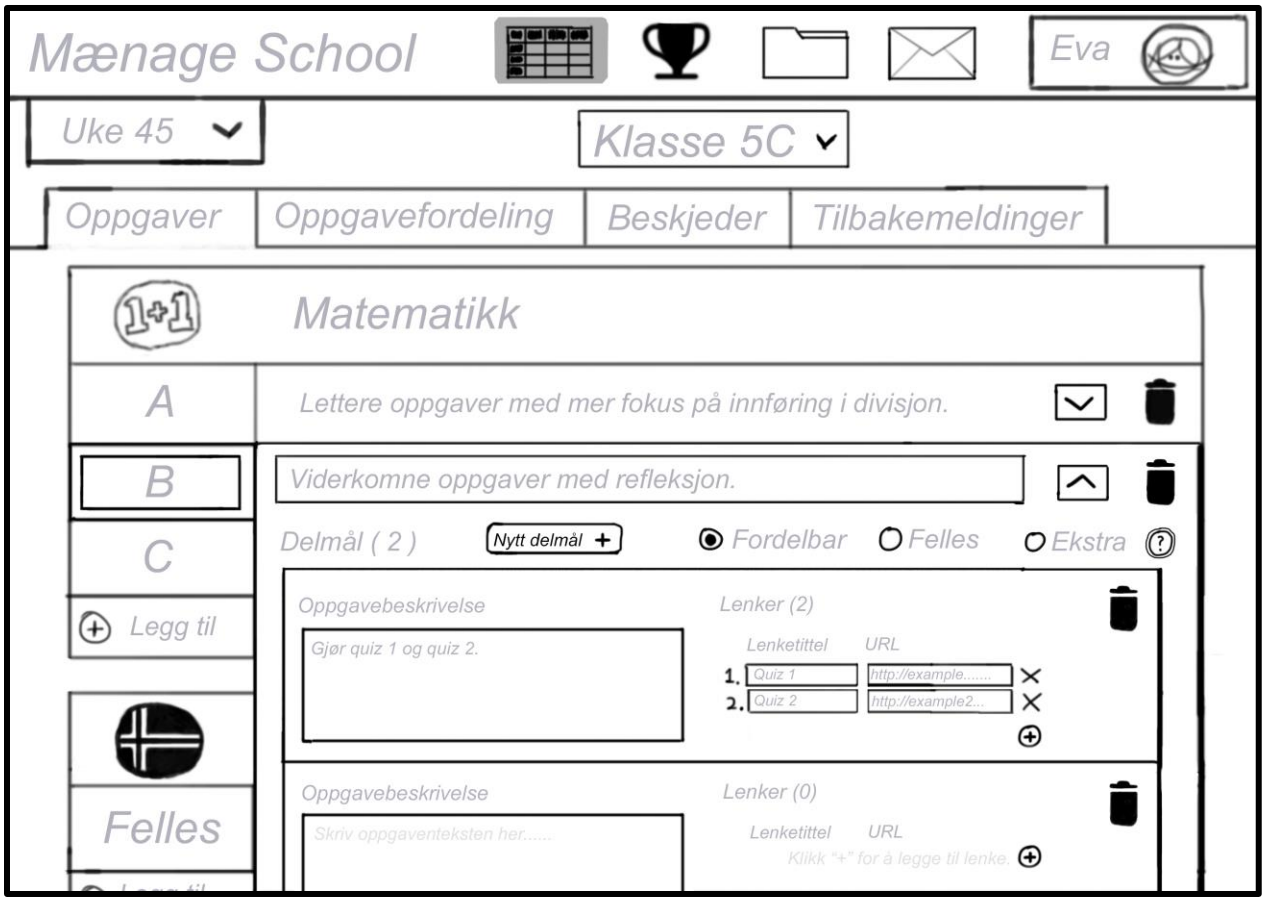

Figure 15-3: Prototype 2- Task edit view

The changes made to the task distribution panel, in Figure 15-4, were based upon making the table cells more clickable and ensure the user did not have to browse homework sheets from former weeks to check which task groups that pupil had last time. The table cells would now display an edit icon when hovered, and when clicked it would list the available task groups from that week and display which ones he or she had earlier.

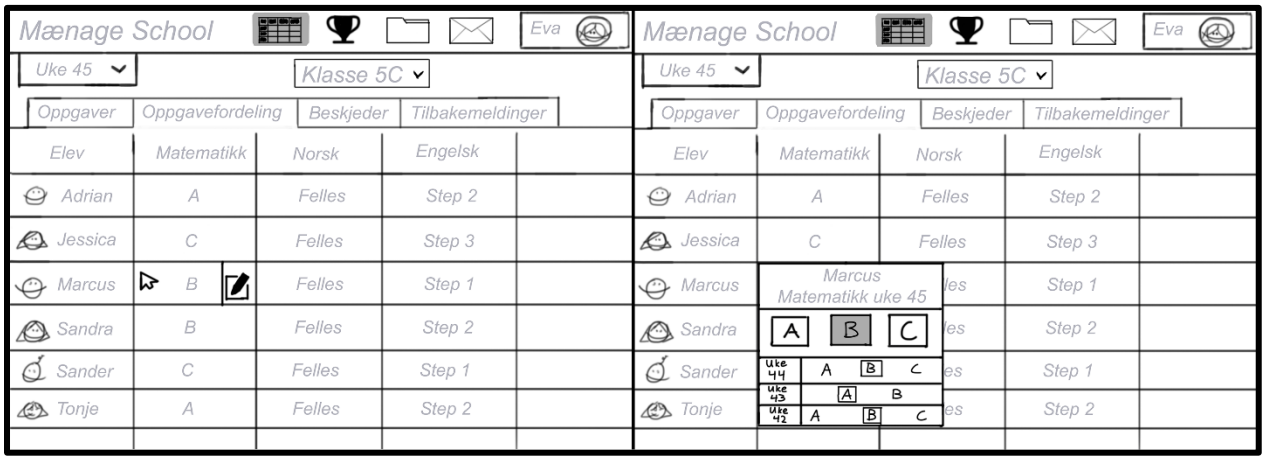

Figure 15-4: Prototype 2- Task distribution panel views

The information view and feedback view only got minor changes where the "+" in the information view was changed to an exclamation point icon and reintroduced as a button. The feedback view started using the same caret as the expand icon, both seen in Figure 15-5 and Figure 15-6.

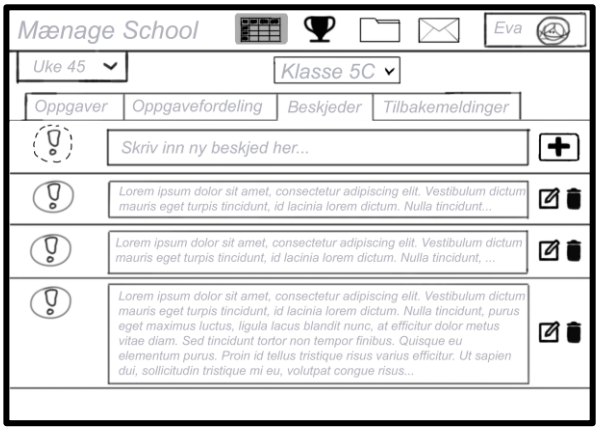

Figure 15-5: Prototype 2- Messages view

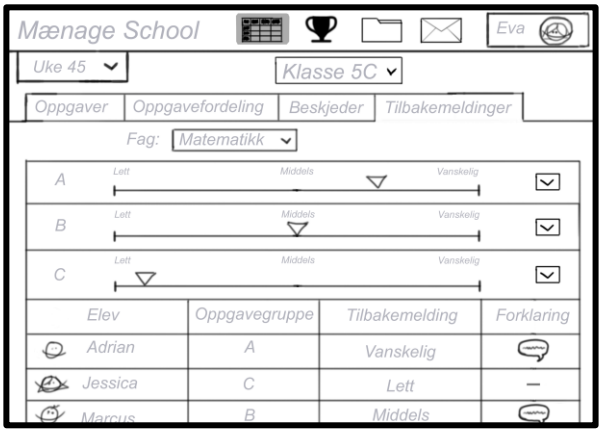

Figure 15-6: Prototype 2- Feedback view

In the main navigation bar a new icon was introduced, namely the trophy representing the reward aspect of the concept, seen in Figure 15-7. Here the user could set what the school class' reward was, see how far away from the goal the class was, set the total amount of points required, and adjust how many points each pupil would get for completing the different task types. The values should be prefilled and could be adjusted by the teacher if needed.

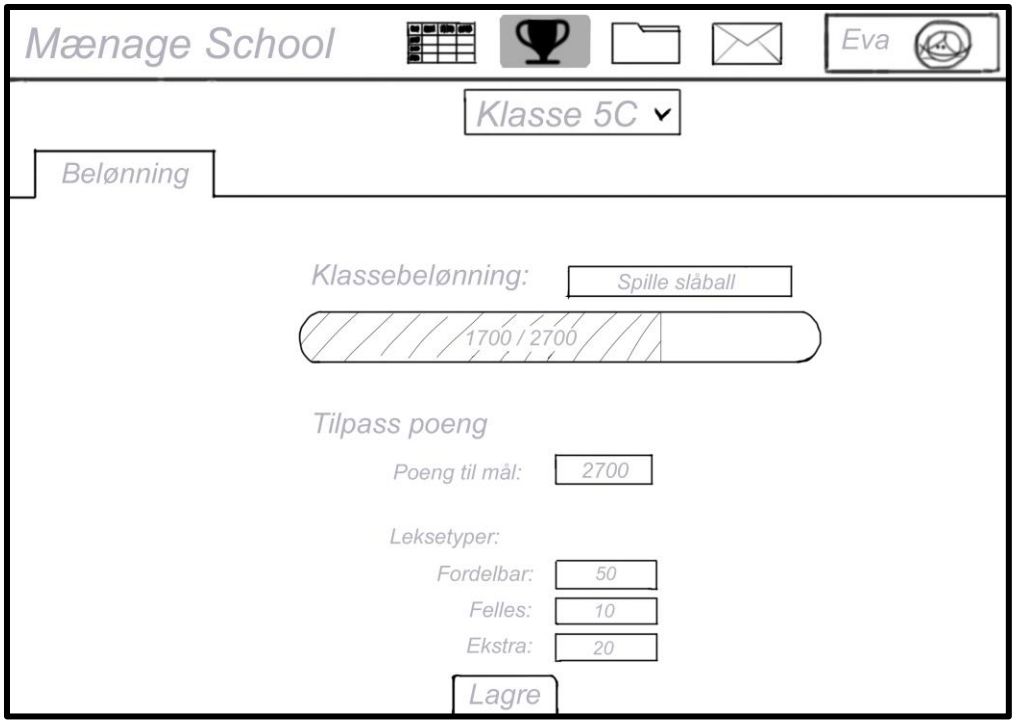

Figure 15-7: Prototype 2- Reward view

16. Results and Analysis – Iteration 2

This subchapter presents the results from the testing of the second iteration of the paper prototypes. When a tester had completed the scenarios without assistance they answered a SUS form and gave their comments on the prototype.

16.1. Pupils' Concept Feedback

In Table 16-1 follows the results of the second test with the pupils and is the result of feedback (F) from the tester and the observations (O) during the testing of the second paper prototype of the pupils' concept.

Scenario 1: Complete your mathematics homework.	
O1.1	Did not check the boxes at first, but when nothing happened he went back and clicked on different things and realized that it got a green check when he clicked it. After that he understood what it was for and he checked them all and got the feedback view.
O1.2	It is not initially obvious that the checkbox is clickable, but they try to click it and then understands what it is for.
F1.1	I learned addition in first grade, why do I have it as homework now?
Scenario 2: Check if there are any messages from your teacher.	
-	They all managed without any problems.
Additional feedback	
O3.1	When they come to a text description they stop up and fail to notice things around the text.

Table 16-1: Feedback for pupils' low-fi prototype iteration 2

The pupils filled out the SUS schema in Appendix B, in Table 16-2 are the results and the calculated SUS scores. The SUS translation is from Bangor et al. (2009).

System Usability Scale	T_1	T_2	T_3
1. I think that I would like to use this product frequently.	5	5	5
2. I found the product unnecessarily complex.	1	3	2
3. I thought the product was easy to use.	5	4	4
4. I think that I would need the support of a technical person to be able to use this product.	1	4	2
5. I found the various functions in the product were well integrated.	5	4	5
6. I thought there was too much inconsistency in this product.	1	3	2
7. I would imagine that most people would learn to use this product very quickly.	5	4	4
8. I found the product very awkward to use.	1	5	1
9. I felt very confident using the product.	5	5	4
10. I needed to learn a lot of things before I could get going with this product.	1	2	2
SUS score	100.0	62.5	82.5
Average SUS score	81.7		

Table 16-2: SUS scores for pupils' low-fi prototype iteration 2

An average score of 81.7 is within acceptable boundaries, the score could still be improved with the feedback gathered from the testers, especially since one of the testers are within the “should be reimplemented” range.

16.2. Teachers’ Concept Feedback

In Table 16-3 follows the results of the second test with the pupils and is the result of feedback (F) from the tester and the observations (O) during the testing of the second paper prototype of the teachers’ concept.

Scenario 1.1: Add “1+1=” as a new sub goal to task group “B”.	
F1.1	Where do I save the changes?
F1.2	The carets should be arrowheads instead, I thought it was check symbols.
F1.3	I would like the whole task groups to look clickable and expand when clicked as well as the caret.
F1.4	I would like an edit icon instead of the carets for opening the edit view and a check symbol to save instead of upside down caret.
F1.5	How can I know if it is saved or not?
F1.6	Is the caret icon a menu icon?
F1.7	I would like a confirm button for when I am done.
O1.1	Some users seem to get confused after finishing the task and start looking for a save button.
Scenario 1.2: Make task group “B” common to all pupils in 5C.	
O1.2	Everyone found this in less than 10 seconds.
Scenario 1.3: Make task group “B” an extra task for pupils that have finished the rest of their homework.	
O1.3	Everyone found this in less than 10 seconds.
Scenario 2: Give Marcus of class 5C task group “A”.	
F2.1	The log of past weeks was very nifty.
O2.1	It is difficult to demonstrate hover effects on paper, but they understand that the hover icon means edit.
Scenario 3: Remind the pupils of 5C to bring gym clothes next Wednesday.	
F3.1	Expects “+” for opening a new message since “+” has been used to open new thing until now in the other tasks.
O3.1	Two users clicked the “+” first and therefore created an empty message first and had to edit it after creation.
Scenario 4: Check whether task group “C” in mathematics was a reasonable difficulty.	
F4.1	I want the extended feedback from the pupil to show up as an on-hover tooltip, not in its own window, although I would like that option too if there are much information.
O4.1	Not all users notice the “?”.
Scenario 5: Change the extra tasks to only give five points as reward.	
F5.1	It took some time to find the reward icon. I think that a trophy is a good symbol for the rewards, but maybe find a better trophy icon.
F5.2	I like the trophy, it represents the rewards well.

F5.3	I would like to have another tab with an overview of all the points of the pupils as a second tab next to where it says “Belønning”.
F5.4	I would like feedback when I save the at the reward page.
Additional feedback	
F6.1	I think “+” should be opening something, and a check symbol should save.
F6.2	I think there should be a save button on in the task view and task distribution panel instead of saving on the go, this way you are certain you have done the correct thing every time.
F6.3	I would like to see how long time the pupils spend on their homework, it would complement the other information from them nicely.

Table 16-3: Feedback for teachers’ low-fi prototype iteration 2

The teachers filled out the SUS schema in Appendix B, in Table 16-4 are the results and the calculated SUS scores. The SUS translation is from Bangor et al. (2009).

System Usability Scale	T_1	T_2	T_3	T_4	T_5
1. I think that I would like to use this product frequently.	5	4	4	5	4
2. I found the product unnecessarily complex.	4	2	1	2	1
3. I thought the product was easy to use.	4	5	5	4	5
4. I think that I would need the support of a technical person to be able to use this product.	3	2	1	1	1
5. I found the various functions in the product were well integrated.	5	4	4	4	5
6. I thought there was too much inconsistency in this product.	1	2	1	1	1
7. I would imagine that most people would learn to use this product very quickly.	5	5	3	4	5
8. I found the product very awkward to use.	2	1	1	1	1
9. I felt very confident using the product.	5	4	4	5	5
10. I needed to learn a lot of things before I could get going with this product.	2	2	3	2	1
SUS score	80.0	82.5	82.5	87.5	97.5
Average SUS score	86.0				

Table 16-4: SUS scores for teachers' low-fi prototype iteration 2

An average score of 86.0 is within acceptable boundaries, the score could still be improved with the feedback gathered from the testers.

16.3. Analysis

After the testing of the second iteration was finished the results were reflected upon to identify what worked and what could have been done differently.

Pupils

The biggest problem for the younger range of pupils seemed to be that they were just learning to read, which made scenarios that contained a lot of text difficult to understand, because they must concentrate on understanding the meaning of the text. It also seemed difficult for them to relate to the pool that was intended for them, since it did not have their own name, as well as the school class name on the owl not matching their real-life school class name.

Teachers

There were two things that seemed to cause confusion in this iteration of the prototype- the lack of feedback and whether "+" meant save or open. In the task view users expected both that the task group would unfold when the row was clicked as well as when the caret was clicked. When it unfolded it was clear to all the users where you added a new sub goal and the scenarios went quickly. The only bottleneck was when they were told to make the homework common to all the pupils in the class, although they figured it out in the end. The users became insecure when they finished adding the sub goal because they did not know if it was saved or not as a result of lacking feedback from the prototype.

