

Alias

*Designing an application for creating personalised
comics aimed for the Children and Youth Clinic at
Haukeland University Hospital*

Idar Antonsen Syslak

Master's thesis in Software Engineering at

Department of Computing, Mathematics and Physics,
Western Norway University of Applied Sciences

Department of Informatics,
University of Bergen

December 2019



**Western Norway
University of
Applied Sciences**



Abstract

Children and youth (...)

This project explores different (...)

Acknowledgements

I would like to...

Contents

1	Introduction	6
1.1	About the thesis	6
1.2	Motivation	6
1.3	Research question and expected results	7
1.4	Thesis outline	7
2	Background	8
2.1	Guideline pathways	8
2.2	Problem areas	9
2.3	Preceding projects	9
2.3.1	Pictogram-me	9
2.3.2	PictogramApp	9
2.4	Related work	10
3	Methodology	13
3.1	Design process	13
3.2	Interaction design	13
3.3	Prototyping	14
3.3.1	Prototyping tools	15
3.4	Evaluation	15
4	Planning the design	16
4.1	Inspiration	16
4.2	Target groups	16
4.3	Domain	17
4.4	Requirements	18
4.4.1	Functional requirements	18
4.4.2	Non-functional requirements	18
5	Iterating the design	20
5.1	Iteration 1: Paper sketches	20
5.1.1	Considerations	20
5.1.2	Analysis	23
5.2	Iteration 2: Form study prototype	23
5.2.1	Analysis	26
5.2.2	Considerations	26
5.3	Iteration 3: Small extension	26
5.3.1	Analysis	27
5.4	Iteration 4: Interactive prototype	27
5.4.1	Analysis	31
5.4.2	Considerations	31

5.5	Iteration 5: Further UI experiments	34
5.5.1	Analysis	36
5.6	Iteration 6: Redesign	36
5.6.1	Analysis	41
5.7	Iteration 7: Final prototype	46
5.7.1	Analysis	46
6	Evaluation	51
6.1	The test group	51
6.2	Performing the evaluation	51
6.3	Results	52
7	Application outline	54
7.1	Implementation details	54
7.2	Architecture	54
7.2.1	Backend	54
7.2.2	Frontend	54
7.3	Integration with existing systems	54
7.4	Anticipated challenges and feasibility	57
7.4.1	Personalised avatars	57
7.4.2	Realistic avatar projections	57
7.4.3	Visual art and template designs	58
7.4.4	Connections between client and administrator applications	58
7.4.5	Integrations towards current healthcare systems	58
7.4.6	Security concerns	58
7.4.7	Service workers and offline content	58
7.4.8	Scaling	58
7.4.9	Costs	58
7.5	Handoff	58
8	Tools and technology	60
8.1	Choice of application setup	60
8.2	Frameworks	61
8.3	Database system	61
8.4	Storage	63
9	Conclusion	64
9.1	Discussion	64
9.2	Reflections	65
9.3	Further work	65

List of Figures

2.1	Guideline pathway for mental health and intoxication	8
2.2	PictoTheatre, shown at the 2016 RØST conference in Bergen	10
2.3	Screenshots from PictogramApp	11
2.4	Snapshot of the instruction video ‘Safety onboard’	12
3.1	The ‘double diamond’ design process model	14
3.2	An interaction design life cycle model	14
4.1	Domain model showing core concepts	17
4.2	Use case diagram depicting use cases for a patient and a member of the staff	19
5.1	Sketches of the first design: viewing a procedure	21
5.2	Sketches of the first design: editing a procedure	22
5.3	The home page	24
5.4	A single frame of a procedure	24
5.5	Two ways to view a video	25
5.6	An emoji grid used in the prototype	26
5.7	The home page with bigger elements	28
5.8	Five feelings with bars	28
5.9	The application before accessing sensitive data	29
5.10	The timeline page	30
5.11	The procedures page (previous home page)	30
5.12	The feelings page	32
5.13	Interactive procedure page	32
5.14	The new rating overlay	33
5.15	Profile sidebar	33
5.16	Timeline with two alternatives for showing rating history	35
5.17	Dropdown element	36
5.18	Procedures page with new layout	37
5.19	Updated feelings page	37
5.20	Summary page showing an overview of the last week	38
5.21	Snapshot of popup element when tapping on the avatar icon	38
5.22	Procedure page with thumbnails	39
5.23	Ratings with coloured sliders	39
5.24	Flowchart of the application as of iteration 5	40
5.25	Redesigned timeline	42
5.26	Redesigned feelings page	43
5.27	Profile page showing the user’s avatar	43
5.28	Redesigned procedure page	44
5.29	Redesigned home page	44
5.30	Administrator application	45

5.31 Onboarding sequence	47
5.32 Updated rating overlay	48
5.33 A group containing several procedures that can be rearranged	49
5.34 The new dropdown element	49
7.1 Extended use case diagram	55
7.2 Extended domain model	56
7.3 Application model as illustrated through a guideline pathway	57

List of Tables

7.1	Different ways to project an avatar on a screen	58
8.1	List of web developer friendly frameworks for mobile and web application development	62

Chapter 1

Introduction

1.1 About the thesis

This thesis describes an application development project that was held from August 2018 to December 2019. The project supervisor, Carsten Helgesen, proposed the project as a continuation of a bachelor project from the spring of 2018. Both projects seek to improve communication and engagement by facilitating non-verbal communication and to visualise information and emotions.

Around middle of 2018, the project gained interest at the Children and Youth Clinic at Haukeland University Hospital. Ideas for the project have been discussed since then with senior consultant psychiatrist Paul Joachim Bloch Thorsen.

1.2 Motivation

Communication between patients and medical staff is crucial in healthcare. It is important for the ones who get treated to know what they get treated for why the treatment is as such. In addition, the ones who give the treatment can benefit from knowing what the patients feel about the treatments. However, this flow of communication is not always facilitated.

Hospitals carry a lot of information about various treatments and procedures, and often does a nice job putting this information out to patients. The problem, though, is that this information is often not personalized and motivation from patients is often lacking. The amount of information can sometimes also be overwhelming, putting the patients at risk of overlooking important details. This again may lead to missed appointments, unnecessarily long hospital stays and increased costs for hospitals.

For younger patients, these issues become even greater. Although national guideline pathways (see section 2.1) aim to make the treatments more efficient for everyone, the information about them is still mostly text-based and not properly adapted to this age group, contributing to the fact that children are rarely involved in decision-making (Coyne, 2008). Though, technology that can be tailored towards children and youth may be beneficial:

Age-appropriate interactive technology can be used to promote young children's understanding and to facilitate their situated participation in healthcare situations.

— Stålberg et al. (2018)

There is also room for improvement in patient-to-healthcare communication. It is important for patients to give feedback about one's treatment, but this is not always easy. The feedback is often restricted to paper sheets and verbal communication which can result in loss of data and extra work for the medical staff.

1.3 Research question and expected results

When forming the research question, the idea is to see how these problems can be approached. Many of them are a consequence of poor communication from hospital to patients and vice versa. Personalizing the information given from hospitals is one way to improve the communication that can result in several positive benefits; increased motivation, increased quality of life and increased participation in decision-making being a few of them. By focusing on personalization of national guideline pathways, the project may contribute towards several of these problems while working with a local, less extensive domain area.

Therefore, the research question to be asked is:

How can national guideline pathways be made more personalised for children and youth?

Following the research question, two aims are set up for this project to achieve. These should contribute to make the solution beneficial for younger patients:

- The first aim is to look at how the information from hospitals may be formed and the way it is given, and adjust this information flow such that it is more engaging and understandable for children and youth.
- The second aim is to facilitate how children and youth may participate in decision-making and give feedback about their treatment as a step in personalizing the treatment itself.

At project completion, the desired result is a functional prototype (see section 3.3). This prototype should be extensive and functional enough to be developed further on by a healthcare-centralized software development company, or possibly by students as part of another thesis. Given the positive outcome of E-LAN (see section 2.4), it is a possibility that the application may be used among children at the clinic sometime in the future.

As the Children and Youth Clinic has planned a bigger project involving the use of avatars and comics, the outcome of this project will become an indication of whether it is valuable to invest in it. This project will also provide useful knowledge that may come in handy for an eventual succeeding project.

1.4 Thesis outline

The thesis is structured as follows: Chapter 2 lists relevant topics of interest and problem areas while giving an insight into preceding projects. In chapter 3, the project's methodology and approach to the problem is described. Following that, the design process is planned in chapter 4 and then detailed out as it is performed in chapter 5. The result of this design process is then evaluated in chapter 6. Chapter 7 outlines the thought application and its challenges while chapter 8 discusses the setup, architecture and tools needed to make said application. Finally, chapter 9 concludes the project and discusses further work.

Chapter 2

Background

2.1 Guideline pathways

National guideline pathways, in Norwegian *pakkeforløp*, are a relatively new thing in the Norwegian health sector. These are standardized ways of treatment and are politically initiated to ensure increased predictability, safety and participation for patients (Helsedirektoratet, 2019). They may be for a specific diagnosis and for general use depending on the circumstances. The guideline pathway for mental health and intoxication was introduced in 12th September 2018 at Nasjonal lanseringskonferanse (Haugland and Landsholt, 2018) and new patients would be eligible for treatment from 1st January 2019 onwards. This pathway is then specialized towards adults, children and intoxication respectively.

Guideline pathways are centered around the period of hospitalization, that is, from consultation to discharge. Each pathway consists of a set of phases in a given order. For the guideline pathway for mental health and intoxication, the first couple of phases involves clarifying the needs and goals for the treatment. Then, an inquiry will result in an assessment determining what kind of treatment is the most suitable. This is done in cooperation with the patient. Then follows the treatment which is constantly evaluated to ensure the treatment is working. Lastly, considerations about what needs to be done after the inpatient treatment are made. Some phases have deadlines associated with them, meaning that said phase may not take longer than a certain time to ensure the treatment is done in a timely manner.