The changes in the task distribution panel showed positive results where everyone understood that the hover icon meant that it could be clicked, and one user even showed great enthusiasm for the log displaying which task group each pupil had former weeks. In the information view two users clicked the "+" before they entered a message which added a blank message that they then had to edit and claimed it made sense to click it before since they already did that in the task edit view. The feedback panel showed no difference from the last iteration where the only change was the icon for expanding the pupils associated with one task group.

A visible reward configuration panel was new to this iteration and was mostly positively received. The feedback said the icon could be more refined although a trophy was a good icon. In general, the teachers' prototype in this iteration was lacking feedback when saving changes. This meant that the task group view and the reward panel needed to ensure the user that the changes they made were saved. Also, "+" should only be used on buttons where the intention is to create a new element that later could be edited.

VI. Iteration 3 – The Final Prototypes

With acceptable SUS scores from both groups, it was time to move on to making the high-fidelity prototypes. A requirement specification was made based on the results of iteration 2. Then technologies were chosen, and the software architecture decided. After creating two prototypes, one prototype for each user group, they were tested, and the usability was analyzed. The test results beyond the usability is presented in Chapter VII.

17. Requirement Specification

In this subchapter, the different requirements for the two final prototypes will be presented. The requirements for the final solutions are based on the data gathered throughout the thesis. That is, through a preliminary study and two iterations of paper prototyping for each of the two concepts.

17.1. Functional Requirements

This section presents the functional requirements for the high-fidelity prototypes and is a result of the data collected through all the iterations of the projects. It does not contain every suggested feature from the preliminary study, but the features tested with the prototypes, as well as some new ones that were not that easily tested on paper, such as giving the user proper feedback on their actions in the web application and a particle effect for the Unity application.

Pupils' Concept

Table 17-1 presents the functional requirements of the pupils' concept where each functional requirement (F) has an id, description, and an implementation priority (low, medium, high).

ID	Description	Priority
F1	The user should be able to see her/his homework in the task pool.	High
F2	The user should be able to identify one subject from another before opening the user interface.	Medium
F3	The user should be able to see her/his homework.	High
F4	The user should be able to browse the different sub tasks that make up the homework.	Medium
F5	The user should be able to mark a sub task as completed.	Medium
F6	The user should be able to unmark a sub task as completed.	Low
F7	The user should be able to open a web link from the application.	Medium
F8	The user should be able to state her/his opinion to the teacher if all sub tasks are finished.	Medium
F9	The user should be able to see that her/his class gets points when homework is completed.	Low
F10	The user should be able to open her/his school class panel.	High
F11	The user should be able to close her/his school class panel.	Medium
F12	The user should be able to get extra homework from the school class panel.	Low
F13	The user should be able to see the school class reward.	Medium
F14	The user should be able to see the school class' progress against the class reward.	Medium
F15	The user should be able to see the messages from her/his teacher.	High

F16	The user should be able to see the top three point collectors in her/his school class.	

Table 17-1: Functional requirements - Pupils' concept

Teachers' Concept

Table 17-2 presents the functional requirements of the teachers' concept where each functional requirement (F) has an id, description, and an implementation priority (low, medium, high).

ID	Description	Priority
F1	The application should have a navigation bar.	High
F2	The user should be able to oversee multiple school classes.	Low
F3	The application should have a separate homework sheet for each week.	Medium
F4	The user should be able to add a homework group to a subject.	High
F5	The user should be able to edit a homework group.	Low
F6	The user should be able to delete a homework group.	Low
F7	The user should be able to add sub goals to a homework group.	High
F8	The user should be able to edit sub goals of a homework group.	Low
F9	The user should be able to delete sub goals from a homework group.	Low
F10	The user should be able to add links to a sub goal.	High
F11	The user should be able to edit links of a sub goal.	Low
F12	The user should be able to delete links from a sub goal.	Low
F13	The user should be able to set the type of a homework group to assignable, common, or extra.	Medium
F14	The user should be able to assign assignable homework groups to pupils in a school class.	High
F15	The user should be able to see which homework groups pupils had earlier.	Medium
F16	The user should be able to add messages to the pupils of a school class.	High
F17	The user should be able to edit messages to the pupils of a school class.	Low
F18	The user should be able to delete messages they have added.	Medium
F19	The user should be able to see summary of the discrete pupil feedback of all assignable homework task groups.	High
F20	The user should be able to see the specific feedback from each pupil.	High
F21	The user should be able to change a school class' reward.	Low
F22	The user should be able to adjust the points needed for reaching the reward.	Low
F23	The user should be able to adjust how many points each task group type is worth.	Low
F24	The user should get feedback when altering any data.	High
F25	The user should get a prompt asking them if they are certain they want to delete elements when they click delete buttons.	Low

Table 17-2: Functional requirements - Teachers' Concept

17.2. Non-functional Requirements

This section contains the non-functional requirements for Mænage School, but for the pupil prototype it only contains those relevant for additions to Mænage and not those relevant to the core application itself. These requirements are only concerned with system properties of the high-fidelity prototypes.

Pupils' Concept

Table 17-3 presents the non-functional requirements (NF) of the pupils' application and where each requirement has an id, category, and description.

ID	Category	Description
NF1	Usability	It should not take longer than 10 minutes to learn how to use the system.
NF2	Usability	The application's navigation should be intuitive.
NF3	Usability	Everything that is clickable should be clearly clickable.
NF4	Usability	The user should be aware of the state of the application.
NF5	Usability	Elements in the back should be distinguishable from elements in the foreground.

Table 17-3: Non-functional requirements - Pupils' concept

Teachers' Concept

Table 17-4 presents the non-functional requirements (NF) of the teachers' application and where each requirement has an id, category, and description.

ID	Category	Description
NF1	Usability	It should not take longer than 10 minutes to learn how to use the system.
NF2	Usability	The application's navigation should be intuitive.
NF3	Usability	Everything that is clickable should be clearly clickable.
NF4	Usability	The user should be aware of the state of the application.
NF5	Efficiency	The user should be able to create a new homework task group in less than 2 minutes.

Table 17-4: Non-functional requirements - Teachers' concept

18. Technology Choices

The core Mænage application was already created as a Unity application for frontend, and MeteorJS as both backend as a RESTful web service and web administration panel. It felt like the natural choice both in time and practicality to continue using these technologies for the pupils' concept. However, since all the teachers interviewed used computers, either Windows or macOS as operating system, an easy solution for cross-platform support was to use web technologies. This subchapter discusses the technologies used both for the pupils' and teachers' high-fidelity prototype, as well as the process of choosing a suitable technology for the teachers' application, which was Vue.js.

18.1. Unity

Unity is a cross-platform game engine developed by Unity Technologies that supports both 2D and 3D graphics which lets you drag and drop built-in functionality and do scripting in C# (Unity Technologies, 2018). Unity supports building to a variety of platforms such as iOS, Android, and Windows for mentioning the most relevant for tablet development. The engine comes with a free option limited to standard cloud build queue, 20 concurrent users for multiplayer, $100,000 revenue capacity, and the application splash screen must announce it is made with Unity- this is the version used for Mænage. Mænage School continued with version 5.5.4 because of third-party code dependencies existing in the original application. In addition, the development focus is on Android tablets, which is the intended usage of the original Mænage application.

18.2. MeteorJS

MeteorJS is a free open-source full-stack JavaScript platform written using Node.js by the Meteor Development Group for building mobile and web applications (Meteor Development Group, 2018). Meteor provides a curated set of Node.js packages as well as its own templating engine, Blaze, although you can use other JavaScript frontend frameworks if you so choose. The core Mænage application have a Meteor application that provides data to the Unity application through a web API and have its own administration page where you can alter the family information, such as family members, tasks, and rewards.

18.3. Web Technologies

At its core, web technologies are made up of several technologies. HyperText Markup Language (HTML) is used to describe the content of webpages and makes up the document object model (DOM) as a tree structure of HTML elements. Cascading Style Sheets (CSS) describes how the content should be presented in the webpage, and the Hypertext Transfer Protocol (HTTP) delivers hypermedia content to the page, such as HTML and images (Niederst Robbins, 2012). JavaScript is the language that provides interaction in the browser, but it can be used server-side as well thanks to Node.js. By using Web APIs we can also manipulate the DOM and track different events.

As webpages became more powerful and dynamic, more of the functionality was moved from the server to the browser because of JavaScript, resulting in lots of JavaScript code connecting HTML and CSS files with no formal organization. This is one of many reasons developers use JavaScript frameworks (Pollack, 2017). In 2018 there are many JavaScript frameworks with different design philosophies for solving different problems.

According to GitHub the most popular frontend JavaScript frameworks or libraries are React, Vue.js, and AngularJS, with 94’801, 92’759, and 58’396 user stars respectively (GitHub, 2018). These three served as my candidates when selecting the one to use because with a big community supporting them it would be easier to get support when encountering problems.

The evaluation criteria were:

- Ease of testing with users (install/maintenance), can be tested on different platforms
- Knowledge about the technology
- How flexible is the technology?
- Does it do what you need, and does it do it efficiently?
- How easy is it to get support? How big are the communities?

All three of the candidates run on top of Node.js, which is a cross-platform JavaScript run-time environment (Node.js Foundation, 2018), and can be set up with a module bundler such as Webpack to handle code module dependencies. All three have a quick way of getting started with “getting started projects”, a well-documented API, and in terms of speed the three projects are similar enough (Krause, 2017) that speed is not necessary the deciding factor. In terms of flexibility AngularJS have a certain way of organizing the application structure while Vue.js and React are more optioned since React itself only tends to the view aspect of the application and Vue.js can be used on the parts you want or the entire project. However, all three can be used for making single-page applications (SPAs), which are web applications that are loaded once and their content are dynamically updated as needed (Wasson, 2013). All three could get the job done without any doubt, which made the decision highly subjective. I ended up selecting Vue.js because it seemed like a well reflected framework that have picked the parts other JavaScript frameworks have done well (You, 2018a), such as having an easy readable templating syntax similar to Angular 1.x and React’s speed with a virtual DOM.

18.4. Vue.js

Vue.js is an open-source JavaScript framework for frontend web development that can be used for making single page applications and is easy adoptable because you can use it gradually on parts of a project or the entire project (You, 2018b). When scaling is needed Vue.js provides the Vuex library for centralized state management, the vue-router library for handling routing between components, and single file components which lets you group HTML, JavaScript, and scoped CSS into one file which makes up a component- a piece of the webpage. Vue.js comes with its own command line interface which makes it easy to create a new project and provides vue-cli, a project for setting up a ready-to-use modern frontend workflow with Webpack, Babel, ESLint, and more (You, 2018c).

19. Software Architecture

This subchapter introduces the software architecture of both the Vue.js application and Unity application that together makes up the Mænage School concept. When it comes to the Unity application, only features introduced with Mænage School will be presented, not the entire system. However, the most essential ones are listed under "Old Logic" in Figure 19-1.

19.1. Unity Application

Since the finished products from this thesis are two high fidelity prototypes with the purpose of testing the concept, rather than having a finished system, mocked data in the manager classes are used instead of a real database. The core Mænage application has its own controllers to the pools and tasks, as well as synchronizers to synchronize the information between the server and the application. To remove the need to rewrite the server code, ease of testing and being able to personalize the data for testers to better relate to the application, the last added user to the family (the right most on the screen) would receive the homework tasks in their pool as well as use their avatar and name in the user interfaces. The tasks and homework tasks are also independent from one another, since the homework tasks did not affect the reward pool in Mænage, but instead contributed to the school class points.

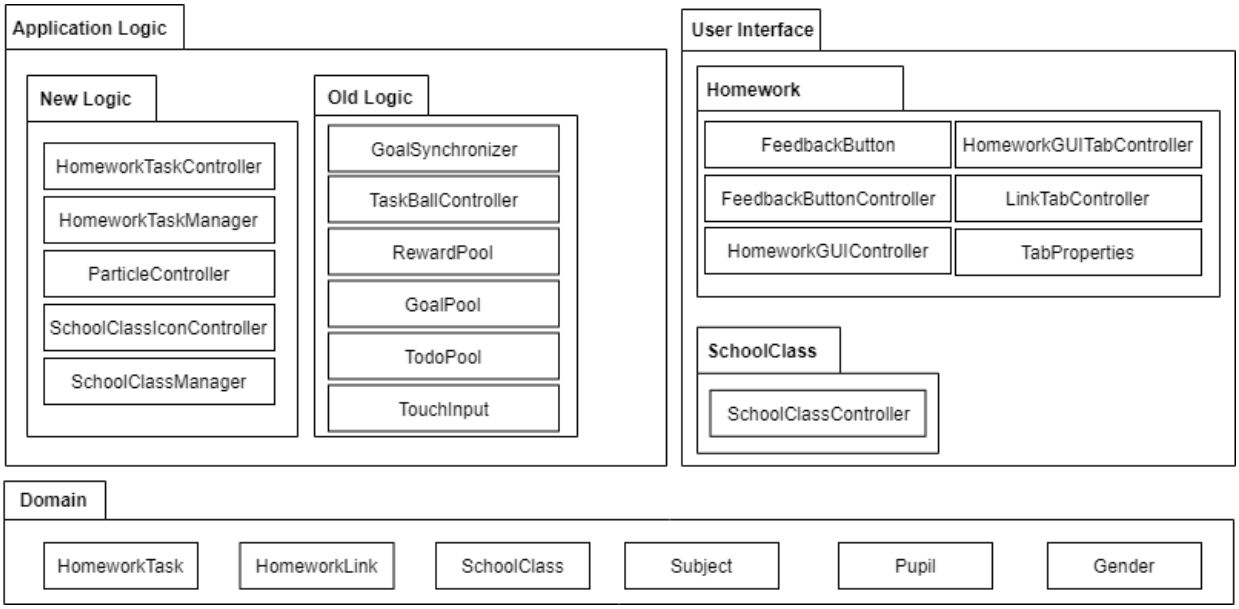

Figure 19-1: Unity application class overview

Figure 19-1 presents a class overview of the Mænage School Unity application. All of the new features in Mænage School take place in the MainGameplayScene, which is the scene with the tasks and pools. When the scene launches there are controllers that handles the setup of all the prefabs in the scene, such as giving a task to the user that owns that task. When they have received all the tasks the HomeworkTaskManager instantiates homework task prefabs in the right most user's pool. These homework tasks interact with the application physics just as the

normal tasks, and the SchoolClassManager instantiates the owls in the top right part of the screen for each person in the family that has a connection to a school class. In general, managers handle the instantiation of prefabs, controllers control the functionality of a prefab, and classes and enumerations in the domain represents models and types for representing real life objects, such as homework tasks, pupils, and gender. The managers and controllers also inherit from MonoBehaviour, which is the base class for which every Unity Script derives and allows scripts to execute code on runtime events such as start, update, when enabled, and so on. The classes under "User Interface" handles interactions in the homework view and school class view.

19.2. Vue.js Application

The Vue.js application for the teachers' concept is a single-page application, which means it initially loads into the browser and uses AJAX (Asynchronous JavaScript and XML) to make asynchronous calls to the server to request specific content as it is needed. This makes for a faster user experience since only small data are requested as the user interacts with the user interface (Molin, Gurov, & Engwall, 2016; Wasson, 2013).

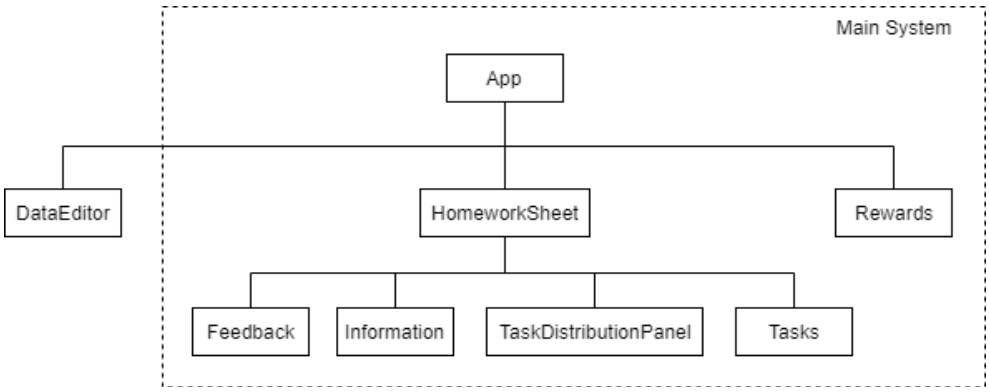

Figure 19-2: Vue.js single page application component diagram

App is the root component. It is always loaded and is the parent of all the other components as seen in Figure 19-2. It contains the main navigation bar that is displayed in the top of the screen. From here, the section below the navigation bar is filled with either DataEditor, HomeworkSheet, or Rewards. HomeworkSheet also got four child routes; Feedback, Information, TaskDistributionPanel, and Tasks. To change which components that should render we must change the route. The application has a default route;
App →HomeworkSheet→Tasks, and when we change the URL the application looks up the routing and checks if it matches any paths it holds. If it does it renders the component bound to that path. This high-fidelity prototype also uses mocked data, this data is contained in the root scope of the application. As seen in Figure 19-2 the DataEditor component is not part of the main system and therefore does not have a link for a user to click to reach it. It is simply a tool that utilizes Vue.js' data binding feature to be able to edit any data in the entire application in real-time and is used to make test data and personalize the name and avatar of the tester.

As explained in the Technology Choices section each Vue.js component contains its own HTML, CSS, and JavaScript. What this means is that each component can contain a template that can use Vue.js directives, contain its own style, pass props to other components, and bind functions to different lifecycle hooks, and contain its own set of functionalities, and so on.

20. The High-Fidelity Prototypes

This subchapter presents the high-fidelity prototypes for both the pupils' and the teachers' concept, and were the final software products of this master thesis. Both of the applications' color choices were based upon Dahlstrøm's design guidelines (2016) meant for the core Mænage Unity application.

A demo of the application can be seen at: https://youtu.be/O_1RdmQKWMI

20.1. Pupils' Concept

The high-fidelity prototype of the pupils' concept is very similar to the second iteration of the paper prototype due to minimal feedback and good SUS scores. The main goals with the prototype was to test if the pupils understood how to perform all the interactions now that it was not an abstract paper concept anymore, as well as to test if they understood that the homework tasks are separate from the chores. After requests from the teachers, a question asking how long time the pupils spent on their homework was added. When it comes to the assets used, already existing assets from the core Mænage application were reused where possible, but the owl icon and Internet icon (from the homework GUI) were from the Noun Project under the Creative Commons license (The Noun Project, 2018). The rest of the assets were made by myself using Photoshop. Below follows an explanation of the main features of Mænage School- the augmentations in the main view, the homework GUI, and school class view.

20.1.1. The Main View

The new additions to the application were the school class owls and homework tasks as seen in Figure 20-1. Here you can see two owls, one for “Helene” (3B) and one for “Sebastian” (5C), each with their own progress bar to indicate progression towards the school class reward. The user could click one of the owl icons to be brought to the school class view or click one of the tasks with books to be taken to the homework GUI. In order to separate the homework from one another they each got their own icon as seen below, but for consistency they still used the color of the user to indicate that they belonged to that user. As in the core Mænage application, the GUIs used a dark backdrop to make them easier to tell from the background, as well as showing parts of the background to show they were not far away from the main view. Also, the mathematics icon was changed from the last iteration from “1+1” to the mathematical operations icons to better appeal to more pupils in different ages, as well as to better fit into the circle.

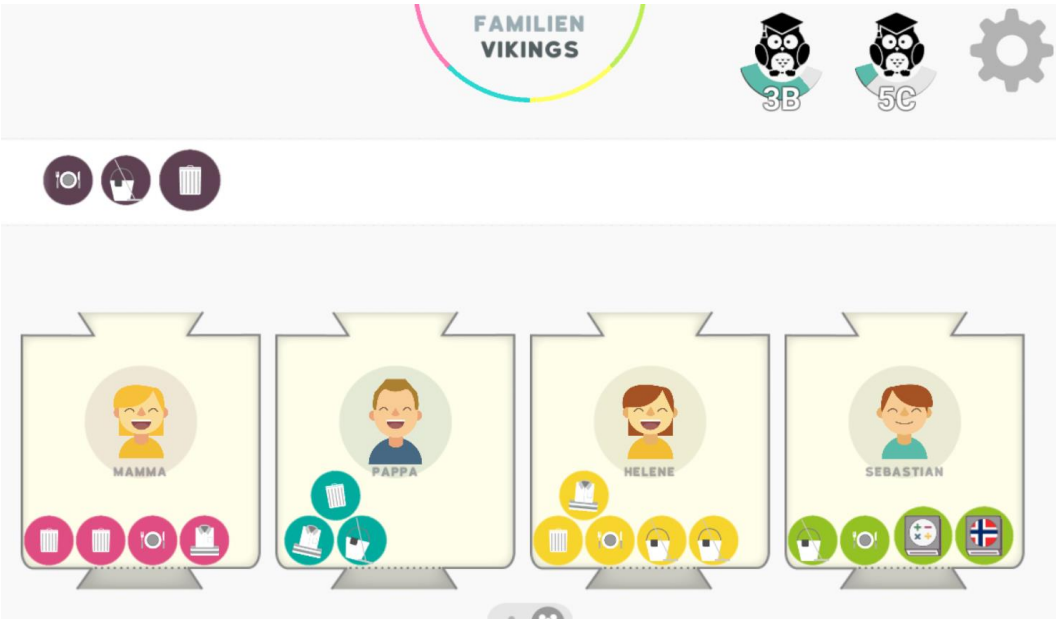

Figure 20-1: Mænage school Unity main view

The user that was testing the application changed the name, avatar, and color of the right most user by using the Meteor web administration panel from the core Mænage application before the testing started. The school class name (here: 5C) was changed in the code for making it easier to relate to the icon. Even though the chore tasks and homework tasks had nothing to do with one another, they still interact with the same environment, meaning both collided with one another and the pool borders.

20.1.2. The Homework View

If a user clicked one of the homework tasks they would open the homework GUI, a generic homework task can be seen in Figure 20-2, Figure 20-3, and Figure 20-4. Each numbered tab represented a separate sub goal added by the teacher that had its own color based on the order it was added, as well as its own checkbox, description and links if added, as seen in Figure 20-3. The user could also close the window by clicking the “X”. To keep the window consistent with

the chores, it displayed the icon of the task at hand, the user's avatar, and name within the window to tell the user it was their homework. This got more important as the core application used the user's color as the entire tasks background, but the homework did not, as the color is used to separate tabs from one another.

The user could click a checkbox to indicate that that part of the homework was finished, as well as clicking it again to undo her/his action. If all checkboxes of all the sub goals were clicked, they would be taken to the feedback form.

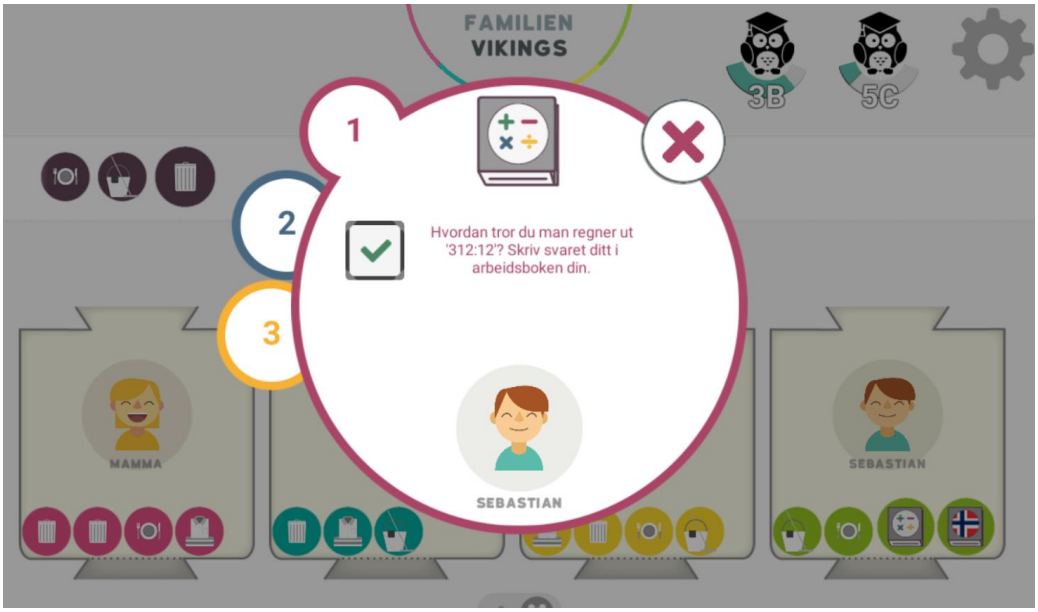

Figure 20-2: Homework GUI 1

Figure 20-3: Homework GUI 2

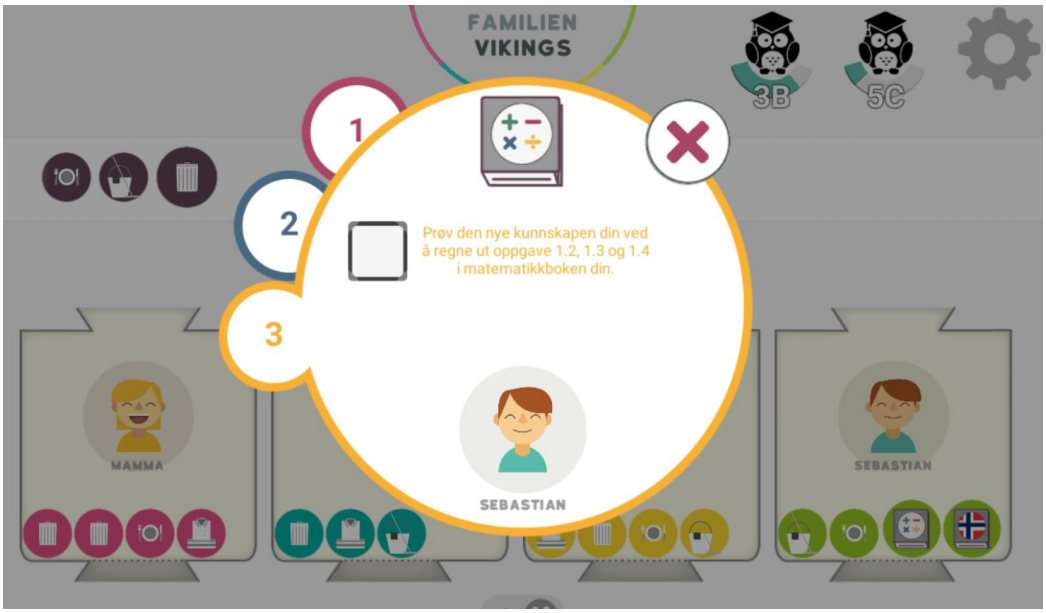

Figure 20-4: Homework GUI 3

In the feedback form the user got a motivational message, "Well done!", and was presented with three questions. The user was asked how difficult the homework was, how long time they approximately spent on the homework, and if they would elaborate on what they found difficult. After answering the two first questions the "complete button" appeared as seen in Figure 20-5 and Figure 20-6. If the user clicked the button the GUI would close, and the "homework completed" animation would play.

Figure 20-5: Feedback form (unanswered)

Figure 20-6: Feedback form (answered)

Figure 20-7 shows what happened to a homework task when the user clicked the complete button. The task disintegrated into small circles with the same color as the task background, spread in all directions, paused for a little while, and rushed towards the school class icon the user belonged to. The intention of this was to indicate that the homework contributed towards the school class reward.

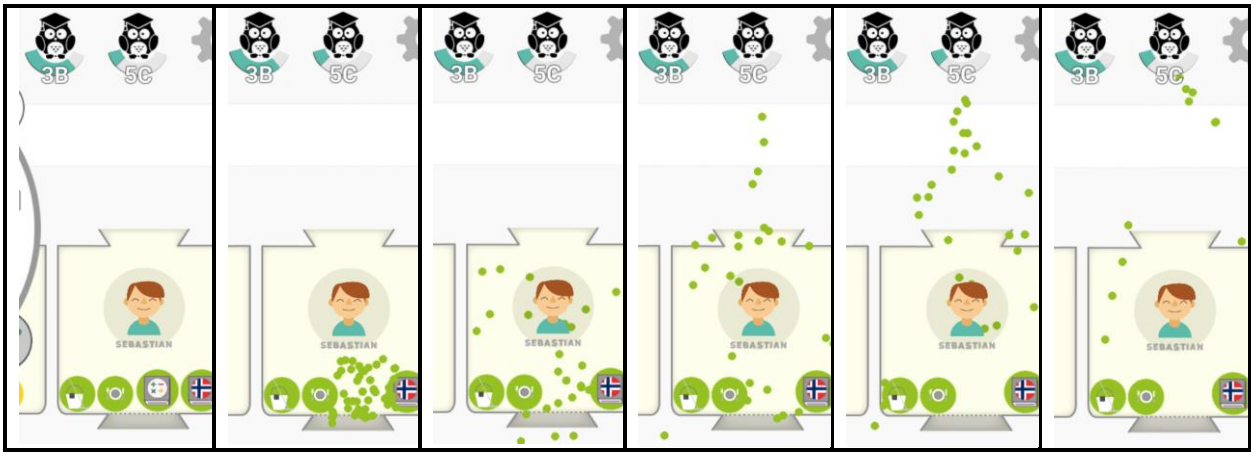

Figure 20-7: Homework completed animation (left to right)

20.1.3. The School Class View

When clicking an owl, the user was taken to the school class view. Here the user would see how far her/his school class had progressed towards their reward, get extra homework by clicking the green button, see messages from the teacher in the bottom, and see the top three point collectors in the school class as seen in Figure 20-8. To help the user understand what the different parts were, small descriptions were added where needed based on feedback from earlier iterations. Both clicking the extra tasks button and the "X" would take the user back to the main view.

Figure 20-8: Mænage School - School class view

20.2. Teachers' Concept

Below follows the high-fidelity prototype of the Mænage School application for the teachers. As mentioned earlier it was a web application and therefore behaved like a web page with HTML input elements, and at some places it used the built-in prompt boxes to ask if the users were certain they wanted to delete elements. Although with more time, a custom prompt modal, as used in the task distribution view history, would have been made for consistency instead. Some of the biggest benefits with the high-fidelity prototype were that it used colors to separate elements from one another as well as the hover effects and feedback toasts. One of the toasts can be seen in Figure 20-9, where a teacher just assigned a task group to a pupil. The green toast with the checkmark appeared in the top of the browser window and was animated as it appeared and disappeared.

Figure 20-9: Mænage School toast

For ensuring that the icons used throughout the application were similar to each other, as well as for saving time, Font Awesome (Fonticons, 2018) was used as icon library. Below follows an explanation of the changes in each view from the last prototype, as well as the functionality each view carries.

20.2.1. The Homework Task View

The homework task view only received slight changes from the last iteration. The caret that expanded and unfolded the editor for a group was changed to a pencil and get changed to a checkmark when it unfolds, as well as the whole row was now clickable which made you able to click the group name and description to change them faster. Also, the mathematics icon was changed for consistency with the Unity application. In Figure 20-10 we see that the prototype still had four icons in the main navigation bar, however, only the two left-most icons (homework sheet and reward) were implemented as explained under iteration two.

Throughout the application, the user could select week and school class. The teacher would have all school classes they taught available to them in the dropdown menu as well as a different version of the homework for each week. As seen in Figure 20-10 the teacher was presented with each subject they taught, here mathematics and Norwegian. For each subject the teacher could create infinite groups of homework and either make them assignable to specific pupils, common to all pupils in the class, or optional for those who wanted extra points. By

clicking on the edit button, or anywhere else on the row, the group unfolded as seen in Figure 20-11. The group could also be deleted by clicking the trash can. It is worth noting that it was completely up to the individual teacher if the groups were to be treated as homework of different difficulties. It could just as well be used as a way of dividing the school class into project groups with different topics, or translating homework to for example English since not all pupils have Norwegian as their primary language.

Figure 20-10: Mænage School homework task view

When a group was clicked the user could edit the content within. The name and description in the top was for the teacher only and was intended as an aid for them to keep track of each group's purpose. As mentioned above, a task could be assignable, common, or extra, this was selected by clicking one of the radio buttons and was explained by the question mark to the right. By clicking the "Nytt delmål +" button blank sub goals appeared, and new web links could be added as well by clicking the plus under the links section. There were counters for both the sub goals and links to indicate that a link was added to the data set. As seen in the figure, the links used "X" instead of the trash can, this was to signal the impact of the action to the user, since the trash can could possibly delete a lot of work, but the "X" only removed a single element set. For saving changes to the data the checkmark was used, which earlier was the edit icon next to the trash can for the entire group.

Figure 20-11: Mænage School task view (unfolded)

20.2.2. The Task Distribution View

After making assignable homework task groups, the teacher could go to the task distribution panel to assign them to individual pupils as seen in Figure 20-12. When a cell was hovered, the cursor would change to pointer and the cell background would darken to indicate that it was clickable. The first row contained the pupils' names and all available subjects were listed in their separate column from left to right. In iteration two, there was a hover icon as well, but it was decided to not keep it as it was clear enough that it was clickable and the icon just made more visual clutter.

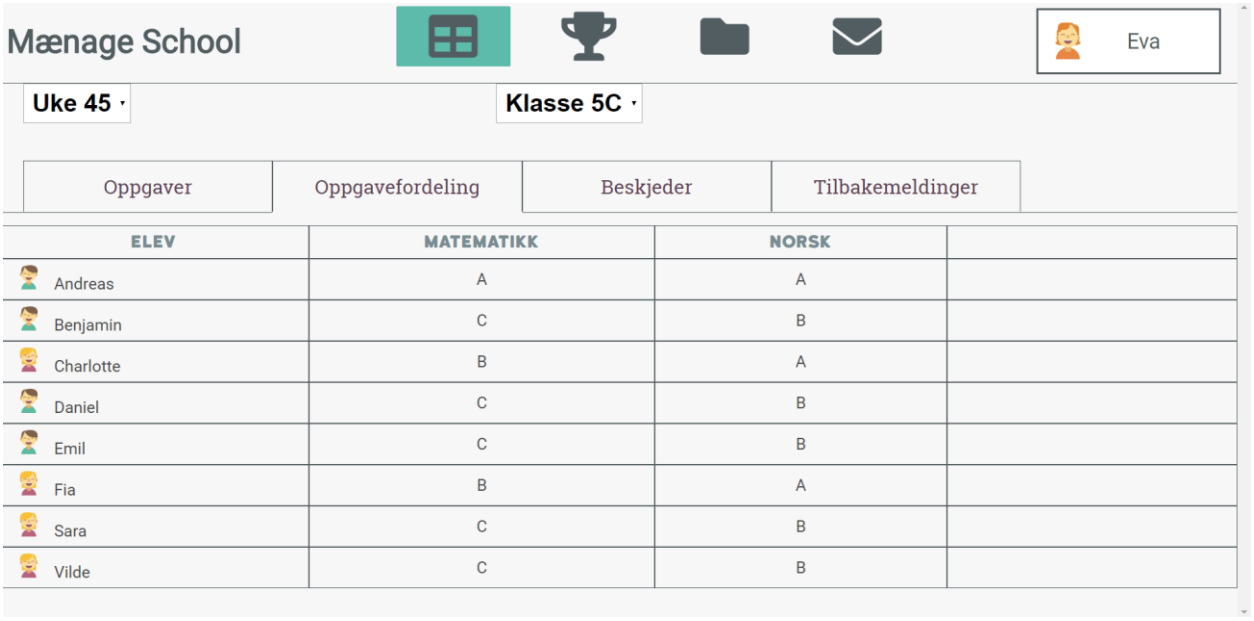

Figure 20-12: Mænage School task distribution view

When a teacher clicked a table cell, a modal overlaying the table listed all available homework task groups for that week in that subject so that the teacher could assign them. A history of former homework was listed to save the teacher from having to manually click through multiple weeks checking each individual pupil's homework. As the case in Figure 20-13 where the teacher decided that the groups were of different difficulties from A-C, with one time even a D. The teacher could then see that Charlotte had made good progress and assign the new homework thereafter. The modal behaved like one would expect where you can both close it by clicking "X" or clicking anywhere in the dark backdrop.