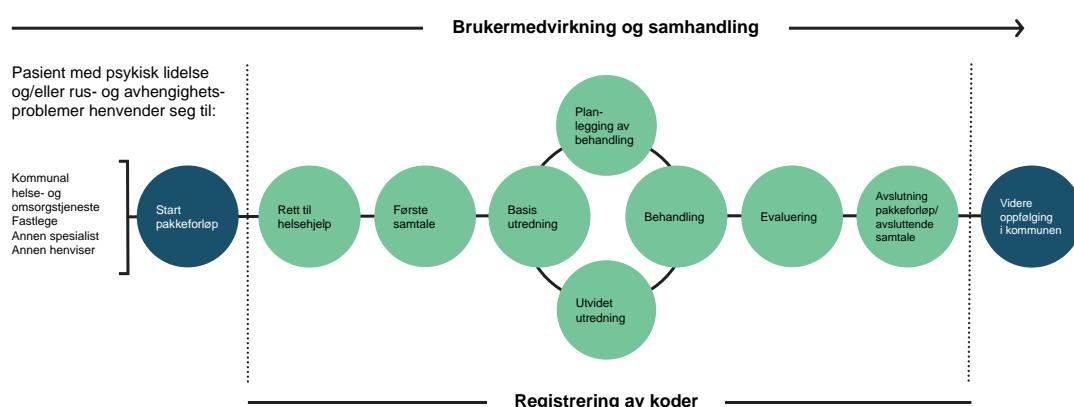


Figure 2.1: Guideline pathway for mental health and intoxication
Image from Haugland and Landsholt (2018)

2.2 Problem areas

The Children and Youth Clinic stated that they want to improve the ways of which children are informed about upcoming procedures. One of the areas to improve upon is the communication between children and health care services together with its staff. Patients and their relatives have a need for practical information about their treatment while health care services have a need for knowledge about the patient's wishes and feedback. If this communication is problematic, or there is a lack thereof, patients may start to miss out on information and feel excluded from the decision-making. Use of medical terminology without explanation can contribute to this exclusion (Coyne, 2006).

Another related issue is that the information that is handed out at hospitals is often not personalized. This includes paper documents, brochures, web pages, internal systems among others. Currently, the information that is given here is primarily textual and of varying interest for younger patients. When this information lacks personalization, there is an increased chance that patients—especially younger ones—will miss out on details, not be motivated and not engage in their treatment.

Comics and cartoon drawings may work as a measure against both problem areas. It is shown that cartoon illustrations help to make instructions easier to grasp and make sense of (Delp and Jones, 1996). This may be combined with personalization as seen in *E-LAN* (see section 2.4) – where the comic character is replaced with a patient's respective avatar. Doing this, the anticipation is that patients may find themselves in the situation, rather than seeing someone they don't associate with.

2.3 Preceding projects

This project builds upon experience from a bachelor thesis named *PictogramApp*, which was based on another project named *Pictogram-me*.

2.3.1 Pictogram-me

Since 2011, associate professor in graphic design Linda Lien and professor in visual communication Ashley Booth have researched on creative usage of pictograms. A pictogram, also called a pictograph, is a simplified figure that resembles and represents a physical object. They vary in shapes and sizes, but they are ultimately designed in a way that make them easy to interpret and understand their symbolic meaning.

Lien's and Booth's artistic research project, named *Pictogram-me*, experiments how pictograms can be used to express complex social messages (Lien and Booth, 2018). The aim is to illustrate challenging situations that people who have a difficult life may endure. Despite pictograms being flat and simplified, Lien and Booth wanted to show how pictograms also can visualise difficult topics and promote empathy.

Pictogram-me presents a new set of pictograms that are designed for the purpose of the project. In addition, the project has resulted in various concepts including

- *PictoBooth*, a photo booth that translates the body and gestures into real life pictograms,
- *PictoFont*, a symbol typeface consisting of various pictograms, and
- *PictoTheatre*, a small-scale theatre where pictograms can be arranged on a scene. A tablet can be placed behind the scene and function as a background as illustrated in Figure 2.2.

2.3.2 PictogramApp

In 2017, the Western Norway University of Applied Sciences issued a bachelor project in collaboration with Linda and Booth, with the purpose of creating a smartphone application. The application, which



Figure 2.2: PictoTheatre, shown at the 2016 RØST conference in Bergen
Photograph by Lien and Booth (2018)

was later named *PictogramApp*, was meant to be a digital version of PictoTheatre where pictograms can be arranged on the screen and form visual messages in a mobile manner (Fure et al., 2017). The application allows users to place pictograms in context in order to create their own stories. Two screenshots from this app are shown in Figure 2.3. PictogramApp was targeted towards the Church City Mission, a voluntary organisation which offers help and services for people living near the street. A beta version of the application was released in June 2017.

2.4 Related work

Haukeland University Hospital has prior to this project experimented with different ways to engage younger patients. One initiative was a lan party event named *E-LAN* held in October 2018 (Helse Bergen, 2018). The purpose of this event was to connect gaming towards a healthy lifestyle and to let children and youth find a sense of achievement in new areas. As a part of this initiative, an avatar generation system was created by Helse Vest IKT that lets users create personal avatars which represent themselves. These would be printed onto physical name tags of which children and youth could attach on their clothings and carry with them. The avatars did not necessarily reflect their visual appearance, though they could be immediately recognized by their respective owner.

In order to discover related work and gain further insight in the problem area, a set of queries were performed on academic literature search engines. Each query contained a set of the following keywords:

- Hospital
- Patient
- Pediatric
- Children
- Information
- Informativ
- Interaktiv
- Understanding
- Comprehension
- Engage
- Cartoon
- Comics
- Illustrations
- Personalised

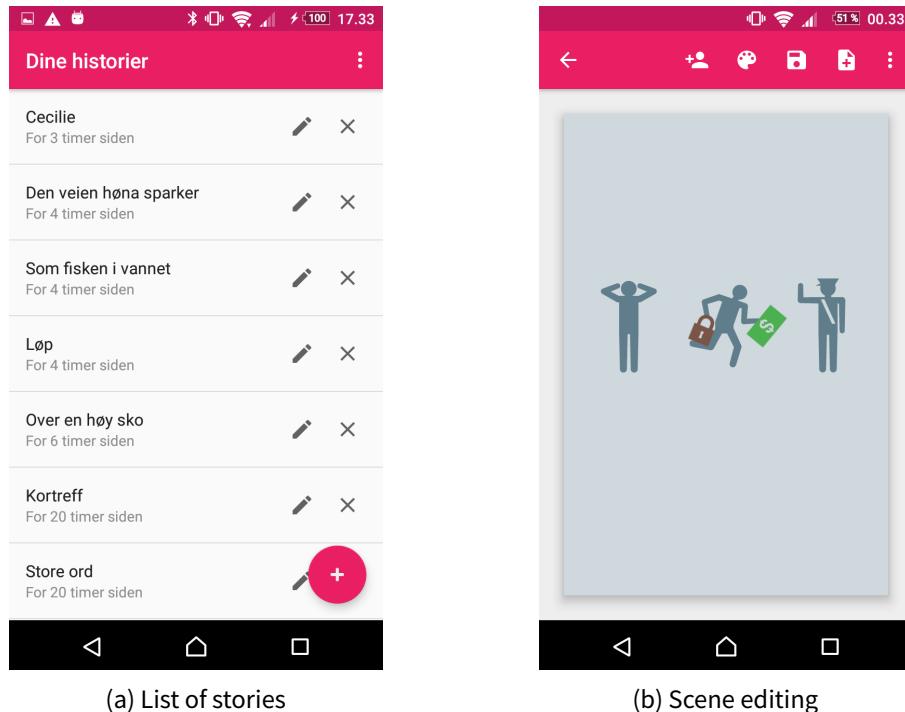


Figure 2.3: Screenshots from PictogramApp

Several applications and prototypes have been made that aim to provide information about and illustrate a child's hospital stay. A notable example is *IACTA*, short for *Inter-Active Communication Tool for Activities*. This application was co-designed together with children (Stålberg et al., 2016) and then analysed as children used the application (Stålberg et al., 2018). Another example is an inpatient portal application named *MyChart Bedside*, developed by Epic Systems Corporation for tablet devices. The application shows a calendar, a list of diagnoses to be treated, a list of medications and lab results. The portal was shown to be well received by children's parents (Kelly et al., 2017). A third example is by Maher et al. (2016), a tool visualizing a roadmap interface on a tablet device. The roadmap is a metaphor of the hospital stay, consisting of several phases that make up the hospitalization period.

Literature about communication with hospitalized children is growing. The topic of consultation with children and their participation in decision-making has been investigated in Coyne (2006), Coyne (2008) and Coyne and Gallagher (2011). Throughout consultations, a literature review and interviews respectively, the findings indicate a lack of participation and engagement for the children. These papers have a unified experience that children's views are rarely taken into consideration, often neglected in favour of communication with the parents instead. Sometimes this is what the child wants, as Lambert et al. (2011) says that health professionals identified children as either passive bystanders or active participants. This has a direct consequence of the child's participation in communication.

Medical procedures may be looked upon as step-by-step instructions that should be replicated. Public instructions are plentiful, but for brevity, an example to consider is one used by Norwegian Airline Systems on their aeroplanes. Instead of paying attention to the cabin crew who demonstrates the use of safety gadgets and emergency procedures, an animated video (Norwegian Air Shuttle, 2012) is shown for the passengers. This animation depicts a child and their parent as they go through each procedure. Not only does this provide visual information that the cabin crew cannot show on their own; children and parents may identify themselves as the characters in the video, attracting further attention.

Another step in increased personalization is the use of personal avatars, where a user may create a character that represents themselves. Herein lies several examples as well, the most popular one



Figure 2.4: Snapshot of the instruction video 'Safety onboard'
Video produced by Skyline IFE

being Bitmoji. Bitmoji is an integrated app in the popular social media platform Snapchat that features personalized cartoon avatars for their users. It is a spin-off of Bitstrips.com, a web application that was more focused on comic strips designed for educational use.

Chapter 3

Methodology

The approach that this project will undertake is a mixture of a iterative design and prototyping process, which is then evaluated to seek the answer of the given research question.

3.1 Design process

The design process will focus on iterating over designs and prototypes in a user-centered manner. By conducting an iterative design process, the design will be improved upon repetitively – starting from low-fidelity sketches and ending at high-fidelity prototypes.

Using this method, stakeholders and potential users will be able to try out the design throughout various phases of its development. This user testing may consist of focus groups and uncontrolled experiments, and the gained experience can be applied in the next development stage. In this case, the testing will be restricted to an internal group at first, involving other users once the project hits its evaluation stage.

In addition, heuristics are used to analyse elements that are not thoroughly investigated during the design process. Heuristic evaluation is about evaluating a user interface based on a set of heuristics, that is, usability principles or simply rules of thumb. Some examples include ‘error prevention’ and ‘recognition rather than recall’ (Nielsen, 1994). Such evaluation can be performed by a single person, as long as said person follows a predefined set of heuristics.