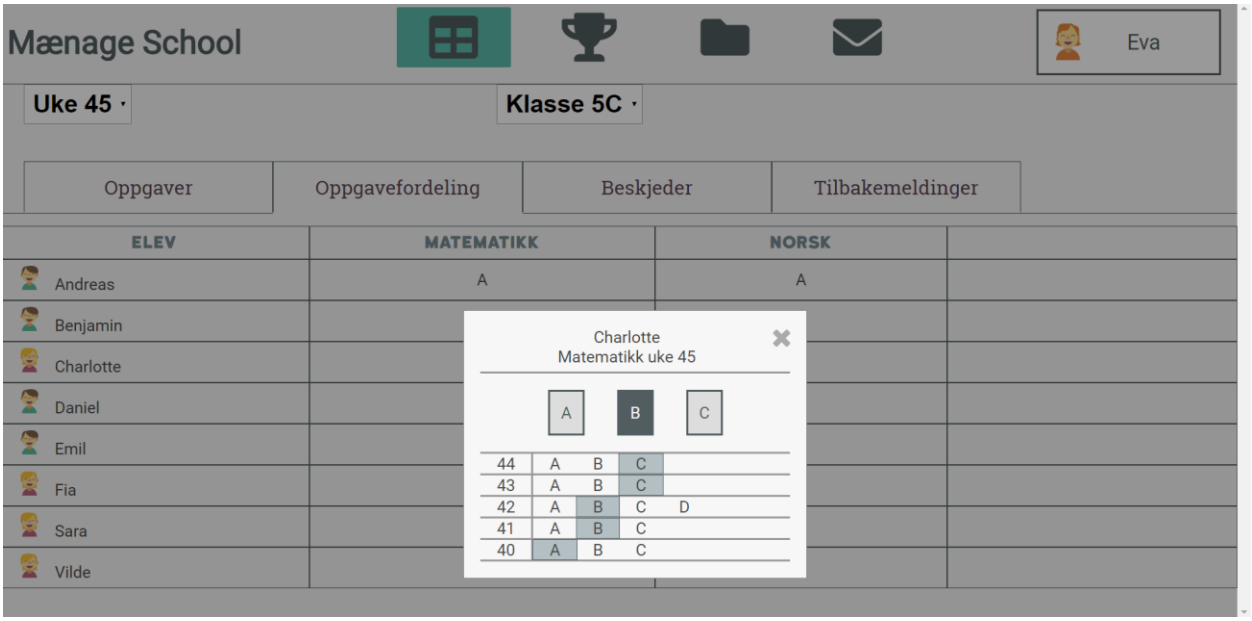

Figure 20-13: Mænage School task history modal

20.2.3. The Information View

In the second iteration some users thought the message icon was the button and felt it was inconsistent with how plus icons were used. Therefore, the information view in Figure 20-14 tried to make the buttons more obvious and remove the circle from the icons which were confused with buttons. It also leveraged web technologies by using the disabled property in HTML to make a visual and physical constraint, meaning the user could not click the submit button without writing anything and could not edit a text field before it was the active one. As in the earlier iterations, the teacher could add, edit, or delete messages to the school class.

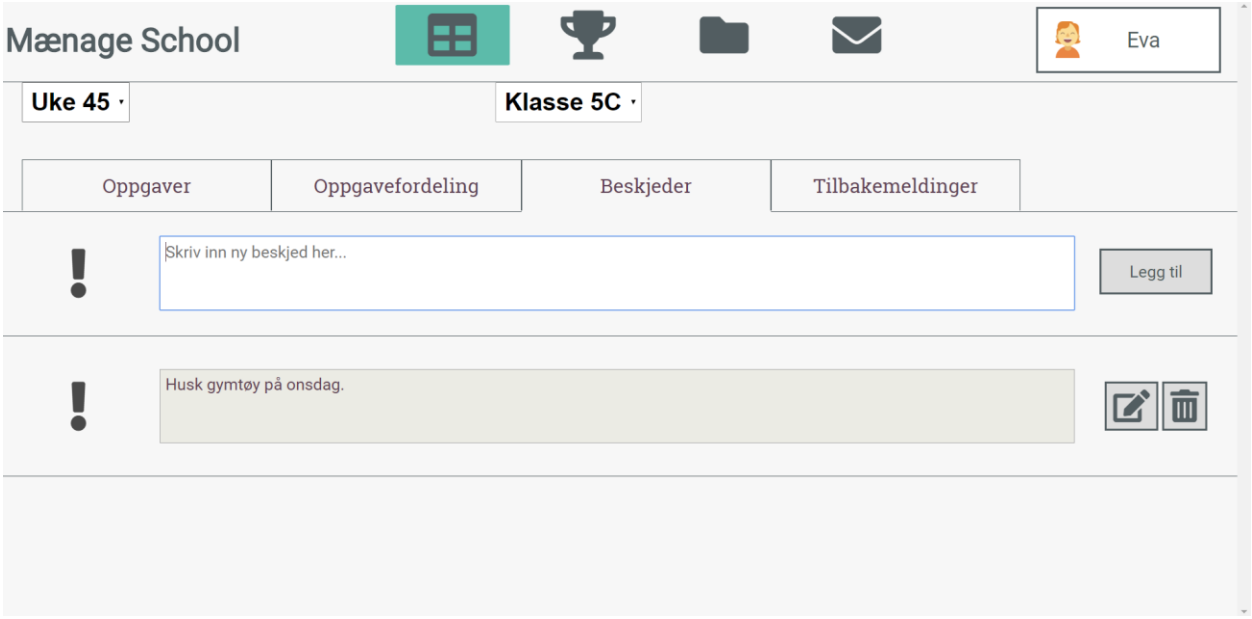

Figure 20-14: Mænage School information view

20.2.4. The Feedback View

The feedback view was also one of the views with little change, the only noticeable change made was that it got an additional column in the table with how much time the pupils spent on their homework. The teacher could here see the average discrete feedback for each homework task group and expand the group to show what each individual pupil answered. The feedback view and how it unfolded a group can be seen in Figure 20-15 and Figure 20-16.

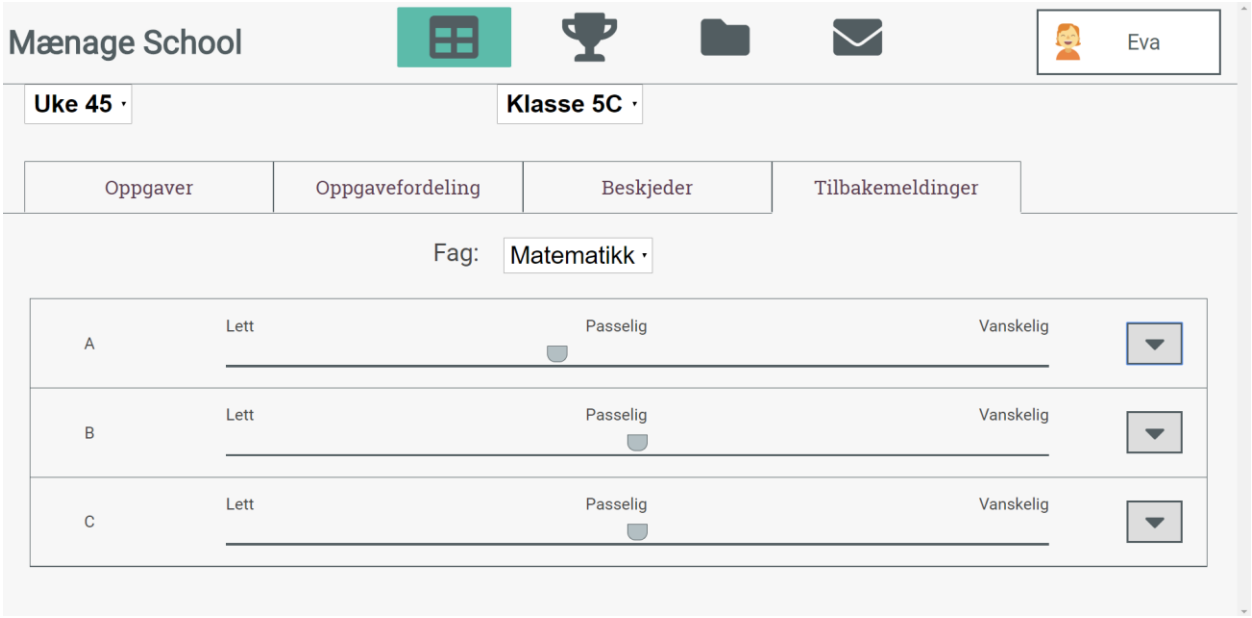

Figure 20-15: Mænage School feedback view

Figure 20-16: Mænage School feedback (unfolded)

20.2.5. The Reward View

The reward panel in Figure 20-17 let the teacher adjust the school class reward, points needed for reward, and how much each group type was worth, with default values in place for less setup. As the teacher updated the required points for the reward, the progress bar would update in real-time to give the teacher a visual indicator of how close they were to the goal.

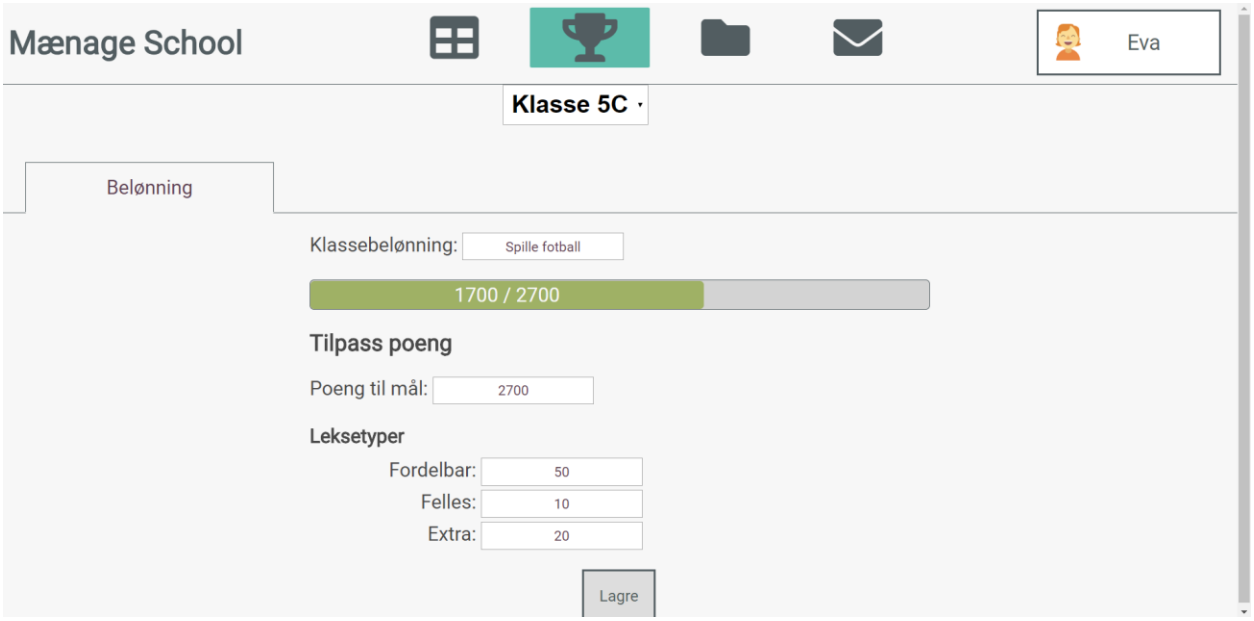

Figure 20-17: Mænage School reward view

21. Results and Usability Analysis

This subchapter presents the results from the testing of the third iteration, the testing of the high-fidelity prototypes. When a tester had completed the scenarios without assistance they filled out a Likert scale form, a SUS form, and gave their comments on the prototype.

21.1. Pupils' Concept Feedback

Table 21-1 is a result of the feedback (F) from the tester and the observations (O) made during the testing of the pupils' high-fidelity prototype.

Scenario 1: Complete your homework assignment in mathematics.	
F1.1	It is a little difficult to click the buttons on the form, as they are very small.
O1.1	A user meant the green checkmark meant finished, and that it is correct.
O1.2	At first, they do not know what to click, but after trying to click different things all interactions drastically speed up after the first task.
O1.3	Some clicks through the tabs and closes the homework. When the homework is still in their pool they click on it again and keeps clicking different things, when they hit the checkbox and it becomes green and checked they all seem to get it and goes back to check the boxes.
Scenario 2: Complete your Norwegian homework.	
O2.1	No problem at all, every tester found it and said it was because of the flag, also completing the task seemed easy to them after doing the mathematics one.
Scenario 3: Check if you have any messages from your teachers.	
O3.1	Tried to click their own avatar in the main view to check for messages.
F3.1	The exclamation point makes sense for messages.
Scenario 4: What does your class get to do when you have collected enough points, and how far have you come towards your goal?	
F4.1	Where do you see how long it takes?
F4.2	I think that when it fills up we are finished.
O4.1	A user though the progress bar in the main view meant how far they were through the school year, but changed mind when opening the school view and read the text on the progress bar there.
Scenario 5: Who have collected the most points in your class?	
O5.1	Everyone found this without any problem.
Scenario 6: How can you get more homework for earning extra points?	
O6.1	Everyone found this without any problem.
F6.1	But what if I do not want to do more homework?
Additional feedback	
F7.1	The icons were very easy to understand.

Table 21-1: Feedback for pupils' high-fidelity prototype

The pupils filled out the SUS schema in Appendix B, in Table 21-2 are the results and the calculated SUS scores. The SUS translation is from Bangor et al. (2009).

System Usability Scale	T_1	T_2	T_3	T_4	T_5	T_6
1. I think that I would like to use this product frequently.	5	5	5	5	5	4
2. I found the product unnecessarily complex.	1	1	1	1	1	1
3. I thought the product was easy to use.	5	5	4	5	3	5
4. I think that I would need the support of a technical person to be able to use this product.	1	1	2	1	2	4
5. I found the various functions in the product were well integrated.	5	3	4	5	4	3
6. I thought there was too much inconsistency in this product.	1	1	2	1	2	2
7. I would imagine that most people would learn to use this product very quickly.	3	5	3	5	5	5
8. I found the product very awkward to use.	1	1	1	1	1	1
9. I felt very confident using the product.	5	5	4	5	3	4
10. I needed to learn a lot of things before I could get going with this product.	1	1	2	1	1	2
SUS score	95.0	95.0	82.5	100.0	85.0	77.5
Average SUS score	91.5					

Table 21-2: SUS scores for pupils' high-fidelity prototype

An average score of 91.5 is within acceptable boundaries, the score could still be improved with the feedback gathered from the testers.

21.2. Teachers' Concept Feedback

Table 21-3 is a result of the feedback (F) from the tester and the observations (O) made during the testing of the teachers' high-fidelity prototype.

Scenario 1: Add a new sub goal in task group "B" in Mathematics.	
F	Perhaps there should be two save buttons, it is a little difficult to notice the tiny checkmark.
F	The new sub goal should appear at the top because if you add a few you do not see that you add a new one.
F	How do you save?
Scenario 2: Add a new task group in Norwegian that is extra homework for those who want to do it, and add two sub goals where at least one of them have a link.	
O	Some used long time to notice the question mark when needing the information it gives.
F	Is the link saved now that I added one?
Scenario 3: Delete the task group in Norwegian that is missing a name.	
-	-
Scenario 4: Based on what the pupils had former week, assign them new homework.	

F	I would like to be able to click through all the pupils without closing the window every time.
F	I would like to be able to see who did extra tasks in the log.
F	I would like to see the discrete feedback in the log too so that I do not have to scroll through all the feedback.
F	This would be a little cumbersome if you had 30 pupils.
F	I would like the last pupil you clicked to have a different cell color than the rest, it is difficult to trace back how far you had gotten.
F	Are the numbers in the left column week numbers?
Scenario 5: Give class 5C a message that reminds them to get their parents to sign their note about the school milk offer, the deadline is approaching.	
F	It is a little strange that the entire message written is displayed in the feedback toast.
F	I would like to be able to give messages to specific pupils, some need additional reminders.
Scenario 6: Check if the task group "A" had a sufficient difficulty.	
F	It makes more sense to me that time spent and discrete feedback switch places.
F	It would be easier to see the discrete feedback if it were color coded with green, yellow, and red.
F	The average feedback can be misguiding if one states easy and one hard, it shows up as just right, but it is great if you look at the specific entries.
F	Perhaps it should be possible to answer feedback from pupils in case their extended feedback is a question?
Scenario 7: The pupils want to eat pizza rather than playing soccer, but you think the required points for such a goal is too low. Change the reward to please the pupils and adjust the required points to 6000 to give them a fair challenge.	
F	The save button is a far down, it might be difficult to see it with a smaller screen.
F	Why is the heading in a tab if there is only one?
F	Why is there a save button in reward but nowhere else?

Table 21-3: Feedback for pupils' high-fidelity prototype

The teachers filled out the SUS schema in Appendix B, in Table 21-4 are the results and the calculated SUS scores. The SUS translation is from Bangor et al. (2009).

System Usability Scale	T_1	T_2	T_3	T_4	T_5
1. I think that I would like to use this product frequently.	5	4	5	5	4
2. I found the product unnecessarily complex.	1	1	1	1	3
3. I thought the product was easy to use.	5	5	5	5	3
4. I think that I would need the support of a technical person to be able to use this product.	1	1	1	2	4
5. I found the various functions in the product were well integrated.	5	4	5	4	5
6. I thought there was too much inconsistency in this product.	1	1	1	1	1
7. I would imagine that most people would learn to use this product very quickly.	5	5	4	4	5
8. I found the product very awkward to use.	1	1	1	1	2

9. I felt very confident using the product.	5	5	5	2	3
10. I needed to learn a lot of things before I could get going with this product.	1	1	1	1	2
SUS score	100.0	95.0	97.5	85.0	70.0
Average SUS score	89.5				

Table 21-4: SUS scores for teachers' high-fidelity prototype

An average score of 89.5 is within acceptable boundaries, the score could still be improved with the feedback gathered from the testers.

21.3. Usability Analysis

After the testing of the third and final iteration was finished the results were reflected upon to identify what worked and what could have been done differently.

Pupils

The biggest hurdle for most of the pupils was the initial task. Everyone found the subjects in their own pool, but they did not understand everything that was clickable from the start. The good part of the design was that when the pupils started clicking everything to check what could be clicked it was impossible to break something and the actions were easily reversible. For the most part, all pupils understood that the "X" meant closing the window, next they found out what the tabs did. One out of two things happened, either the pupil figured out the tabs and started traversing them without checking the checkbox, but went back and checked all of them when they realized it. Or, they got the point of the checkbox from the start and traversed the tabs. There was never any doubt about how the links worked, and after completing the mathematics task, the Norwegian and extra task were easy. The clickable areas of the feedback form made some testers click multiple times as they seemed to be a too small to hit the first time, this could perhaps be fixed if the elements accepted input further away from themselves.

It seemed like a few pupils did not understand the concept of a progress bar, but because of how the reward name was put in the middle of it there was something to it. Also, a user tried the avatar's window to check for messages from the teacher, although after not finding them there the school class view was clicked second. To sum up, the interactions were easy to understand after getting over the first hurdle.

Teachers

The biggest improvement using the high-fidelity prototype was the possibility of giving clear feedback to the users. The task editor is by far the most complex part of the system but did great for the most part. Some minor feedback was that the new sub goal should be added on top of the others in case the new one would appear below field of view, something I did not even consider. What would need a change when further working on the concept would be to make the save button much more obvious when you save a homework group. Not everyone noticed the edit button turning into a checkmark and some did not find the button at all.

When assigning the groups to pupils, the teachers wished for it to be more efficient, namely that when having a large amount of pupils it would be annoying having to close and open the log 30 times. In addition, when having to close the modal between every pupil it sometimes got difficult to see who was the last pupil you clicked. Further work with the concept should try to have a way of clicking through the pupils and perhaps even marking which was the last visited pupil cell. Mostly the users seemed to feel in control where the feedback toast was a contributor, however, the toast message would need to have shorter feedback and not print the whole messages such as in the information view.

VII. Discussion & Future Work

When the last prototypes had been tested, it was time to look back and reflect upon the process. The research design was evaluated, both how the research strategy was used and the data generation methods. Then the results beyond usability were discussed from the iteration 3 testing, followed by evaluating the project by answering the research questions and fulfilling its goal. The Chapter rounds of by presenting what ought to be done in the future of the Mænage School concept.

22. Research Design Evaluation

This subchapter presents a discussion of the different research methodologies and how they were used in the thesis. As well as factors that could have affected the results throughout this thesis.

22.1. Research Strategy Evaluation: Design and Creation

Throughout this thesis the design and creation research strategy was used and resulted in a limited instantiation of the concept, namely two high-fidelity prototypes. By talking to teachers and pupils I developed an awareness of what needs they had towards a concept that should motivate children to do homework and at the same time ensure the teachers would spend their time efficiently. From this data and the theories and applications studied under Chapter II Background, a suggestion was made to address their problem. The idea was then implemented as prototypes, the first and second iterations as paper prototypes and the third as high-fidelity prototypes. After each iteration the results were evaluated and the new knowledge obtained was identified.

What was good with design and creation?

The design and creation strategy focuses on developing new IT artifacts, and is a problem-solving approach with a process similar to a "normal" software development process. The positive effects of this can be that you have something to showcase, in this case a Unity application and a Vue.js application. This strategy comes natural in technical and development work, which may appeal to people who like to create and design, such as myself. Since technology keeps moving forward there might be plenty uses for technology in Norwegian elementary school, some good examples of such applications were mentioned in subchapter 4 Related Work.

Potential downsides and problems

A challenge when using this strategy, however, might be to justify the work as more than just another creative work, which I think is justified throughout this thesis with iterating over the awareness, suggestion, development, evaluation, and conclusion steps of the design and creation strategy. It might also be a point that you will need a certain skillset to pull this off, since you need the technical and design skills to actually make an artifact. In my case, I had little experience in Unity and no experience in Vue.js, but in my spare time I love to create various things and trying out different technologies which resulted in me having the fundamentals to get me started with the two different technology stacks. Another problem with this strategy might be that it can become outdated due to rapid technological advancements, for all I know some the technologies used might be legacy technologies in the near future. As I will be moving on to different projects in the future I do not know if the applications will work in later releases of their technologies, unless they are 100 % backwards compatible.

Having an iterative process

As seen in Figure 22-1, the average SUS score increased for each iteration of the project. I think it was worth having an iterative process instead of a linear one as I was able to constantly ask the intended users for feedback and relatively quickly adapt to their input in a new version of the prototype. This way, I saved a lot of time not implementing unnecessary features, and since the paper prototypes looked unfinished and rough around the edges it might have been easier for the users to criticize them. As the figures indicate there were clear problems with the first iteration of the pupils' concept, if I had developed that solution it is possible I would not have as satisfactory results as I got.

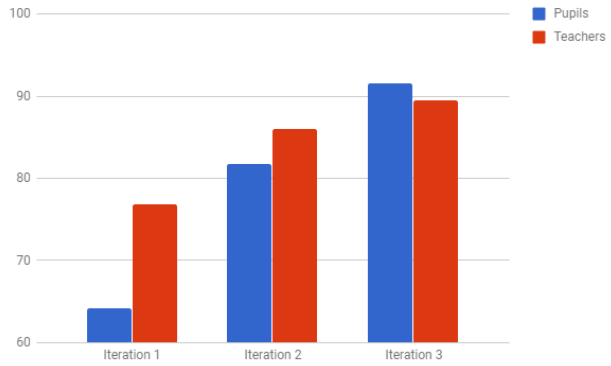

Figure 22-1: Average SUS score chart

At the same time I thought the gap between iteration two and three would be bigger since the second was on paper and not on the actual device. Thanks to the iterative nature of the project I detected a disconnect between what I thought the pupils wanted and what they actually wanted, which resulted in a redesign in their concept which had to be accommodated in the teachers' concept as well as mentioned in Chapter V, Iteration 2 – Concept Refining. By having a linear software development process I might have gotten further developing a product, but again, maybe not a product that met the users' needs well.

22.2. Data Generation Methods Evaluation

Through this thesis, data was generated through the use of interviews, observations, and documents. Below follows some advantages and disadvantages I experienced when using these methods.

Semi-structured Interviews

As the primary data generation method, interviews provided a lot of data in this thesis. What makes this method stand out is the amount of data it gets you and dependent on what level of structure you chose, you only need your communication skills to conduct one. You can check that the interviewee fits your focus group, which you would not be able to do if you spread for example a questionnaire on the Internet. The people interviewed also seemed happier when they could freely state their opinions and ideas as opposed to filling out the questionnaires. The

amount of unstructured data comes at a price though. First it is the interview itself, then transcribing said interviews, and after that you are left with a lot of unstructured data that is not necessarily similar to each other. A reason I felt it was a good idea to have more data generation methods than only interviews was the reliability of the data. I as the interviewer might affect the situation just by being there, especially when talking to shy pupils it might have been difficult for them to criticize the prototypes. Also, when there were two or more pupils interviewed, sometimes the other pupil(s) would claim their idea as the best and prohibit the others from saying what they meant. Although it is difficult to know if the benefit of discussing things together with someone else outweighs this problem. The reliability of the data can become highly subjective and is purely based on what the interviewee say or think they do, opposed to what they actually do. Overall, I think it synergized especially well as semi-structured together with questionnaires such as the SUS scale which together yielded both a formative and summative evaluation of the prototypes.

Observations

Systematic observations help mitigate the problem mentioned above, that the reliability of the data from interviewees is solely based on what they say or think they do, it reveals what they actually do. Observations were used during the testing of the prototypes and the data were categorized with each scenario test which meant they were ready for analysis after the test. Observations can provide you with data you and the user are unaware of, but may be limited to obvious behavior since it might be difficult to determine the reason behind it. If I was to do this project all over again I would have considered using eye-tracking with the observations, since heat mapping and point mapping might have revealed more of the underlying reasons.

Questionnaires

Questionnaires feel like the most time-efficient method I utilized during the thesis. By having only closed questions, it was easy for the pupils and teachers to fill them out and the data was easily categorized and ready to analyze, and require no social skills from the researcher to affect the quality of the results. In my case, I used a five-point Likert scale. The downside to that seemed to be that pupils would often default to the extremes, 1 and 5, as a discrete answer. The downside of using the System Usability Scale on pupils was that the language was a little hard to understand for them, and some were out-maneuvered by 5 changing from being best to worst every other question.

Documents

Lastly, homework sheets were collected from teachers, parents, and pupils. The benefit of using documents is that it can be done quickly and asynchronous, meaning you can send out emails to parents and teachers, who then answers you when they can and can opt to forward it to people they know. Another great benefit is that the homework sheets already existed independently of the thesis and therefore were available in great number and highly accessible, and also authentic- they were not fabricated by a teacher to show you how a “normal” homework

sheet looks like. However, when collecting them like this I could only verify their authenticity by verifying them against teacher and school class.

23. Result Analysis

This subchapter presents and analyses the responses from the testing of the two final pupil and teacher prototypes. The SUS scores were presented in subchapter 21 Results and Usability Analysis, this part focuses on the results from the five-point Likert scale with statements related to the research questions and goal which were answered in addition to the SUS form. The alternatives "strongly disagree" and "disagree" are grouped together, as well as "strongly agree" and "agree" because I was most interested in knowing whether the subjects disagreed, agreed, or were neutral. The full results can be seen in Appendix D.

23.1. Pupils' Concept

17 pupils, 11 boys and 6 girls, participated in this thesis through its different iterations. As seen in Figure 23-1, there were 6 pupils participating in the testing of the high-fidelity prototype and 17 in total throughout the thesis.

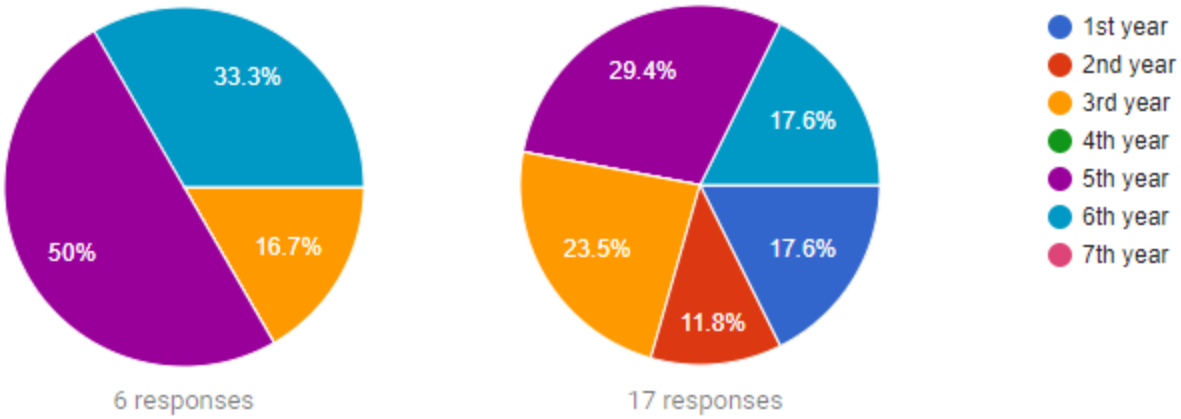

Figure 23-1: Pupil participation

Two school years are not represented at all which are 4th year pupils and 7th year pupils. However, since there are participants from both 3rd and 5th year one can perhaps come to some conclusions for the 4th year as well. Assumptions about 7th grade pupils are therefore limited to the experiences of the 8 teachers that contributed to this thesis. However, one thing to notice is that they were not asked in the Likert scale about the difficulty of the homework and thereby the game. This was because the difficulty of the homework would be set by the teacher, and Mænage School simply enables this.

23.1.1. Motivation

Table 23-1 presents statements from the Likert scale which has to with the pupils' motivation when doing homework in Mænage School.

ID	Statement	Group	Disagree	Neutral	Agree
3	It was fun to do homework in the application.	All Female Male	0% 0% 0%	16.7% 33.3% 0%	83.3% 66.7% 100%
4	I felt like an important part of my class when I got us more points.	All Female Male	0% 0% 0%	16.7% 33.3% 0%	83.3% 66.7% 100%
5	I thought it was fun that I had collected the most points in the class.	All Female Male	0% 0% 0%	33.3% 66.7% 0%	66.7% 33.3% 100%
8	I thought it was fun getting points for doing homework	All Female Male	0% 0% 0%	0% 0% 0%	100% 100% 100%
9	I thought it was so much fun getting points for doing homework so that I wanted to do even more homework.	All Female Male	0% 0% 0%	50% 66.7% 33.3%	50% 33.3% 66.7%

Table 23-1: Motivation questions results

There is mostly a positive attitude towards doing homework in Mænage School. The application aimed to motivate the pupil by presenting the homework in a clear format, providing a sense of belonging to her or his school class by providing a shared goal, a partial high score list for the ones that are concerned with competition, and awarding points towards the goal. The answers show that the different aspects can be rewarding, but not as much for everyone, which also is reflected in results from earlier iterations. However, no one was de-motivated by the different aspects that did not appeal to them, they were only indifferent to it. As indicated by item 8 and 9, points are motivating to get, but perhaps not enough for everyone to go ahead and complete extra homework tasks. It is also interesting to see that the female participants were the least motivated by points.

23.1.2. Execution: Homework Sheet Tasks

Table 23-2 presents the results of the Likert scale that has to do with doing homework in Mænage School, this makes up usability, engagement, and control.

ID	Statement	Group	Disagree	Neutral	Agree
10	I thought less about time and place when using the application.	All Female Male	0% 0% 0%	33.3% 66.7% 0%	66.7% 33.3% 100%
11	By looking at the application I understood I had executed an action.	All Female Male	0% 0% 0%	0% 0% 0%	100% 100% 100%
12	It was easy to understand what I was working towards at all time.	All Female Male	0% 0% 0%	16.7% 33.3% 0%	83.3% 66.7% 100%
13	It was easy to see what my homework was.	All Female Male	0% 0% 0%	0% 0% 0%	100% 100% 100%

15	It was easier to see my homework in the application than in my traditional homework sheet.	All Female Male	0% 0% 0%	0% 0% 0%	100% 100% 100%
16	It was easier to use web pages in the applications than writing the links into the web browser myself.	All Female Male	0% 0% 0%	16.7% 33.3% 0%	83.3% 66.7% 100%
17	It was easy to view messages from my teacher.	All Female Male	0% 0% 0%	16.7% 33.3% 0%	83.3% 66.7% 100%

Table 23-2: Execution: Homework sheet tasks questions results

Items 10, 11, and 12 were are concerned with some parts of the Flow experience (Csikszentmihalyi, 1990) and Malone's (1980) challenge category where a player should always be able to know what goal they are working towards. Item 10 might indicate that Mænage School was engaging to some extent, but that more work could be put towards engagement. It is clear that they all thought it was easier to see their homework in the application than on their traditional homework sheets, and that it was easy to use web resources and find messages from their teacher. All in all, it seemed like the pupils enjoyed having their homework sheet in Mænage School and that they managed to complete their homework assignments.

23.1.3. Codetermination

Table 23-3 presents the two items that had to do with being able to participate with their opinions towards improving homework.

ID	Statement	Group	Disagree	Neutral	Agree
6	It was easier to state my opinion about the homework.	All Female Male	0% 0% 0%	0% 0% 0%	100% 100% 100%
7	I liked how easy it was to state my opinion without having to speak out loud in the classroom.	All Female Male	0% 0% 0%	16.7% 33.33% 0%	83.3% 66.7% 100%

Table 23-3: Codetermination question results

Item 6 and 7 indicate that the pupils enjoy being able to give the teacher feedback on their homework assignments, and that some enjoy the ease of not having to tell their teacher in person. Pupils also did not seem to mind having to fill out the feedback form after every homework and enjoyed having closed questions with a finite set of alternatives. They also agreed with having the continual feedback optional, but that most of them did not have anything to say as it was just a test. In further work, I would like to find out if there was something to the one pupil who liked the easy of giving the opinion, but that it did not necessarily has to do with not having to speak up in the classroom.