This process may function as a initial part of the application development. Ideas are sought for and discovered, then shaped into designs that form a basis for a software development phase. Looking into the ‘double diamond’ design process model (Design Council, 2007), this can be viewed as the first two stages shaping the first diamond. This model is built on the idea of going from a generic problem statement to defining specific problems and then creating specific solutions for said problems, diverging and converging the area of focus during the process.

3.2 Interaction design

The idea of iterating a design while putting the user in the front seat is also key in interaction design. As the name suggests, this method is about emphasizing and facilitating interaction between humans and computers. Close monitoring by user testing is important to see if interactions with an application succeed. Preece et al. (2015) developed a life cycle model for interaction design that can illustrate the iterative process used in this project. The model, which is shown in Figure 3.2, consists of four phases:

Establishing requirements is centered around getting to know who the users are and their needs. This knowledge is then used to form the product’s requirements.

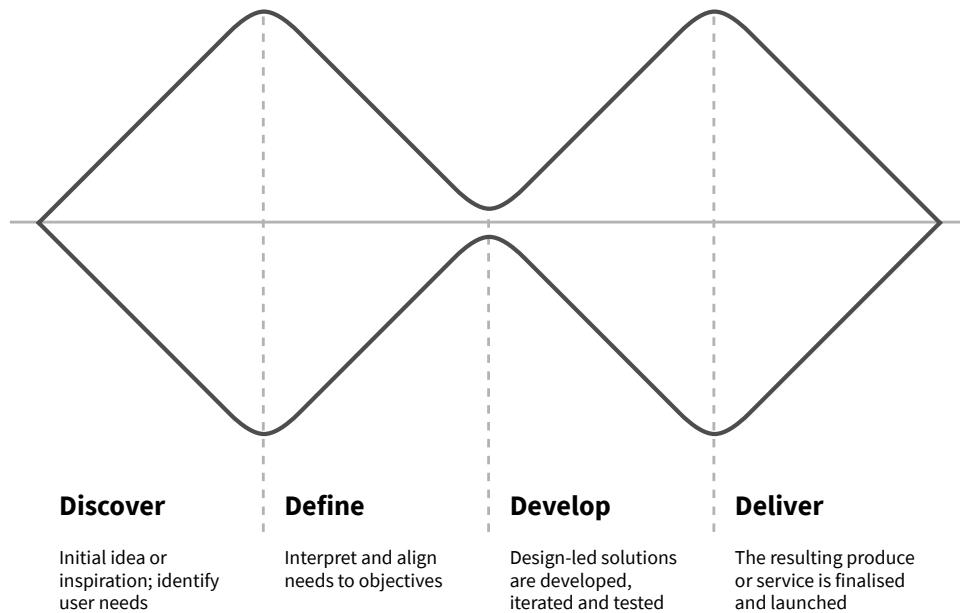


Figure 3.1: The ‘double diamond’ design process model

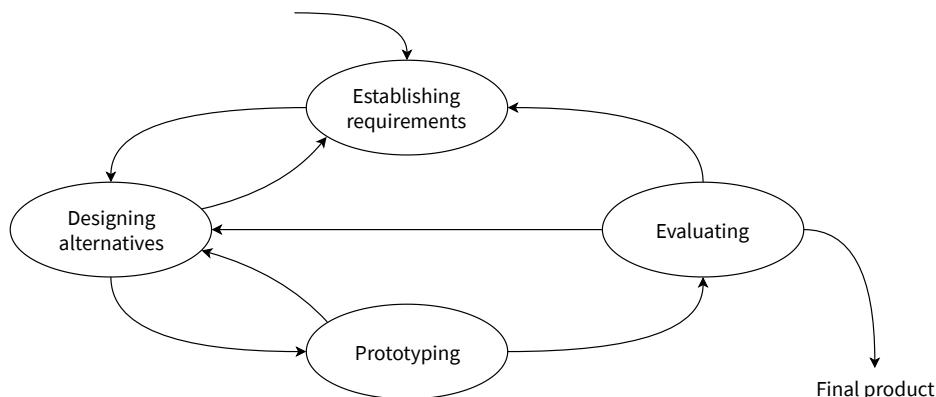


Figure 3.2: An interaction design life cycle model

Designing alternatives is where different approaches to the problem are explored. These approaches are made to meet the aforementioned requirements.

Prototyping is the process of turning the design into something that is interactive. Being interactive does not necessarily mean that the prototype is a piece of software – see section 3.3.

Evaluating is then performed, leading to an assessment of whether the design is usable and meets the user’s needs.

3.3 Prototyping

A prototype in this sense is an early version of the product or the application. It does not mean that the prototype needs to be interactive, although a prototype certainly may be. During an iterative design process, each iteration leads to a new and improved prototype that may be tested. Basic prototypes with plain visuals are called *low fidelity* while more polished prototypes that resemble a final application more closely are *high fidelity*. Following are a few types of prototypes mentioned in this document:

Form study prototype is a prototype with more focus on geometry and less focus on colours and detail. Prototypes are normally considered low-fidelity at this stage.

Functional prototype has an emphasis on the functional aspects of the application, but also the visual appearance of it. Such prototypes should be close to indistinguishable from a final product, although it may be made in a different shape or form.

Interactive prototype means that the prototype may be interacted with through use of equipment (keyboard, mouse *et cetera*), tactile movements (touch, gestures *et cetera*) or by other means. The interaction should help the user accomplish their goals of using the application.

3.3.1 Prototyping tools

Prototypes may be made with a wide selection of tools. The most basic ones may be created by simply using pen and paper. This may be sufficient to create something interactive, using several sheets of paper to change the prototype's appearance.

Dedicated prototyping software come in handy for more high-fidelity prototypes. Most prototyping applications are based on a set of screens with hotspots linking them together. A hotspot defines an area to click or tap on, leading the user to the desired screen – optionally coupled with an animation. Little to no code is involved in making such prototypes.

Creating prototypes with the intended software and architecture is a possibility, although more time consuming, as the prototype is built with tools that are not primarily meant for prototyping. The time spent on making a prototype, especially in the first few iterations, should not be too high in case the client is not satisfied – in which case the efforts put in are nullified. This approach is more useful when the design process is nearing its end and the architecture is well thought of.

3.4 Evaluation

This project functions as a pilot study in preparation for a bigger project held at the Children and Youth Clinic. It is also an explorative study as it may discover new ways to communicate between patients and the hospital, possibly supplementing the current way of informing patients. This will allow the clinic to run a small-scale project and see how the application compares to the existing systems at an early stage with reduced investment and costs.

The final prototype will be evaluated by a usability test. A small group will be invited to test and evaluate the application. The users are to be handed an interactive prototype and asked to use it at their will. In addition, the users will give their impressions of the system through a semi-structured interview. These questions, if not already answered, are centered around topics such as *informing*, *ease of use* and *trust*. The results are to be analysed qualitatively.

Chapter 4

Planning the design

This chapter deals with the initial planning of the design, where the most important factors are taken into consideration.

4.1 Inspiration

The PictogramApp application, of which the master project will primarily be based on, provides a foundation for this project to build upon. In PictogramApp, users may create their own *stories* consisting of an arbitrary number of *scenes*. Pictograms may then be added and placed in each scene, creating a story. These concepts can be applied to the new application albeit with different names (see section 4.3).

Inspiration has also been obtained from social media platforms where children and youth make up an notable part of the user base. *Reactions*, often seen in social media and messaging platforms, are a way to interact with a message and express an opinion about it without giving a textual reply. A classic example is Facebook's Like button which has since been expanded to include emojis and other visual content. The concept of reactions can be joined into the design to make it more attractive for children and youth.

4.2 Target groups

The application is intended for several kinds of users. It is therefore important to know who these users may be and in what context they will use the application. For this project, these users are described in form of distinctive target groups:

- The primary target group will be children and youth at the clinic with ages raging from 5 to 12. The content of the application must therefore be adapted to the target group and be suitable for their age.
- The second target group will be health professionals and staff at the clinic. This includes physicians, practitioners, consultants, medical assistants and other people working with healthcare.
- A third target group is relatives and parents of patients. This group is worth considering as they have a considerable impact on the treatment and influence on the patient's stay. In fact, it is common for parents to participate in decision-making matters for children aged below 16 years (Helsedirektoratet, 2018).

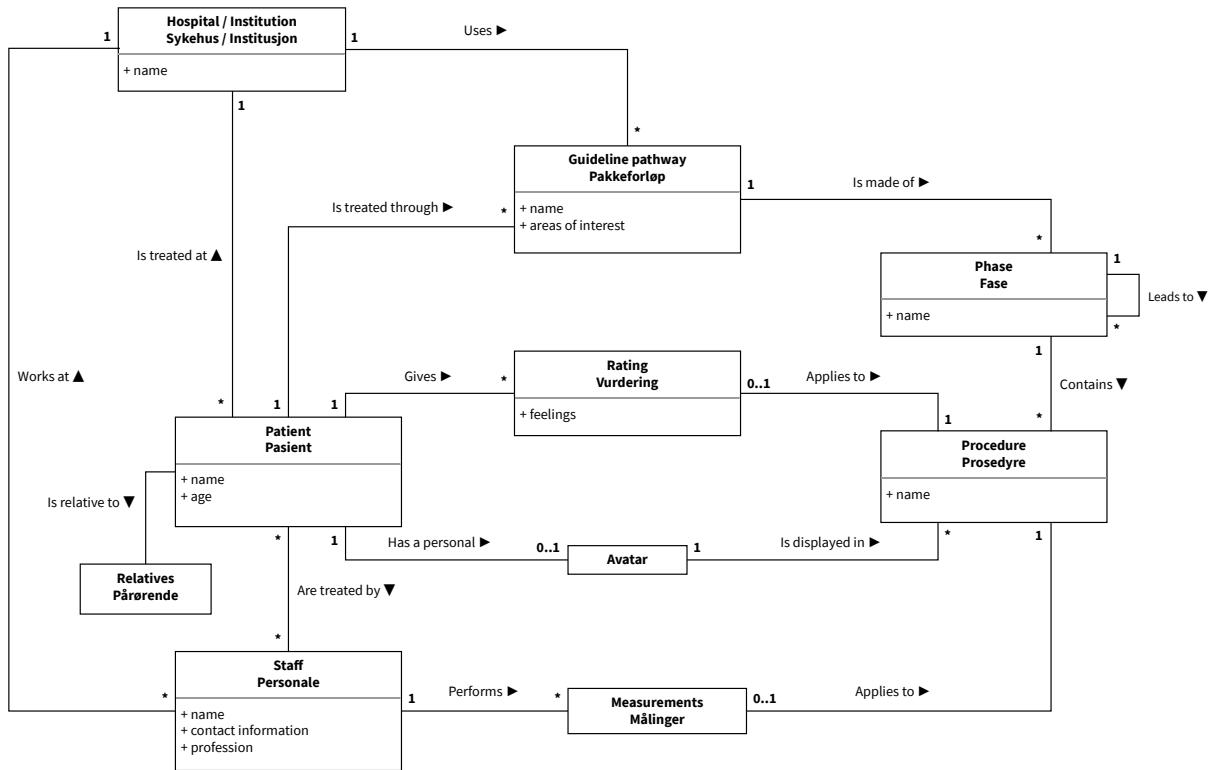


Figure 4.1: Domain model showing core concepts

4.3 Domain

The domain of the application is centered around healthcare and treatment of patients. Given that the application will be used in a hospital setting, the associated terminology will be extended to the application. Terms like *institution* (part of the hospital of which one is situated in), *patient* (a person who is hospitalized or is getting treatment) and *procedure* (a standardized routine to be performed) are included.

National guideline pathways can be integrated into this domain too. As shown in Figure 2.1, guideline pathway may consist of several phases. Adding to this, each phase may consist of several procedures. When undergoing a guideline pathway, the patient transitions between phases of it, going from one phase to another (or even back to a previously visited one).

A class diagram of the domain is shown in Figure 4.1, illustrating core concepts the application may deal with. As some concepts do not have proper English translations, both Norwegian and English names are displayed in order to avoid confusion. Each association has a label describing the association and its context.

Each patient may configure their own avatar representing themselves. The idea is that these are displayed in procedures to give them a personal touch. Each procedure should be able to be rated – more on this in section 4.4.

The scope of this project will be restricted, involving minimal integration with existing healthcare and journal systems at the Children and Youth Clinic and Haukeland University Hospital. There are not many options for an integration process as of now, and thus any integrations will only be thought of and exact details may be missing.

4.4 Requirements

The first step of the interaction design life cycle is centered around establishing requirements. This involves having a dialogue with the client, getting an idea of what they expect and correcting the requirements if they change. Preece et al. (2015) lists out two aims of a requirement activity:

One aim is to understand as much as possible about the users, their activities, and the context of that activity, so the system under development can support them in achieving their goals. Building on this, our second aim is to produce a set of stable requirements that form a sound basis to start designing.

— Preece et al. (2015)

The initial requirements were formed after a meeting with Helgesen and Thorsen. These are divided into functional requirements which describe what the application should do, and non-functional requirements which tell something about constraints of the application and its development. Some of the requirements mentioned here appeared during the design process.

4.4.1 Functional requirements

The Children and Youth Clinic wishes to have an application where the user may register an account and create a personal avatar. The latter is already achieved through the avatar generation system by Helse Vest IKT (see section 2.4) and thus the challenge lies in incorporating this system into the application.

The user should be able to view personally targeted procedures. These will feature the user's own personal avatar along with information about an upcoming procedure at the hospital. Afterwards, the user should be able to rate their experience, and if possible, this rating should be reflected when the procedure is shown in retrospect. As a step to facilitate decision-making, some procedures should be able to be rearranged.

At the end of a hospital stay, a graphical epicrisis should be generated. It should take the user's ratings in mind and showcase periods which stand out rating-wise. This epicrisis is intended to be a supplement to text-based epicrises which remain untouched.

In addition, in order for such a system to work, medical staff should be able to create graphical procedures and assign users and dates to them. Template procedures should be made as to make this process less time-consuming for health professionals.

An use case diagram is shown in Figure 4.2. Although some use cases are shared amongst both patient and staff, it may be appropriate to split them across different applications.

4.4.2 Non-functional requirements

To begin with, the Children and Youth Clinic expressed that this application is intended to be used on devices provided by the hospital. These should be portable as the application may be freely used in beds, in semi-public spaces or other designated areas. An idea is to use tablets with medium to large screens. There are no requirements regarding which operating systems the software should run on, but the clinic informed that most of their tablets run Windows and Android operating systems.

As the system is intended for children and youth, the application should be shaped for children and youth. Extra attention to detail is necessary in order to make the application usable, not to mention suitable, for the target group.

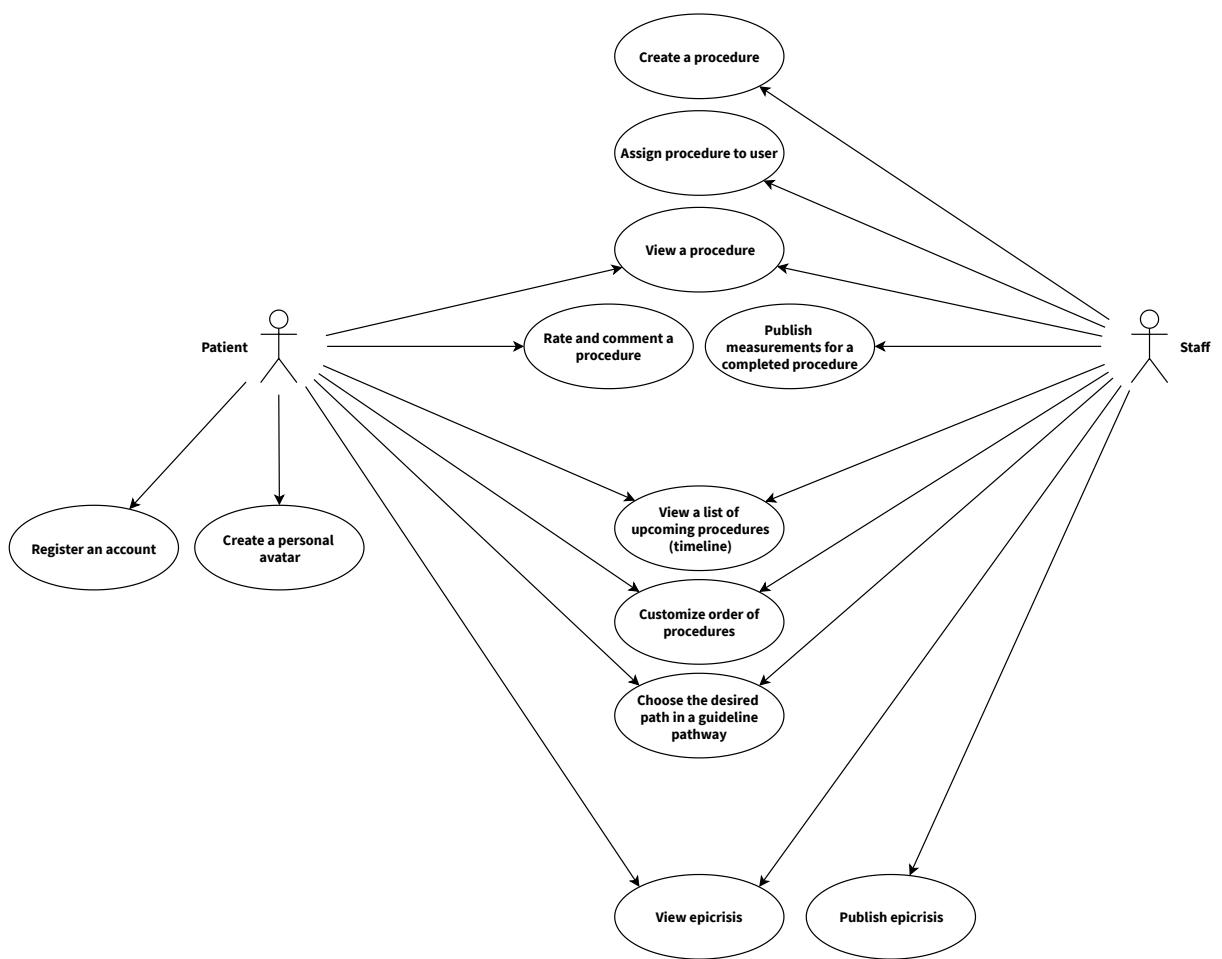


Figure 4.2: Use case diagram depicting use cases for a patient and a member of the staff

Chapter 5

Iterating the design

Once the basic requirements are established, the iterative process of the design development begins. More detailed requirements will emerge as a result of the feedback and communication in the iterative design process. Each iteration works as a distinct step towards the final design of the application, from bare-bone paper sketches to high fidelity prototypes.

After collecting feedback about each prototype, the feedback is analysed to give a clue of what is good and what needs to be refined. Considerations, while not a part of the analyses, reflect upon the situation and contribute toward the development of the design.

5.1 Iteration 1: Paper sketches

The version made in the first iteration is also the simplest, made with pencil and printed sheets of paper. It illustrates two sides of the application: in the first, the user enters a procedure and evaluates it (Figure 5.1), a common use case in this application. The procedures are shown in a list and if a procedure has been rated, a smiley will be shown. Each procedure can be viewed as a cartoon comic with a horizontal, scrollable sequence of frames. The user will be able to scroll across the whole procedure from left to right and to put each frame in focus, essentially becoming a step-to-step tutorial. This is a good way to get an overview of the procedure on its own, but it provides less interaction than if the user would, say, walk through the steps in a game-like approach. At the end of the procedure, the user is prompted to express their experience through use of smileys, a method proven to be quite successful (Stålberg et al., 2016). The rating system is very basic and simple to understand for children, containing only a sad, neutral and a happy face.

In the second side of the application, the sketches illustrate how a procedure may be edited by an authorized user (Figure 5.2). The process involves creating frames, inserting elements and modifying them. A toolbar is shown at the top with a varying amount of buttons, showing only the ones that are relevant for the current situation. Compared to PictogramApp, the interface is supposed to be more drag-and-drop oriented with possibilities to drag pages between each other. Another improvement is that elements must be clicked/tapped before they can be modified.

5.1.1 Considerations

The scope of the application had been partially accounted for at this stage. It was clear that the application would be used to inform patients about upcoming procedures and let patients rate them afterwards. However, it was not known whether it was intended to be used during procedures and in context with a health professional.