23.1.4. General

Table 23-4 presents the one item that was new and experimental in the high-fidelity, the complete animation. According to item 14 almost all the pupils understood what it meant that the

task dissolved in to small particles and traveled in to their school class icon. For further work it might be interesting to test if for example the use of sound could further engage the pupils.

ID	Statement	Group	Disagree	Neutral	Agree
14	It was easy to see that my class got more points as I did homework.	All	0%	16.7%	83.3%
		Female	0%	0%	100%
		Male	0%	33.3%	66.7%

Table 23-4: General question results

The overall feedback from the pupils was that they enjoyed Mænage School and would like to have their homework in an application like this, instead of in the traditional homework sheet.

23.2. Teachers' Concept

Five of the eight teachers that had contributed to this thesis tested the high-fidelity prototype and rated the five-point Likert scales below.

23.2.1. Execution: Creating the Homework Sheet

Table 23-5 presents the results that have to do with performing the tasks the teacher would normally do when creating the homework sheets but in Mænage School, this means creating and assigning homework as well as giving messages to the pupils.

ID	Statement	Disagree	Neutral	Agree
1	I think it will take less time to set up homework in Mænage School than in a traditional homework sheet.	0%	40%	60%
2	I think Mænage School will distribute homework more efficiently than a homework sheet on paper.	0%	0%	100%
3	Mænage School made it easier to adapt teaching to pupils at different skill levels than a traditional homework sheet.	0%	0%	100%
4	It was easy to use the homework group tool.	20%	0%	80%
6	It was easy to see which task groups a pupil was assigned.	0%	0%	100%
7	The homework group history made it easier to assign new homework to pupils.	0%	0%	100%
10	It was easy to use the message tool.	0%	0%	100%

Table 23-5: Execution: Creating the homework sheet questions results

Item 4 along with the usability analysis of iteration 3 indicates that the homework group was too complex and did not score good enough usability wise. However, the rest of the items indicate that the other major parts were easy enough to use. There was no doubt among the teachers that distributing the homework would be more efficient with Mænage School, but 40% is neutral to that it would save them time than doing it the traditional way. One possibility of this might be what was pointed out in the task distribution panel, that it took too long time assigning

homework to one pupil, closing, and assigning to the next pupil. Another possibility could also be that the teachers have a procedure they are used to when making homework sheets, and that Mænage School has not been through the different phases of the technology domestication process by Lie and Sørensen (1996) yet.

23.2.2. Utility

In order for the teachers to even considering incorporating Mænage School in to their routines, it had to be of use to them. Table 23-6 presents the items that have to do with the utilities Mænage School provides.

ID	Statement	Disagree	Neutral	Agree
5	By using grouping of homework tasks I can adapt homework to pupils at different skill levels.	0%	0%	100%
8	I think it becomes easier for pupils to use web resources by using Mænage School.	0%	0%	100%
9	Mænage School made it easier to give messages to my school class(es) than in a traditional homework sheet.	0%	0%	100%
11	The feedback from the pupils made it easier to know what to focus on next.	0%	0%	100%
12	It gave increased benefit having the average feedback for each homework group.	0%	0%	100%
13	It was useful to know how long time the pupils spent on their homework.	0%	0%	100%
14	I think it is easier for pupils to give feedback through the app than physically to the teacher.	0%	0%	100%

Table 23-6: Utility questions results

Since all items are at 100% there is a strong reason to believe that Mænage School provide enough utilities for the teacher that they might consider using it. Throughout the thesis the feedback from the teachers indicated that the pupils' feedback was one of the most important features to them because it filled a need the traditional homework sheet could not fill. Second most important was the ability to create homework for the school class, but this is already possible in a traditional homework sheet, just not efficient enough. The overall impression after their comments and feedback was that all teachers deemed the product helpful, and were interested in applying a similar product to their future work which is what the results of question one in the SUS Likert scale indicated as well.

24. Evaluating the Project

This subchapter presents the fulfillment of the research questions and research goal of this thesis. First, each research question will be answered, and from there the research goal will be more of an overview of the research questions of what was accomplished.

24.1. Fulfillment of Research Questions

As indicated by the preliminary study demotivation towards homework was something that started to occur from second year of elementary school and onwards, as first-year pupils thought homework was fun in the degree they had homework. Challenges for the pupils can therefore be that it may be hard to motivate themselves to do their homework, and it can become difficult to maintain engagement throughout the homework session. By attempting to solve these problems it was important to not let it further strain the already limited time a teacher has to create the homework sheets during their work schedule.

24.1.1. RQ1: How does Mænage School affect pupils' motivation towards homework?

In order to affect pupils' motivation towards homework Mænage School builds upon theories defined in Chapter II. By allowing the teacher to split the homework into sub goals, the teacher can ensure optimal information complexity for the pupil. This enables the teacher to use models like the experiential gaming model allowing the pupils to creatively think, reflect, and test solutions. The teacher can create a variety of sub goals: an example could be a task that first reflects on a new topic, then introduce information about the domain by using web resources such as for example video in sub goal two, and then test out their new knowledge as problem solvers with challenges in sub goal three- allowing for models like experiential gaming (Kiili, 2005) and/or flipped classroom. This means that the Mænage School concept does not directly determine the difficulty of the game by itself, the teacher does. Indirectly, however, it does, because it enables the teacher to get appropriate feedback from the pupils' homework and enables them to provide each pupil with homework at appropriate level of difficulty. According to Kiili (2005) problems with games that can prevent Flow are lack of concentration, challenge, player skills, control, clear goals, feedback, immersion, and opportunities for social interaction. In this application, the pupil's concentration is maintained by working towards a reward for the class by earning points, which should encourage a sense of belonging to his or her class. The teacher gets feedback from the pupils to provide homework that is more suitable for the pupil's individual level. Through multiple iterations of user testing and feedback the usability was improved to ensure that the user was always in control, and got appropriate feedback on their actions. All these aspects should contribute towards deep and effortless involvement in the game.

To sum up, Mænage School affects the pupil's motivation by using different game design elements to ensure deep and effortless involvement in the game. The game boosts motivation through awarding points, encourage the feeling of belonging to their class, enabling pupil-

involving teaching techniques, and ensuring that each pupil is challenged at an appropriate level. Furthermore, the pupil should feel like her or his opinion matters by evaluating their homework.

24.1.2. RQ2: How can a digital tool like Mænage School make it easier for the pupils to do homework?

As indicated by the results analysis, the pupils felt it was easier to view their homework in the application rather than their traditional homework sheets. The original Mænage application provides an easily accessible area belonging to the player, a pool of tasks. The Mænage School builds upon this and seamlessly incorporates its own homework bubble to go with the chores but keeps a high affordance towards looking like homework of a specific subject. As mentioned during the discussion of RQ1, the homework is split into sub goals, this also contributes to lowering cognitive load and giving the pupil one clear goal to work towards at a time. In the document research of homework sheets, one could often see long URLs to web resources intended for the pupil to enter into their web browsers, Mænage School trivializes this task by having the web resources one click away. It seems to be the norm for digital tools for Norwegian elementary school to be web-based as seen in subchapter 4 Related Work. This means they can leverage concepts such as hyperreading, which is “reader-directed, screen-based, computer-assisted reading” (Sosnoski, 1999) and thereby connecting content for the pupil.

Generally digital tools such as Mænage can provide the pupil with more control and improved quality of life by using features not possible on paper, such as hover effects, feedback on action, and managing cognitive load by splitting up information. In addition, linking content together can also make content easier available and connected for pupil.

24.1.3. RQ3: How can Mænage School help teachers adapt homework to pupils of different skill levels in a school class efficiently?

Mænage School lets teachers create an infinite number of groups of homework that can be assigned to individual pupils, made common to all pupils in a class, or extra tasks that can be requested from pupils. The groups are flexible in the way that they do not have to be used as difficulty groups, but just as well as a way of helping pupils with another first language that does not understand the default language in the classroom, the teachers use it as they want to. The groups made assignable can then be distributed among pupils where the teacher also can see a week history displaying pupils former groups. In addition to homework, the teacher could also add messages to the pupil and parents to read, just as in a traditional homework sheet. According to results from subchapter 23, Result Analysis, Mænage School provides many utilities for the teachers who participated to this thesis, where some benefits are homework distribution and efficiency in making the homework sheets. The results also state that the homework group tool might be too complex for some, and that they would want assigning groups to pupils faster when assigning to each pupil in the entire class. Mænage School also lets the pupils give feedback on every homework group assigned to them for the teacher to view as a summary or specific for each pupil. The teacher can then see if the pupil thought the homework were appropriate for their

skill level, how much time they spent on their homework, and if the pupil provided one the teacher could view extended feedback on the homework.

To sum up, Mænage School provides the teacher with feedback from homework pupils have completed so that the teacher can quickly adapt new homework to each individual's skill level. The teacher can add messages to the pupils, and can use the homework group tool to make multiple groups of homework to make them assignable to individual pupils, common to all pupils, or extra.

24.2. Fulfillment of the Research Goal

Explore if game design can boost pupils' motivation towards homework, and if such a concept can help the teacher adapt to each individual pupil's skill level more efficiently was the research goal of this thesis. Three iterations of user testing indicated that a concept using game design, such as Mænage School, can contribute to the pupils' motivation towards homework. A web tool for teacher was also part of the concept and provided utilities and features for making the process of homework sheet making and adapting to pupils' skill levels more efficient. The participants of this thesis only make up a very small part of the possible users of such a concept and can therefore only be used as an indication of what could be the results of testing it on a larger set of users. The research questions and goal are therefore concluded fulfilled, although further work would be needed as indicated by the results.

24.3. Challenges

Throughout the thesis some challenges occurred, below are challenges related to planning, technology, and testing and that I in hindsight did not foresee.

Planning

The only real challenge that had to do with planning was the estimation of how long it was supposed to take to complete the data collection in the preliminary study. Nine public elementary schools in Ålesund municipality were contacted via email where of only two answered. One said they had no time for such things, the other administration agreed to ask their teachers, where none of their 60 teachers wanted to participate. With no luck getting pupils from any of the schools, I reached out to parents and asked if they were interested in participating in the research, which thankfully many of them were. They even got the ball rolling by connecting me with teachers they knew, and this was how I in the end got the help of 17 children and 8 teachers, thanks to a lot engaged parents who recognized the problem of children having problem with the motivation towards homework. This process then took two months longer than first anticipated and delayed the whole project since besides the theory everything in this thesis builds upon that valuable initial data.

Technology

As mentioned under the technology section I had little to no knowledge of the version of Unity used and none in Vue.js, but some knowledge in similar technology stacks. During the long data generation phase I reached out to a professional Unity developer which gave me a thorough crash course in Unity and its workings, which again saved me a lot of time. The problem with the original Mænage project was that it was not documented and used some third-party dependencies which I was not able to update to the newest version of Unity, and resulting in settling with Unity version 5.5.4. If I were to do it all over again I think I would have changed the scope to only focus on the pupils' concept and spend all the time delving into that aspect. This would have prevented the need to learn two different technology stacks and making and testing two prototypes for two different target groups in every iteration of the project cycle. Due to the time restraint, it was decided to stop at the high-fidelity prototypes and use mocked data, and not develop a fully connected system. This meant I did not have to learn the Meteor framework as well, since that was what the existing server was coded in.

Testing

Before this thesis, I had never worked with children as a target audience in software development, and I am really glad I got the chance to do it because I encountered challenges I did not expect to have. For example, when testing the paper prototypes, pupils found it weird that they were supposed to click on paper and imagine it to be on a tablet, it seemed to be too abstract to them. Many are used to how radio buttons and checkboxes behaves, but in iteration 1 I realized that pupils might not had enough experience with computers and digital devices to have made up these expectancies yet and therefore needed to change up my approach. Also, as seen in all iterations of testing, there are typically more observations than feedback from the pupils as they had trouble maintaining to think out loud for the duration of the testing. And when it comes to the System Usability Scale the questions got a little advanced for the youngest pupils, it also was confusing to some that 1 and 5 changed being the "best" value in the Likert scale, as they expected 5 to be best all the way, although some grown-ups struggled with this alteration too.

25. Future Work

During the project's duration limitations were implemented to both narrow the scope of the thesis and make it feasible within the time constraint. A lot of suggested features were recommended, as well as more things to further test further. This subchapter presents what would need to be done further in the development of the concept Mænage School, features that would be interesting to explore, and testing that should be conducted.

25.1. Further Development

During the development of the Mænage School concept, there was only time to make one iteration of the high-fidelity prototypes. Before moving on to testing new features to further improve motivation and potentially Learning Management System features I would like to iron out the problems with the teachers' part- the complexity in the homework group tool and increasing the efficiency of assigning tasks to whole school classes. Suggestions for improvement of the task distribution panel was to be able to click through the whole class by assigning and clicking "next" without ever having to leave the modal, and when closing the modal it could highlight the last visited table cell, all usability improvements worth looking into.

Moreover, for the prototypes to become one fully integrated system, the two high-fidelity prototypes would need a common API to communicate with a server and database. This could be in the existing API written in Meteor, or in a separate one if keeping them separate from each other would be preferred. From there, the two applications would be set up with their own HTTP library to request and send resources to and from the server.

25.2. Features to Explore

Throughout this thesis pupils and teachers suggested functionality they wanted to see in a learning tool. In addition, during the development there were ideas that came up that I never had the opportunity to test. Below are some of the features I would have liked to test out in the future development of the Mænage School concept.

- More usages for points earned
- New reward system in addition to points
- Test out the daily system from section 11.2, 'The Owl Class'
- Social interaction features for school classes
- A way for pupils to browse "dissolved" homework bubbles
- Learning Management Features (LMS) that were decided to drop from the concept due to time constraints, such as sending messages to individual pupils and supporting homework delivery and a grade archive
- Homework delivery through the application, both written material and audio recordings
- Let the teacher comment on delivered homework

- Check if applying sound effects to the Mænage School parts could enhance pupils' engagement
- Explore a new homework group type "repeatable" that can homework appear multiple days after being completed. It could be used if a teacher wants pupils to practice glossary
- Let the teacher sort and filter feedback by time spent, difficulty, and pupil name
- Let the teacher have a view for displaying the whole class' feedback for the week to easily see who struggled.

The school class view in the pupils' part could also gain more features to further strengthen the sense of belonging to the class and explored more ways for pupils to collaborate with each other besides having an extrinsic reward provided by the teacher. Also, this thesis does not delve into reward models, for more information see Kartevoll (2017).

25.3. Testing

Due to the time constraint I was not able to get 4th year pupils and 7th year pupils to test the concept. This resulted in the expected behavior from these groups being based on the teachers' experiences and the school years adjacent to them. In further testing the concept should be tested on a much bigger set of pupils, as the ones participating in this thesis make up a very small amount of all elementary school pupils in Norwegian school system. I would also like to find a more suitable evaluation method for younger pupils for evaluating usability of software systems, as the language of System Usability Scale (SUS) can be complex to them and the questions might not necessarily suit what they think of when using an application.

Furthermore, I would have liked to investigate the reason why some of the pupils answered that they liked that it was easy to give feedback to the teacher, but that it was not necessarily because they did not have to speak up in the classroom. It would also be interesting to see Mænage School on additional platforms for better accessibility. Not every family had access to a tablet, but almost every family involved in this thesis either had a mobile phone for their kid or a computer.

VIII. Conclusion

During this master thesis the concept Mænage School was created based upon theories about serious games, gamification, and game-based learning as well as the experiences and opinions of 17 pupils and 8 teachers. Some applications targeted towards Norwegian elementary school pupils were also investigated. The intent of this concept was to **explore if game design can boost pupils' motivation towards homework, and if such a concept can help the teacher adapt to each individual pupil's skill level more efficiently.** Three iterations of user testing resulted in two high-fidelity prototypes being made, one Unity application for the pupils' aspect, and one web application for the teachers'.

Research question 1 uncovers how Mænage School affects pupils' motivation towards homework. The research revealed that the concept could contribute to the pupils' motivation though the use of game design elements and provide deep and effortless involvement in the game. The game boosts motivation through awarding progress with a reward for the class, and thereby strengthening their sense of belonging to the class. The concept allowed teachers to use pupil-involving techniques such as flipped classroom and to use categorized feedback from the pupils to ensure challenges at appropriate levels. This in turn should provide the pupils with a sense of accomplishment and should make it intrinsically motivating for the pupil to further evolve their skills.

Research question 2 reveals how a digital tool like Mænage School can make it easier for the pupils to do homework. The discoveries were that digital tools could provide a handful of utilities for pupils when doing homework such as increased control and quality of life, by using interaction design techniques and managing cognitive load for clear goal progression. Finally, digital tools can allow for increased connectivity and availably for content by utilizing hyperlinks.

Research question 3 investigated how Mænage School can help teachers adapt homework to pupils of different skill levels in a school class efficiently. The testing revealed that letting the pupils provide feedback on their homework on key aspects like time spent and experienced difficulty, provided valuable feedback for the teacher to build upon quickly. The teacher could then create homework by splitting it into groups of different types, making them assignable to specific pupils, common to the whole class, or optional extra tasks, making homework highly modular. In addition, the teacher could add messages to the pupils and parents, and include links in the homework to Internet resources.

This thesis concludes that serious games can positively affect pupils' motivation towards homework. A digital concept such as Mænage School can provide a range of utilities compared to what the traditional homework sheet does. However, thorough research must be conducted on this challenging userbase when making such applications, since the technological and cognitive abilities of children differ greatly between school year two through seven. In addition, no teachers are alike and differ in technological skills and preferred teaching approaches.

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Appendix A

GameFlow

GameFlow Criteria for Player Enjoyment in Games (Sweetser & Wyeth, 2005).