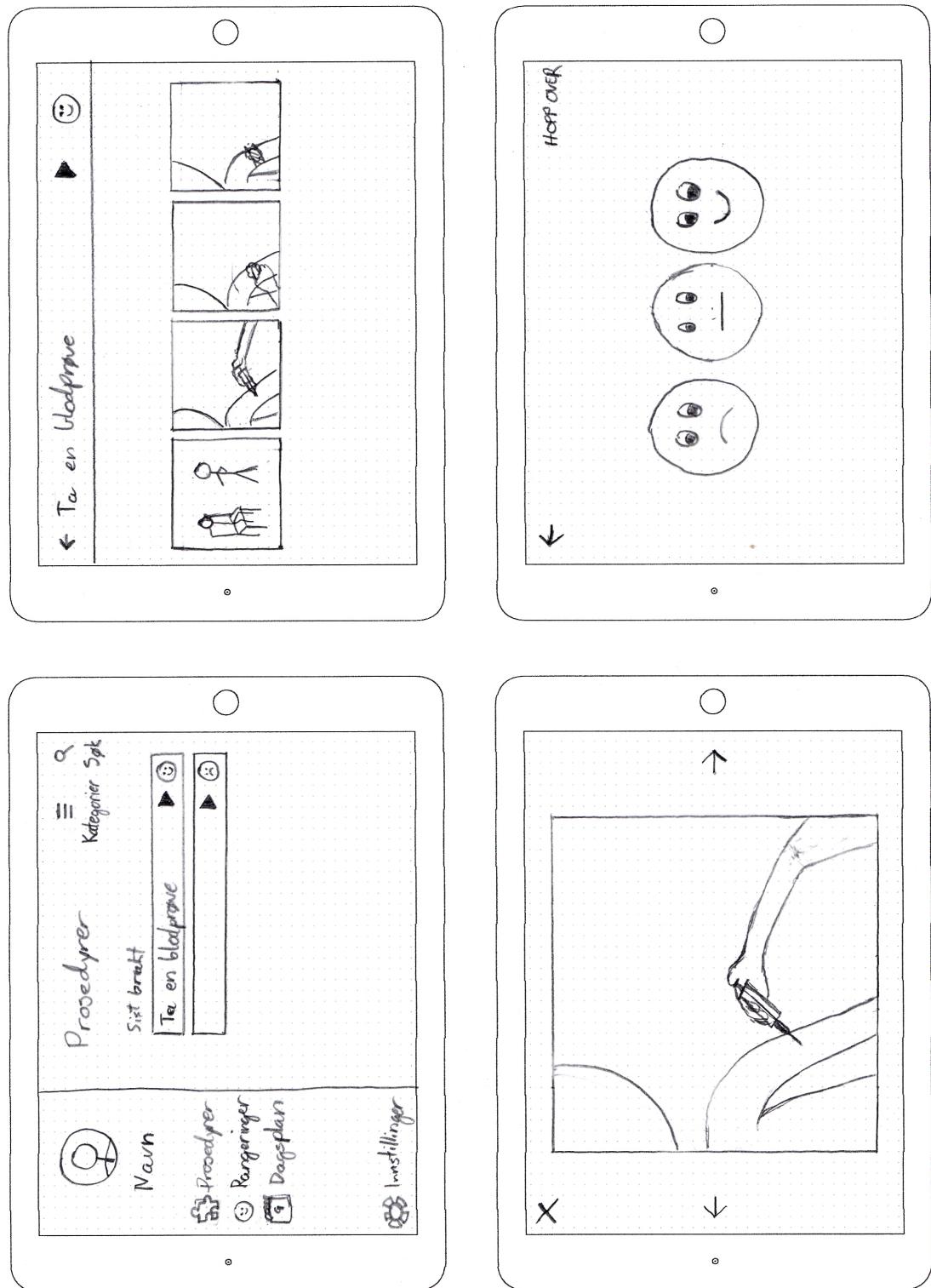


Figure 5.1: Sketches of the first design: viewing a procedure

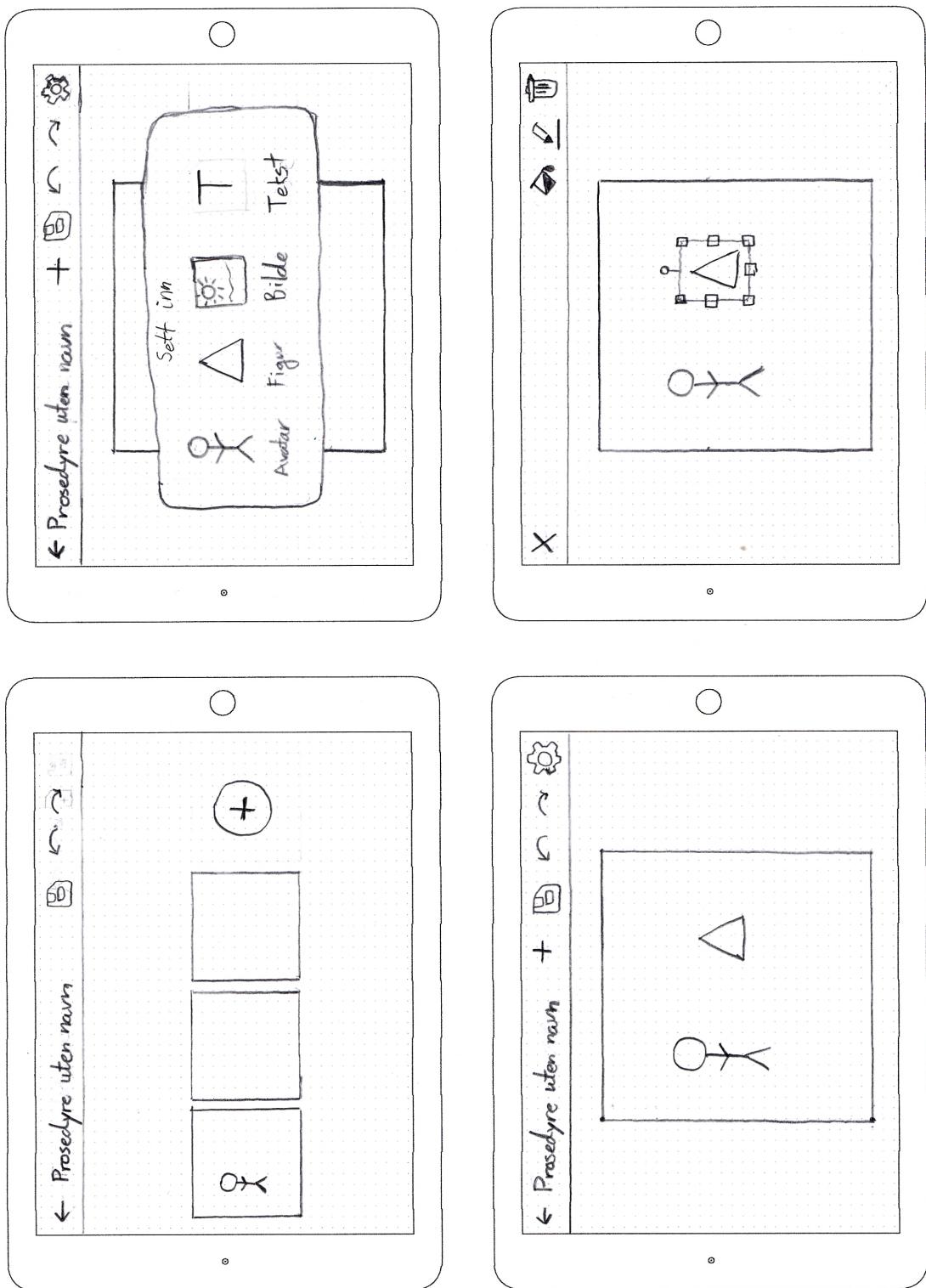


Figure 5.2: Sketches of the first design: editing a procedure

Children at this age have most likely been made known to tablets and interactive devices, but the youngest children of the target group may not have sufficient prior experience, either due to their age or health-related issues or a combination of both. Less experienced users should be able to learn how to use the application quickly regardless. It is therefore a good idea to consider ways to inform and possibly demonstrate the user about possible ways to interact with the application.

These initial ideas to the design will only give an indication of the final visual style of the application. Depending on the feedback of the test groups, the style should be one that the users feel more interesting. Some possible visual styles include a modern and minimal approach with focus on essential elements (similar to PictogramApp) and a more cartoon-ish, fun style with drawing-like pictures and an informal look. Nevertheless, applications like these can be customized to adapt for each user through themes; the ability to choose among several alternatives is better than having no choice.

5.1.2 Analysis

This design was made entirely in landscape mode, that is, with the device laying on its longest side. This felt natural when considering the application layout – especially how procedures are displayed. For future iterations it might be beneficial to primarily design for portrait mode, with the device laying on the shorter side. This will make it easier to port the application to smartphones, and it will follow the flow as the majority of current applications are based on portrait mode (with no support for landscape views).

As previously stated, the rating system shown here is very simple with three distinct options. It was pointed out that a problem here is that this system does not portray what exactly the user is feeling if things are not great. A sad face can represent a lot of feelings, but this information can not be extracted afterwards.

The editing part of the design is also imagined through a touch interface. The main question is whether the intended target group, the medical staff, is willing to use a tablet application for a key use case. Many physicians and health professionals use personal computers at their offices daily, and having to use a tablet—that they might otherwise not need—could possibly reduce their efficiency.

5.2 Iteration 2: Form study prototype

The second iteration yielded a form study prototype that shares many similarities with a wireframe. The prototype is also the first one made with a digital prototyping tool, allowing a higher fidelity despite the simplicity in the current design.

Contrary to the first prototype, this is designed for portrait mode. It keeps the two-folded design of the home page, with a collapsible ‘hamburger’ menu on the left and a list of procedures on the right as shown in Figure 5.3. Procedures may be filtered by their category such as *treatments* and *conversations*.

Procedures are shown frame by frame in this design. Each frame may also have a description that can provide useful information about each step and increase the sense of safety for the user. At the bottom is a small overview of the frames in the procedure, making the user aware of their process.

The prototype also features screens of a procedure containing a video. Two possibilities were considered; one where the video is fitted in a similar way to the procedures that contain images only (Figure 5.5a); and another where the video is resized to fit the entire width of the screen (Figure 5.5b). In the end, the latter may function as a fullscreen mode and act as a supplement to the first design.