Element	Criteria
Concentration Games should require concentration and the player should be able to concentrate on the game	- games should provide a lot of stimuli from different sources - games must provide stimuli that are worth attending to - games should quickly grab the players' attention and maintain their focus throughout the game - players shouldn't be burdened with tasks that don't feel important - games should have a high workload, while still being appropriate for the players' perceptual, cognitive, and memory limits - players should not be distracted from tasks that they want or need to concentrate on
Challenge Games should be sufficiently challenging and match the player's skill level	- challenges in games must match the players' skill levels - games should provide different levels of challenge for different players - the level of challenge should increase as the player progresses through the game and increases their skill level - games should provide new challenges at an appropriate pace
Player Skills Games must support player skill development and mastery	- players should be able to start playing the game without reading the manual - learning the game should not be boring, but be part of the fun - games should include online help so players don't need to exit the game - players should be taught to play the game through tutorials or initial levels that feel like playing the game - games should increase the players' skills at an appropriate pace as they progress through the game - players should be rewarded appropriately for their effort and skill development - game interfaces and mechanics should be easy to learn and use
Control Players should feel a sense of control over their actions in the game	- players should feel a sense of control over their characters or units and their movements and interactions in the game world - players should feel a sense of control over the game interface and input devices - players should feel a sense of control over the game shell (starting, stopping, saving, etc.) - players should not be able to make errors that are detrimental to the game and should be supported in recovering from errors - players should feel a sense of control and impact onto the game world (like their actions matter and they are shaping the game world) - players should feel a sense of control over the actions that they take and the strategies that they use and that they are free to play the game the way that they want (not simply discovering actions and strategies planned by the game developers)
Clear Goals Games should provide the player with clear goals at appropriate times	- overriding goals should be clear and presented early - intermediate goals should be clear and presented at appropriate times
Feedback Players must receive appropriate feedback at	- players should receive feedback on progress toward their goals - players should receive immediate feedback on their actions - players should always know their status or score

appropriate times	
Immersion Players should experience deep but effortless involvement in the game	- players should become less aware of their surroundings - players should become less self-aware and less worried about everyday life or self - players should experience an altered sense of time - players should feel emotionally involved in the game - players should feel viscerally involved in the game
Social Interaction Games should support and create opportunities for social interaction	- games should support competition and cooperation between players - games should support social interaction between players (chat, etc.) - games should support social communities inside and outside the game

Appendix B

System Usability Scale (SUS)

Noen spørsmål om systemet du har brukt.

Vennligst sett kryss i kun en rute pr. spørsmål.

	Sterkt uenig				Sterkt enig
1. Jeg kunne tenke meg å bruke dette systemet ofte.	1	2	3	4	5
2. Jeg synes systemet var unødvendig komplisert.	1	2	3	4	5
3. Jeg synes systemet var lett å bruke.	1	2	3	4	5
4. Jeg tror jeg vil måtte trenge hjelp fra en person med teknisk kunnskap for å kunne bruke dette systemet.	1	2	3	4	5
5. Jeg syntes at de forskjellige delene av systemet hang godt sammen.	1	2	3	4	5
6. Jeg syntes det var for mye inkonsistens i systemet. (Det virket "ulogisk")	1	2	3	4	5
7. Jeg vil anta at folk flest kan lære seg dette systemet veldig raskt.	1	2	3	4	5
8. Jeg synes systemet var veldig vanskelig å bruke	1	2	3	4	5
9. Jeg følte meg sikker da jeg brukte systemet.	1	2	3	4	5
10. Jeg trenger å lære meg mye før jeg kan komme i gang med å bruke dette systemet på egen hånd.	1	2	3	4	5

SUS
Norsk versjon ved Dag Svanæs
NTNU 2006

Scoring SUS

SUS yields a single number representing a composite measure of the overall usability of the system being studied. Note that scores for individual items are not meaningful on their own.

To calculate the SUS score, first sum the score contributions from each item. Each item's score contribution will range from 0 to 4. For items 1,3,5,7,and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Multiply the sum of the scores by 2.5 to obtain the overall value of SU.

SUS scores have a range of 0 to 100.

Appendix C

Possibilities and limitations of research methods (Oates, 2006, pp. 48-50)

Table 4.1 Research strategies and the Internet

Research strategy	Possibilities	Limitations
Survey (Chapter 7)	Obtain data from many people across the world, cheaply and quickly. Could email a list of questions to people and ask them to answer them and return their responses by email. Visitors to a website could be asked to complete an online questionnaire.	People might view your emailed questionnaire as spam. Not everyone has Internet or web access, so your respondents may not be typical of the whole target population.
Design and creation (Chapter 8)	Led to the development of the Internet and the web in the first place. Still many opportunities to design and create new ways of using Internet technology, for example: • mobile computing; • tools for distance learners; • methods for developing web-based systems; • new user interfaces; • new search tools; • new forms of digital art.	Your university's security mechanisms for protecting its networks from intruders and viruses may make it difficult for you to develop a working version of a system. You will not be allowed to do anything that breaches the system's firewall. You might have to develop your Internet application on a home PC or on your supervisor's PC system if it is isolated from the university's network.
Experiment (Chapter 9)	Could design experiments to test for such things as: • the effectiveness of a web-based user interface, • the results from using a particular Internet-based program, • the effect of intervening in an online community.	Most of the Internet is beyond the control of the researcher, so it is difficult to design an experiment that controls for everything that might bias the results, and that can be repeated to see if the same results occur again. People have an offline existence that can influence their online actions and that cannot be monitored or controlled by the researcher.

(Continued)

Table 4.1 *(Continued)*

Research strategy	Possibilities	Limitations
Case study (Chapter 10)	Study in depth a single instance of some aspect of the Internet e.g.: • an online community, • the use of the web by a particular company, • the evolution of a website over time.	Members of an online community also have an offline existence, and a company website is subject to decisions, culture and office politics that occur in the offline world. If you study only the online aspects of your chosen case, your analysis may be incomplete.
Action research (Chapter 11)	Develop and refine the methods people use for developing web- or Internet-based systems. Explore new ways of using Internet technology.	People you work with online have an offline existence too, which might influence their online practices. If you study only the online aspects of your action research, your analysis may be incomplete.
Ethnography (Chapter 12)	Examine what people do in cyberspace. By participating in an online group, you could study the group's culture – the interactions, how some people acquire more authority or power in the group than others, the conventions and norms that develop.	People you interact with online have an offline existence too, which might influence their online behaviour. If you study only the online aspects of your chosen social group, your analysis may be incomplete.

Table 4.2 Data generation methods and the Internet

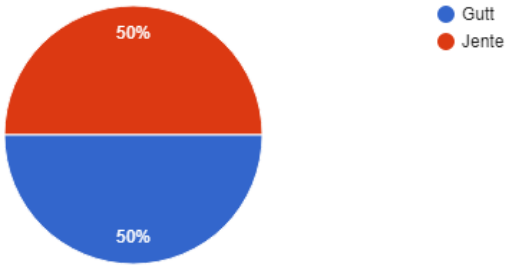
Data generation method	Possibilities	Limitations
Interviews (Chapter 13)	Can question people wherever they are in the world without the expense and time of travelling to meet them. 'Interview' is not spoken, but a set of written questions and answers bounced back and forth between you and the interviewee.	Because written rather than spoken, answers tend to be less detailed. No social cues such as facial expression and body language, so uncertainties and misunderstandings can arise.
Observations (Chapter 14)	Observe what occurs online, e.g. the contributions people make to an online discussion. Can participate as a member of an online group, or just lurk, i.e. watch without people knowing.	Often not ethically acceptable to observe others without them knowing. Online group likely to be angry if they discover you have infiltrated the group.
Questionniare (Chapter 15)	Can be placed within an email message, as an email attachment, or as a web form. Much cheaper form of distribution than postal questionnaires.	Cannot just replicate a paper-based questionnaire in an electronic format. Need to focus on the needs of respondents who are typing or mouse-clicking their answers.
Documents (Chapter 16)	Essential part of Internet-based research since much of what we can know about the Internet is only discoverable by studying (electronic) documents: websites, emails, discussion list archives, bulletin boards, online auctions, cookies, web server logs, etc.	Transitory nature of many Internet-based documents: webpages change, archives go offline, websites disappear. Need to keep copies of all online documents, and monitor whether they change over time.

Appendix D

Pupils' High-fidelity Form

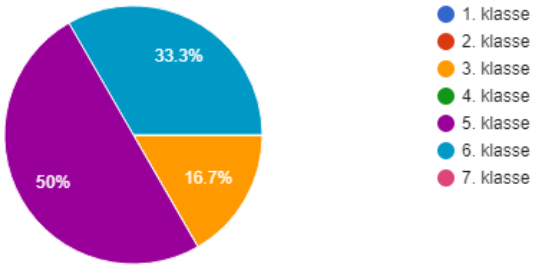
Kjønn

6 responses



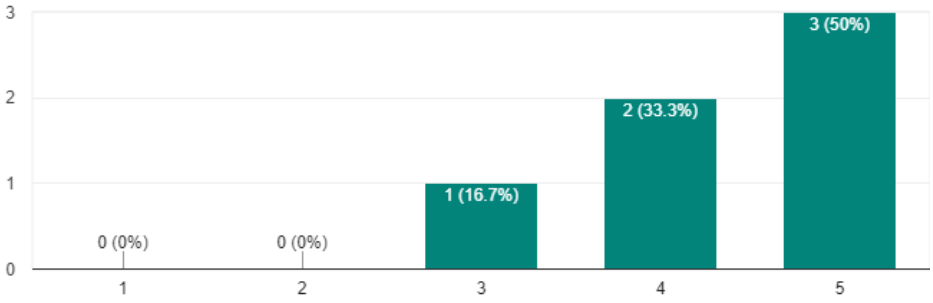
Klassetrinn

6 responses



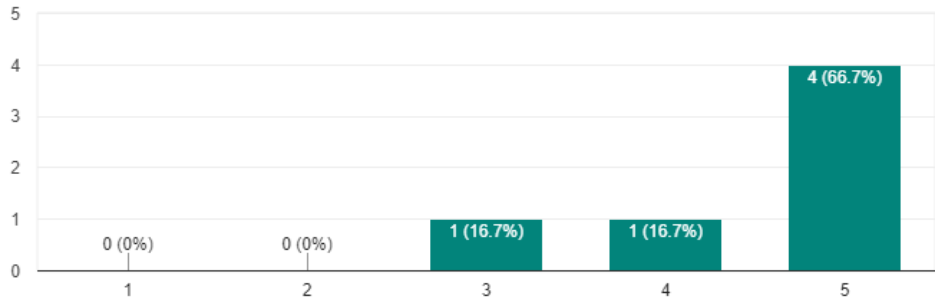
Det var gøy å gjøre lekser i appen.

6 responses



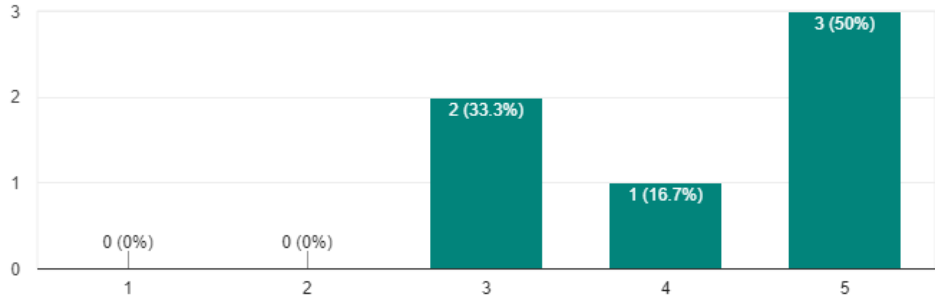
Jeg følte meg som en viktig del av klassen min når jeg skaffet oss flere poeng.

6 responses



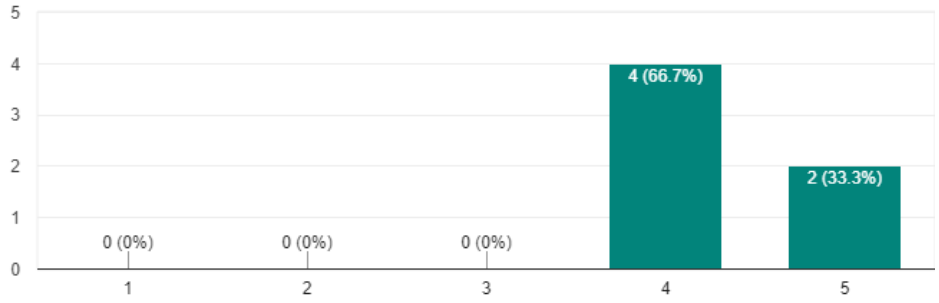
Jeg syns det var gøy at jeg hadde samlet flest poeng i klassen.

6 responses



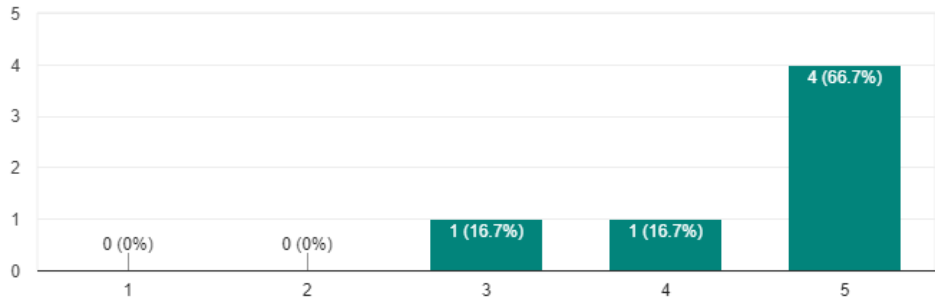
Det var lettere å få sagt hva jeg mente om leksene.

6 responses



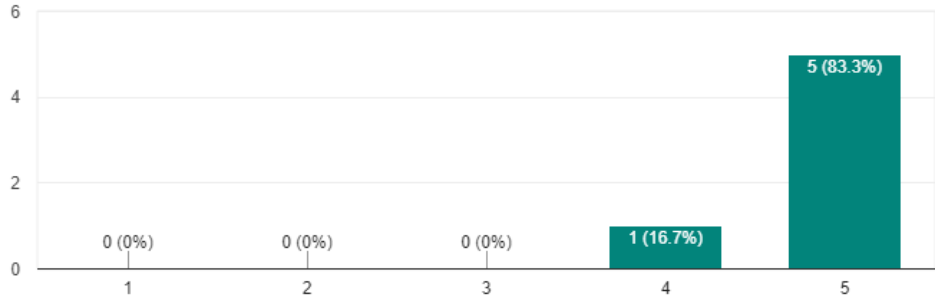
Jeg likte hvor lett det var å få si min mening om leksene til læreren uten å måtte si det høyt i klassen.

6 responses



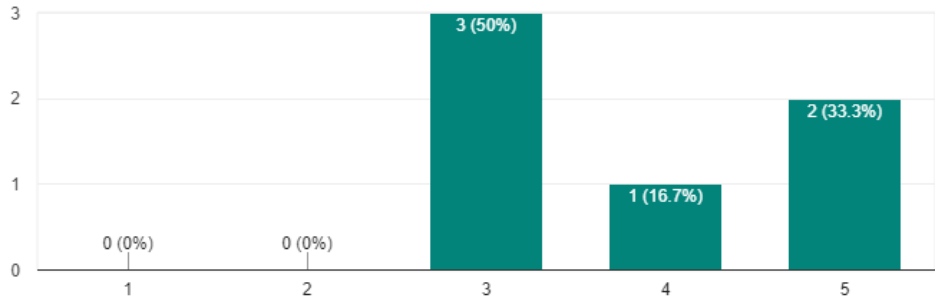
Jeg syns det var gøy å få poeng for å gjøre lekser.

6 responses



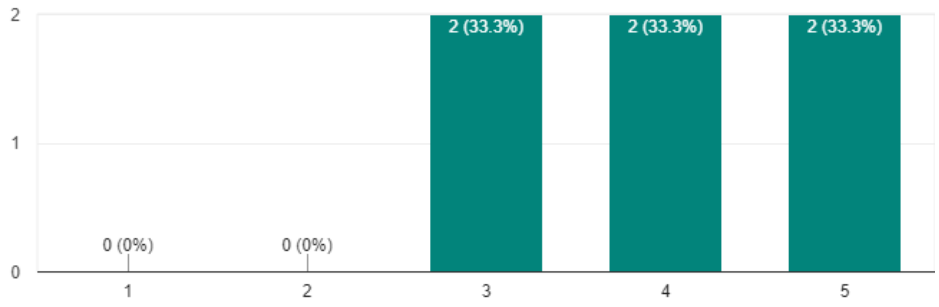
Jeg syns det var så gøy å få poeng for leksene mine at jeg ville gjøre flere oppgaver.

6 responses



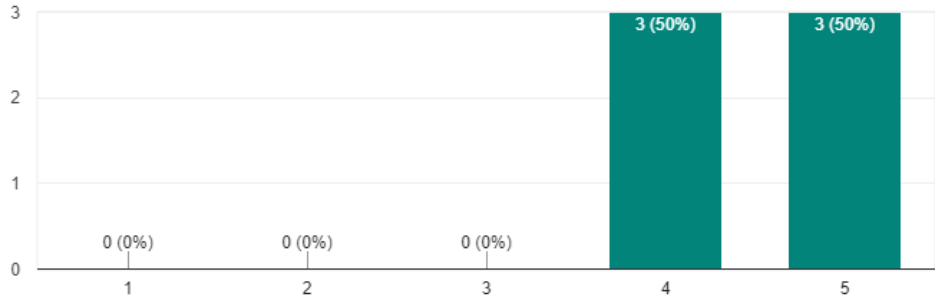
Jeg tenkte mindre over tid og sted da jeg brukte appen.