Lastly, the rating part has been extended from three smileys to nine emojis, featuring feelings such as *delighted*, *tired* and *surprized* (Figure 5.6). The new emojis are placed in a tappable grid, and tapping

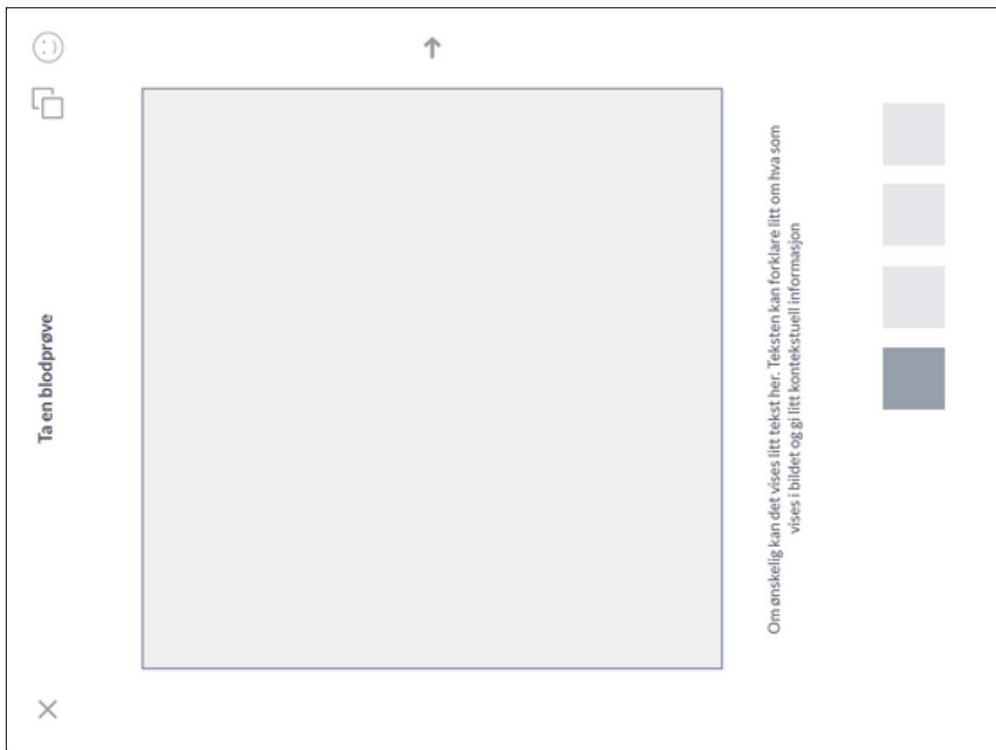


Figure 5.4: A single frame of a procedure

Figure 5.3: The home page

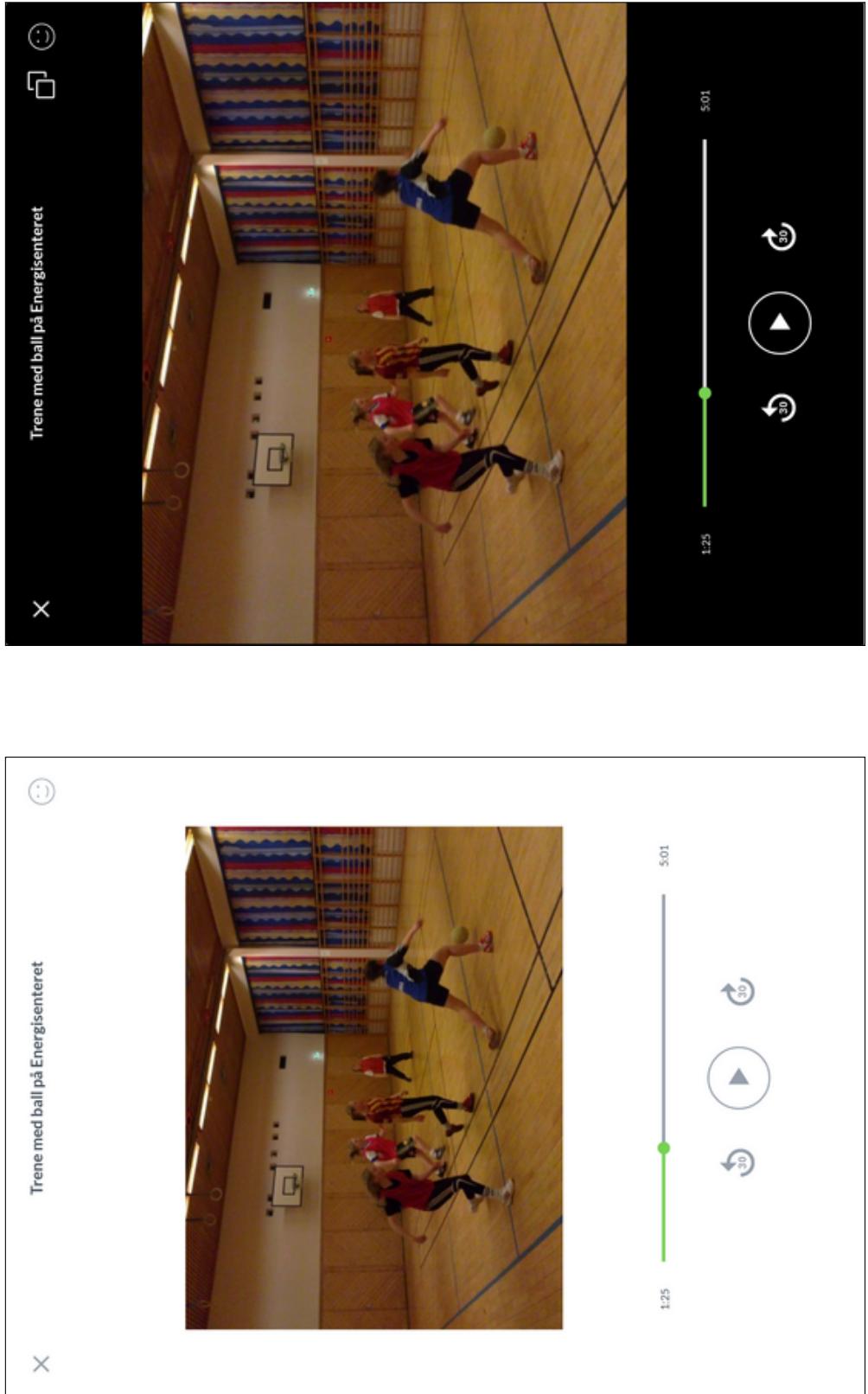


Figure 5.5: Two ways to view a video

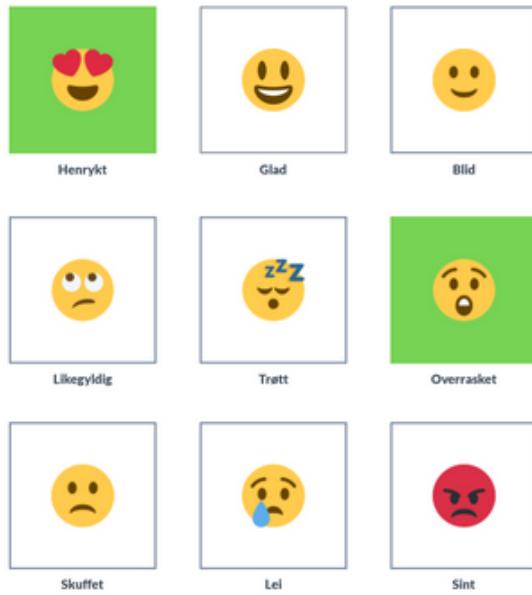


Figure 5.6: An emoji grid used in the prototype

on an emoji turns its background green. Once the user has rated a procedure, the feelings that have been ticked will be shown on the respective procedure on the home page.

5.2.1 Analysis

Both video procedures feature media controls to administer the video playback. Whether these buttons are necessary ultimately depends on the video format. If the video is a local file, then dedicated buttons are indeed necessary. However, if it is determined to use YouTube embeds for videos, then such buttons may not be needed as the embed includes them.

Questions were raised if whether it was necessary to include emojis that closely resembled each other, such as both *glad* and *blid* which both translate to ‘happy’. There was also scepticism if whether *indifferent* qualifies as a feeling. If need be, it would be possible to express indifference by not tapping any emojis. Basically, the current rating system seems to be a bit unnecessarily complicated.

5.2.2 Considerations

After showing this prototype, Thorsen presented their way of rating feelings at the Children and Youth Clinic. This method involves the five feelings *happy*, *sad*, *anger*, *fear* and *disgust*, each with a scale that measured the amount for each feeling. In addition, there is a scale for *sense of achievement*, i.e. to which degree the patient feels they have mastered the activity and achieved something of it.

5.3 Iteration 3: Small extension

The third iteration, albeit a less extensive one, builds directly upon the previous iteration with a few enhancements. It focuses mostly on the home page and the rating page.

The home page shown in Figure 5.7 is similar, but the elements are bigger and also in a grid layout. The bigger elements make space for a preview of the prototype, letting the user see how it looks like before opening it. The idea behind this is to make each procedure easier to recognize, as well as making it a bit prettier for the eye.

The rating system has again been reworked, and this time it uses five feelings (Figure 5.8). Each feeling has a slider that measures the intensity of each feeling, and the more intense, the bigger the emoji grows. The new design also allows space for text that can help describing what each feeling represents. The feelings that are measured to be greater than 50 % will be displayed on the respective procedure – this could mean that two or more emojis are displayed simultaneously.

5.3.1 Analysis

The main issue here is that there is currently no concept of *timeline* in the design yet. There is an entry in the menu named *timeplan* which has not been considered so far. As it stands, the list of procedures here is quite loosely structured considering the use case *View a list of upcoming procedures (timeline)*. They are currently put in a last used list which can quickly change its order, whereas a timeline is a more rigid structure that does not change that easily.

A procedure may also consist of several procedures. This has not been accounted for in this design, but a wish for *procedure groups* is present.

Although the new rating system is now more similar to the existing system used at the clinic, there are still things that can be improved. Among others, there is no initial indication of where you want to drag the sliders. There also seems to be too much whitespace and little context; what are these feelings for? What is the intention here? What happens when the user taps the *back* button? Questions like these need to be taken care of in order to improve the user experience.

5.4 Iteration 4: Interactive prototype

The first interactive prototype is brought to life in the fourth iteration, with a focus on the user experience in its entirety. Although the layouts are mostly the same, the new design brings in a new look for many elements.

The experience starts at the doorstep, which in this case is the home page. The idea behind this is to have an informative, public page that any Internet user can view (Figure 5.9a), along with an image of an avatar which is one of the main points in this iteration. A login step is required in order to view the user's sensitive data such as profile, timeline and procedures (Figure 5.9b), and one of the suggestions since iteration 3 was to use secure Norwegian authentication systems such as BankID. These are systems in use by banks and official entities in Norway, providing an electronic ID for Norwegian inhabitants.

The design and look of the application has been improved; instead of the 'hamburger' menu, there is now a navigation bar. The titles are tappable, and the title of the current page is emphasized through a bigger font size.

The application itself is now divided in three; the first and primary page being the timeline (Figure 5.10). The line itself is shown to the left, with each dot representing a procedure or a group of procedures. To make it clear where the user is, there is a headline *next procedure* which acts like a 'you are here' mark. Past procedures are greyed out to avoid confusion.

The previous home page, listing the last used procedures, is now in a page named *Procedures*. Other than that, there are few changes apart from the visuals. Emojis are now placed over the preview area, making more room for the text below.

There is now a dedicated page for feelings (Figure 5.12) where the user can view information gathered by rating each procedure. The last given rating is shown at the top, with the respective emoji and scale for each feeling. Swiping up, there is a filter for each feeling that show only the procedures that made the user feel happy, procedures that were sad, fearful procedures *et cetera*, combined with a strong background colour for each feeling.



Figure 5.8: Five feelings with bars

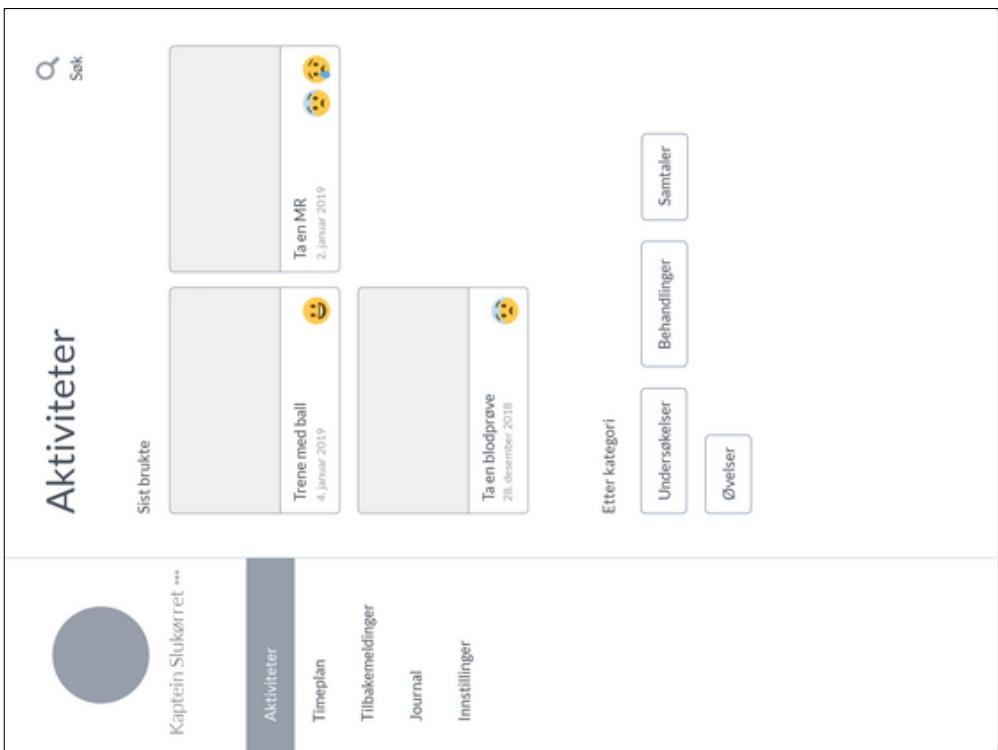
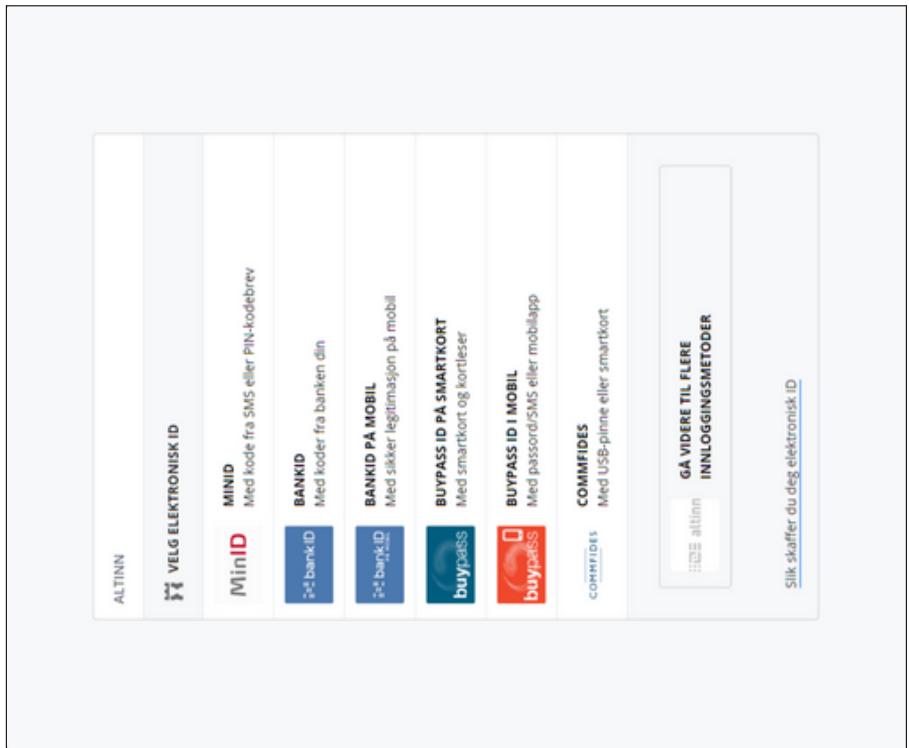
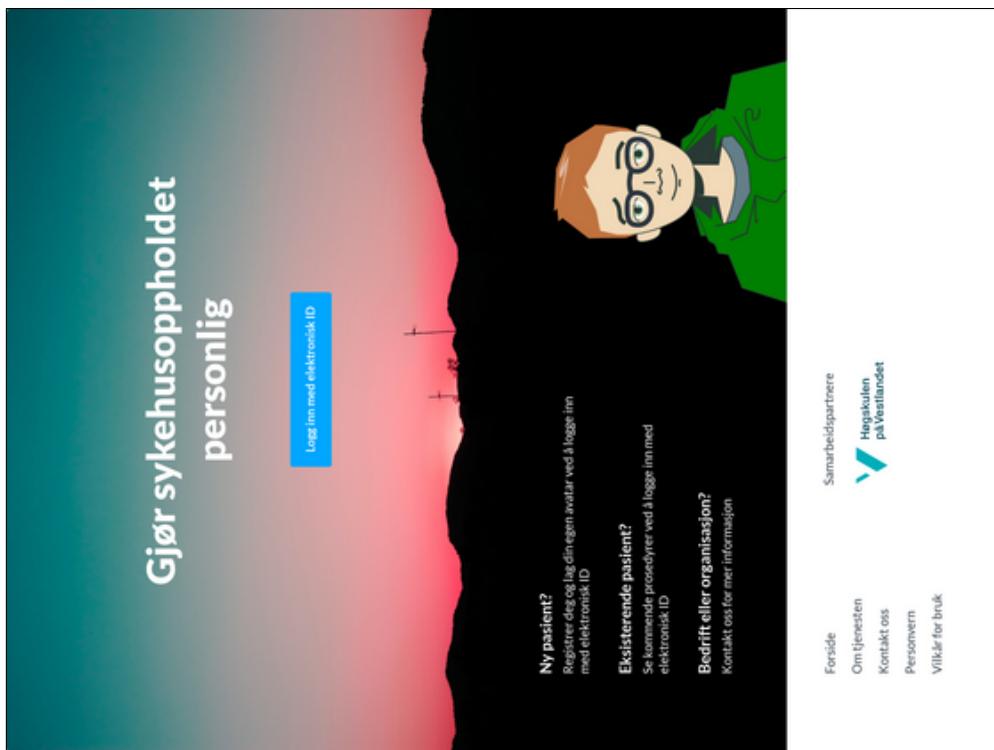


Figure 5.7: The home page with bigger elements



(b) Signing in using secure Norwegian authentication systems



(a) A public home page

Figure 5.9: The application before accessing sensitive data

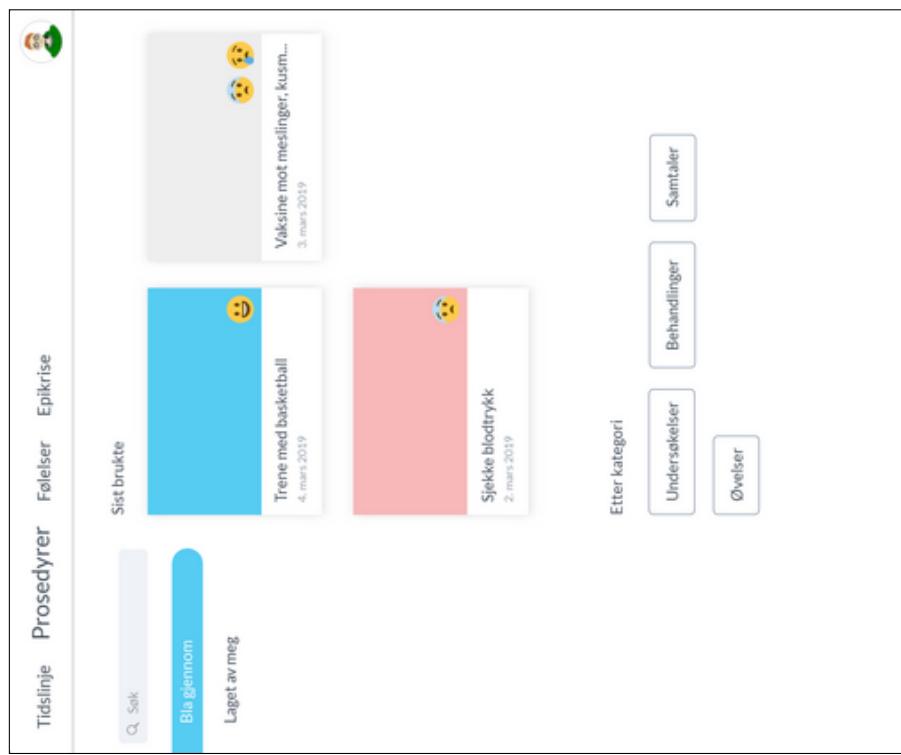


Figure 5.11: The procedures page (previous home page)



Figure 5.10: The timeline page

When tapping on a procedure, the screen in Figure 5.13 slides up into view. For this prototype, one standard graphical procedure and one video-based procedure were made. The layout remains mostly the same as in section 5.2, but now with complete illustrations for the interactiveness of the prototype.