6 responses



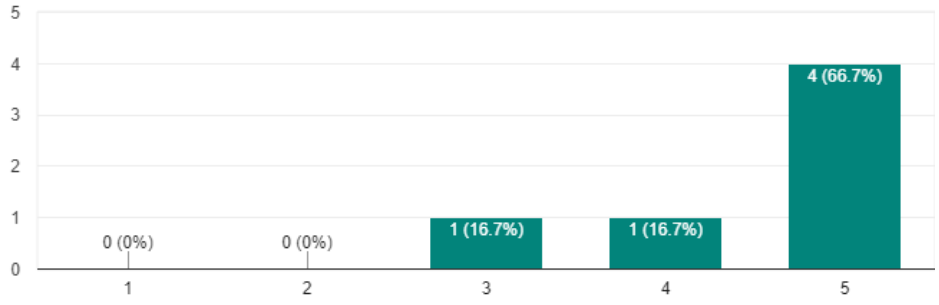
Ved å se på appen skjønte jeg at jeg hadde utført en handling.

6 responses



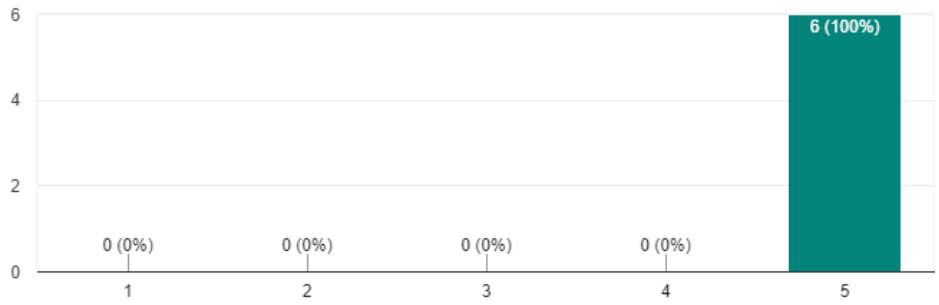
Det var lett å skjønne hva målet jeg jobbet mot var til en hver tid.

6 responses



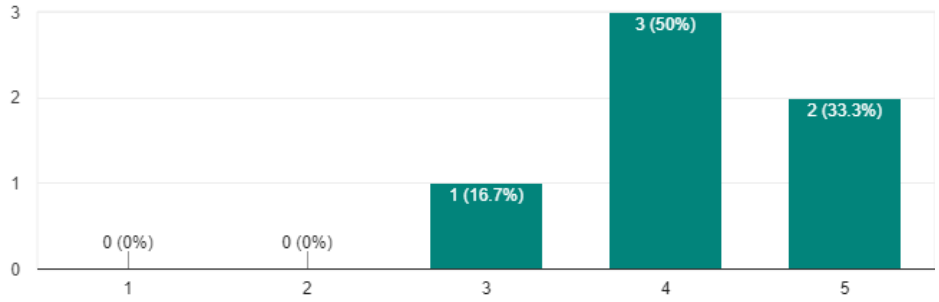
Det var lett å se hva jeg hadde i hjemmelekse.

6 responses



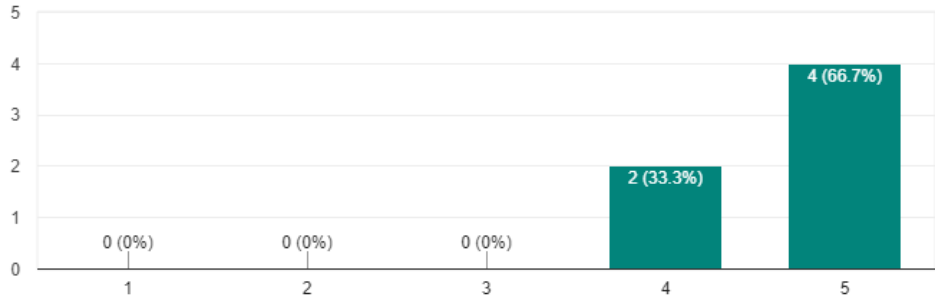
Det var lett å se at klassen min fikk flere poeng når jeg gjorde lekser.

6 responses



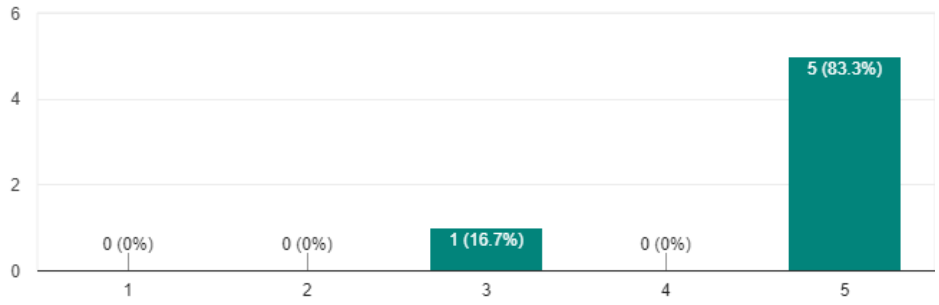
Det var lettere å se leksene i appen enn i den vanlige ukeplanen min.

6 responses



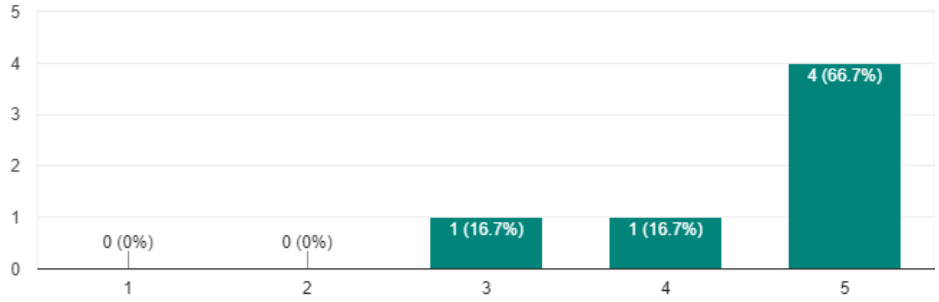
Det var lettere å bruke nettsider i appen enn å skrive inn lenker til nettsider selv.

6 responses



Det var lett å se meldinger fra læreren min.

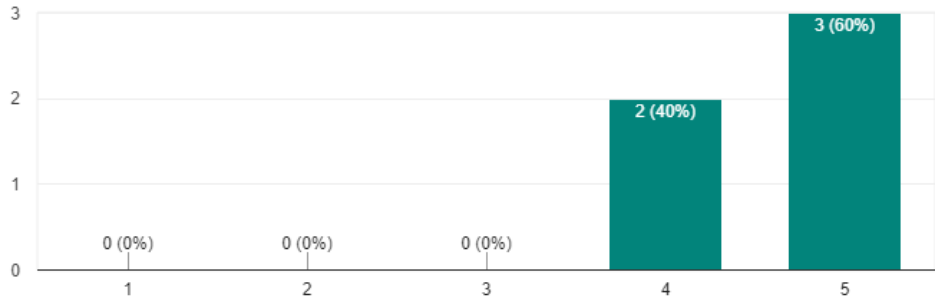
6 responses



Teachers' High-fidelity Form

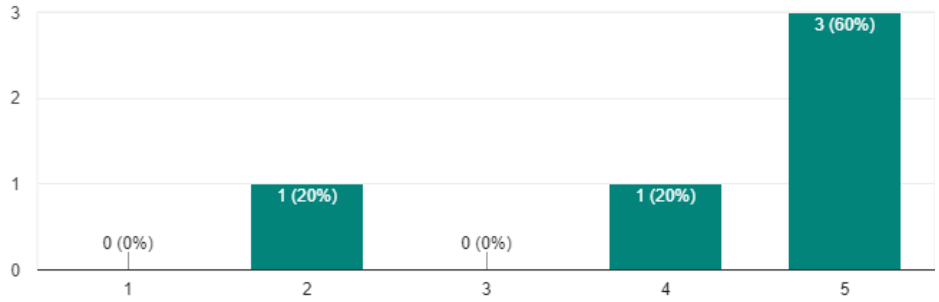
Mænage School gjorde det lettere å tilpasse læring til elever på forskjellige nivå enn på en tradisjonell ukeplan.

5 responses



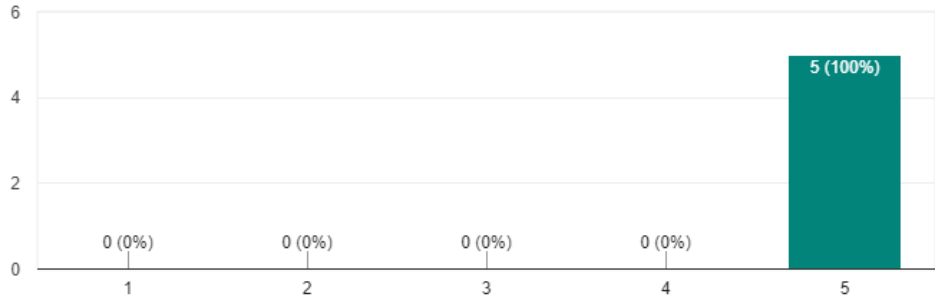
Det var lett å bruke leksegruppe-verktøyet.

5 responses



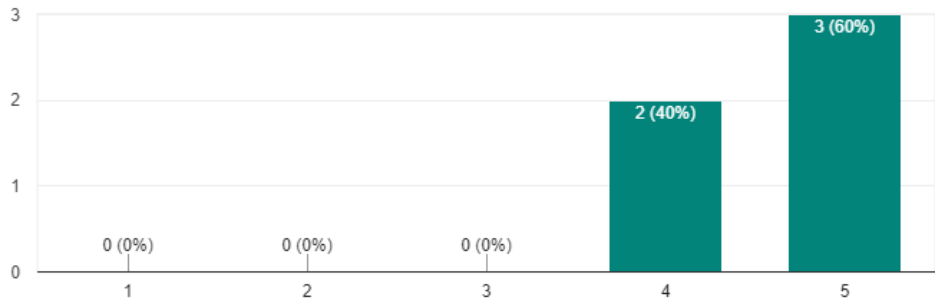
Ved hjelp av gruppering av lekseoppgaver kan jeg tilpasse lekser til elever med ulike ferdighetsnivå.

5 responses



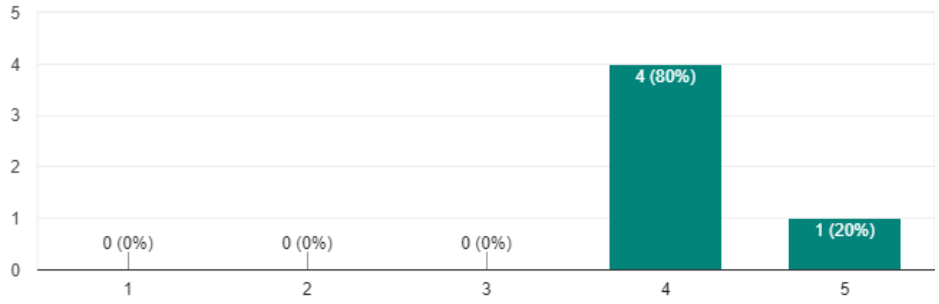
Det var lett å se hvilken oppgavegruppe en elev hadde fått tildelt.

5 responses



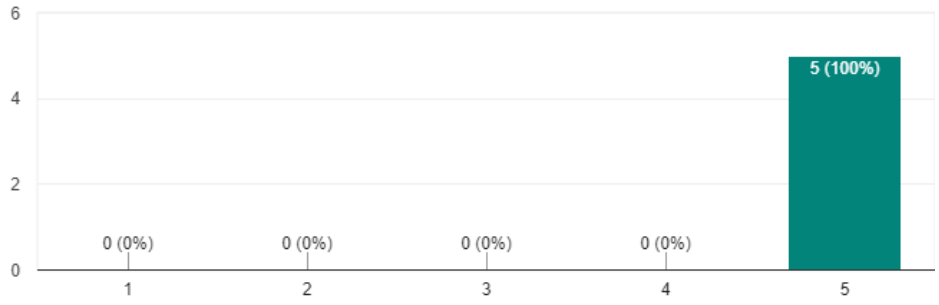
Historikken over leksegrupper gjorde det lettere å tildele ny lekse til elever.

5 responses



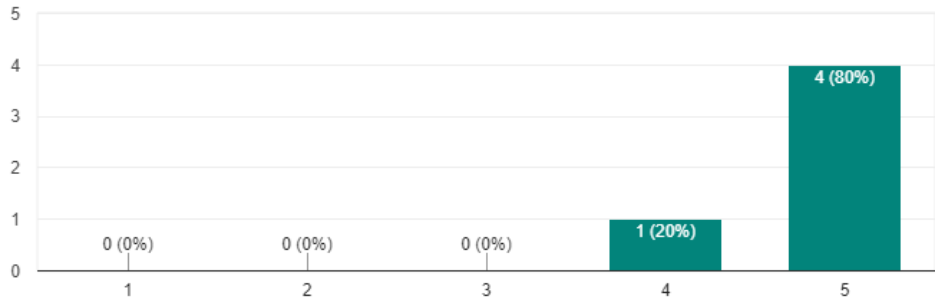
Jeg tror det blir lettere for elever å ta i bruk nettressurser ved hjelp av Mænage School.

5 responses



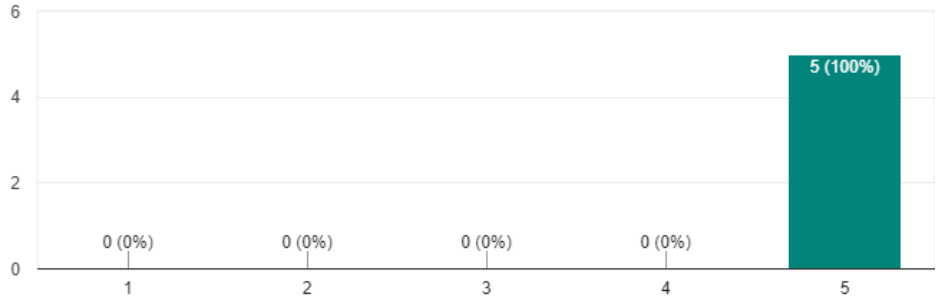
Mænage School gjorde det lettere å gi beskjeder til klassen(e) mine enn på en tradisjonell ukeplan.

5 responses



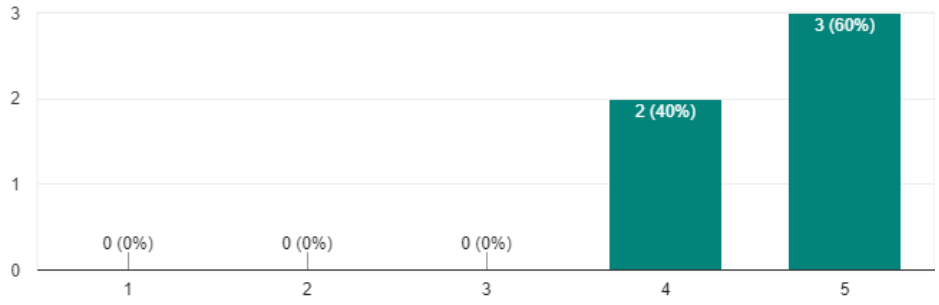
Det var lett å bruke beskjeder-verktøyet.

5 responses



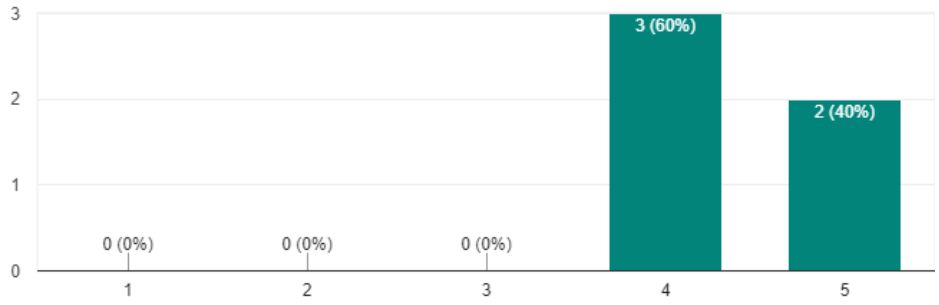
Tilbakemeldingene fra elevene gjorde det lettere for meg å vite på hva som må fokuseres på videre.

5 responses



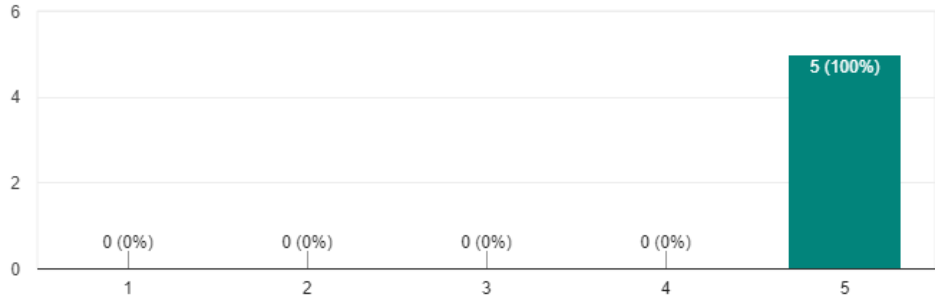
Det gav økt nytteverdi å ha et gjennomsnitt av tilbakemeldingene for hver leksegruppe.

5 responses



Det var nyttig å vite hvor lang tid de brukte på leksen.

5 responses



Jeg tror det er lettere for elevene å kunne gi tilbakemeldinger gjennom appen enn fysisk til lærer.

5 responses