The rating screen has turned into an overlay which, instead of appearing as a new page and covering the whole screen, appears over part of the procedure screen. Tapping on the greyed area has the same effect as tapping on *back*; taking the user back to the previous screen. A new feature for the sliders is a label on the right-hand side. For the happy feeling it displays *ikke glad* (not happy), *lite glad* (little happy), *ganske glad* (pretty happy) and *veldig glad* (very happy) depending on the intensity of the feeling.

Once completing all procedures, a new entry *epicrisis* appears on the navigation bar. The epicrisis page itself has not been designed in this iteration.

The profile icon that previously was intended to be put on the left-hand side is now to be found in the upper right corner. When tapping it, a sidebar will appear as seen in Figure 5.15 with pages such as *my profile*, *my avatar* and *settings*. These were not functional in the prototype.

5.4.1 Analysis

This prototype has been primarily been designed for use with a second generation iPad that could be borrowed. The testing could therefore be done with the intended shape and form, using swiping and tapping with fingers instead of clicking and dragging with a mouse. The prototype was, however, presented on a projector for bigger groups who were pressured on time.

Upon the iteration feedback, it was deemed that the authentication systems as shown in the login sequence (Figure 5.9b) are unnecessary. It is not given that those systems will be used in the final application, although they could prove to be useful for authentication matters, but that is not to be considered until the actual implementation. A simple, local login system will suffice during the design process.

The rating overlay shown in Figure 5.14 is better, but not good enough. The labels provide more information about the feeling, but at the initial state, there is still no indication of where you need to drag the sliders. They remain a bit unintuitive.

Through heuristic evaluation, another issue was revealed. The rating shown at the top of Figure 5.12 is associated with a procedure, but that procedure is not shown. The context is missing, making the user have to navigate to another page in order to find said procedure.

Two features were requested after the user testing. The first is to view a history of ratings. The vision is for the user (and the staff) to see their feelings progress. This way, the patient can see if they have become less fearful, sad or angry of a particular procedure. The second requested feature is to view a textual version of a procedure.

5.4.2 Considerations

Although this prototype was also made with a digital prototyping tool, issues emerged that made it difficult to simulate an actual application. The most notable example is the sliders in figure 5.14. These should in theory be adjusted individually, with the respective emoji scaling up or down depending on the slider value. This could not be solved with the prototyping tool being in use, and the workaround is to create five separate screens—each with a different state for each slider—in order to achieve a sense of progression. This requires the user to tap on each slider consecutively, each slider can be set to one value only, and the user cannot swipe the slider to see the scaling effect of the respective emoji. These issues together made it more difficult to perform user testing with the users navigating the prototype.

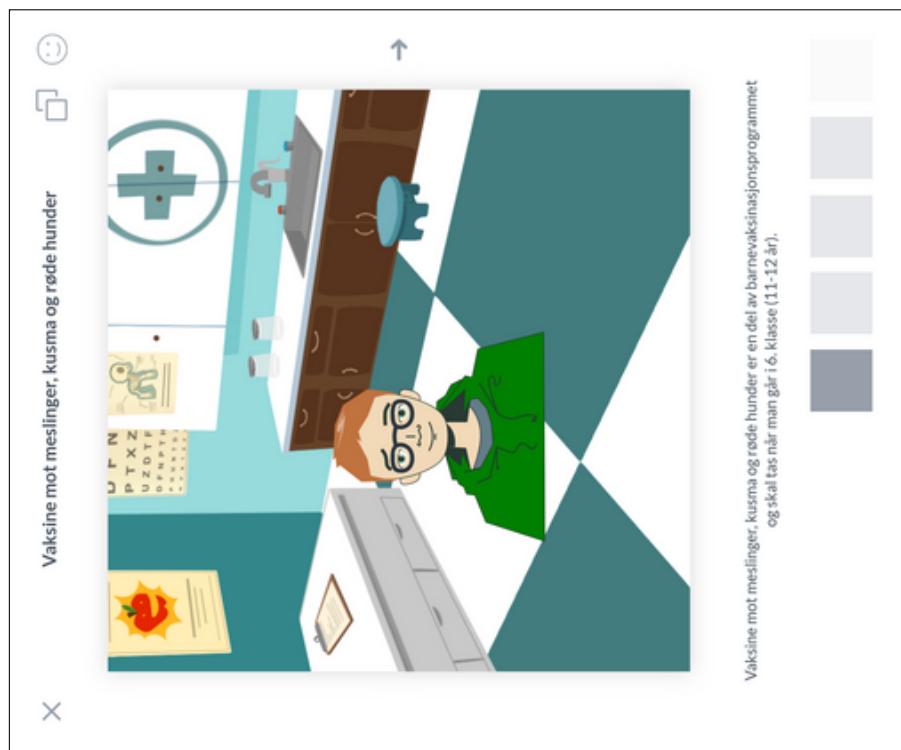


Figure 5.13: Interactive procedure page

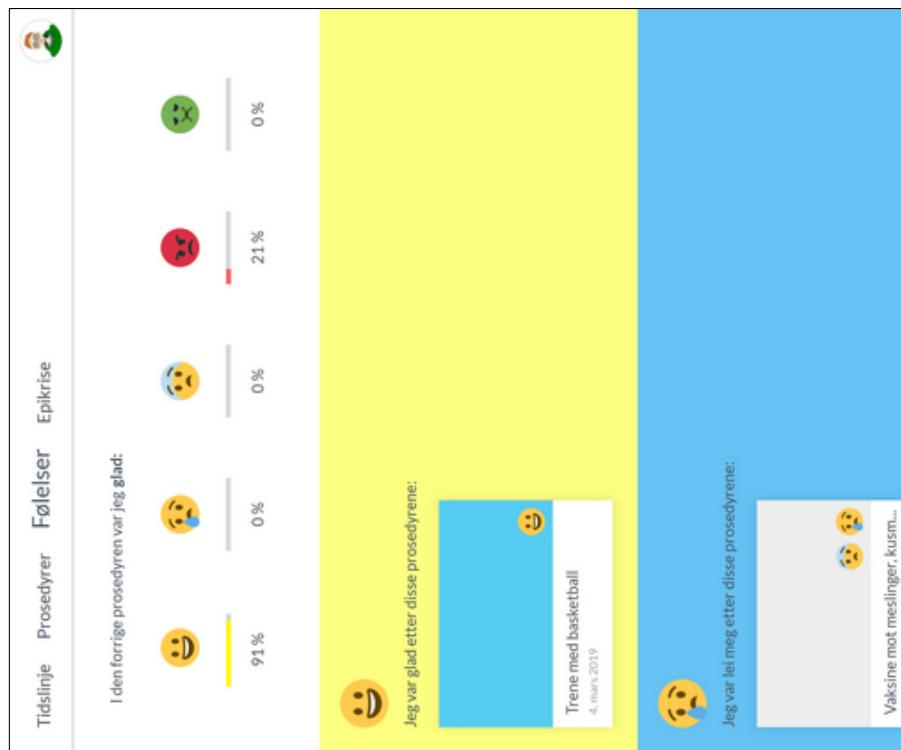


Figure 5.12: The feelings page



Figure 5.15: Profile sidebar

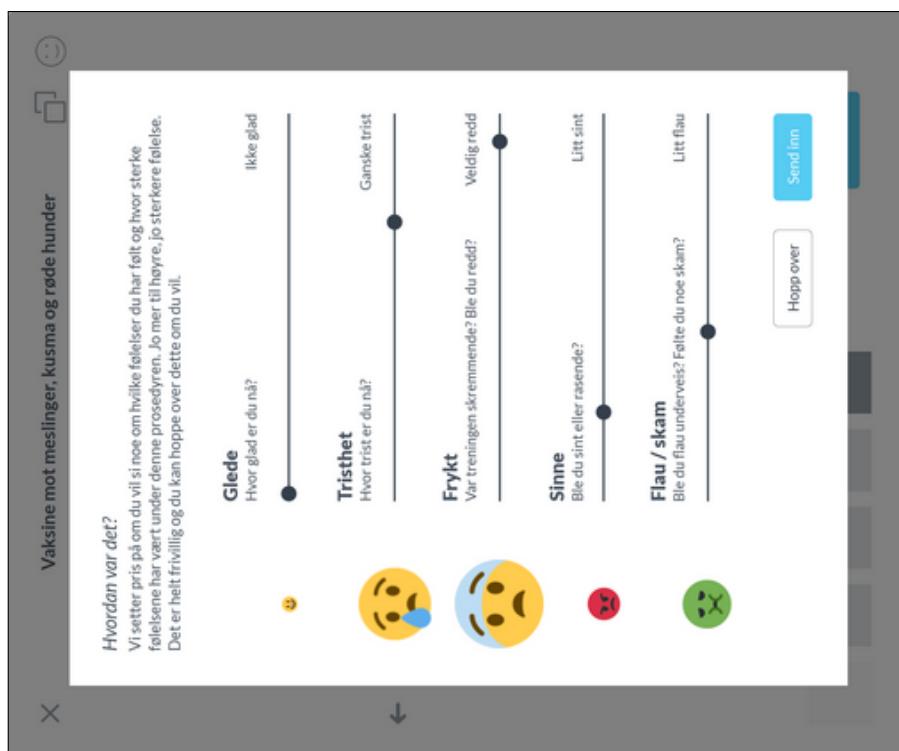


Figure 5.14: The new rating overlay

5.5 Iteration 5: Further UI experiments

The next iteration is more of an experimental kind, working more as an alternative to the design in iteration 4. It tries to discover different ways to display and interact with elements in the application.

Starting with the timeline in Figure 5.16, the layout spans two columns now instead of a single column. When including information about the place in addition to time, the timeline began to look a bit too repetitive and spaced out (fewer procedures which can be shown on the screen). Since this application is aimed for tablet devices, it made sense to utilize the horizontal space and separate the time from the rest of the information. This allows for the date and time of the viewed procedures to remain on the top left of the screen when scrolling down. The previous layout from iteration 4 may still be used for smaller devices such as smartphones.

Among the things experimented with, there are coloured procedure elements and a dropdown panel. The reason behind colouring the procedures is to visualize whether they have been read or not. As one of the aims behind the application is to prepare patients for upcoming procedures, it also makes sense to highlight procedures which haven't been viewed yet with the primary colour. Once viewed, the procedure will be no longer highlighted. The dropdown element brings information about the rating given for each procedure and appears when the user taps on the emoji. The rating can then be expanded to show its history; either represented as a graph (Figure 5.16a) or as a list (Figure 5.16b). The headings in the navigation bar have been put to the center where they are easier to each and seem to be more decorative than being left-aligned.

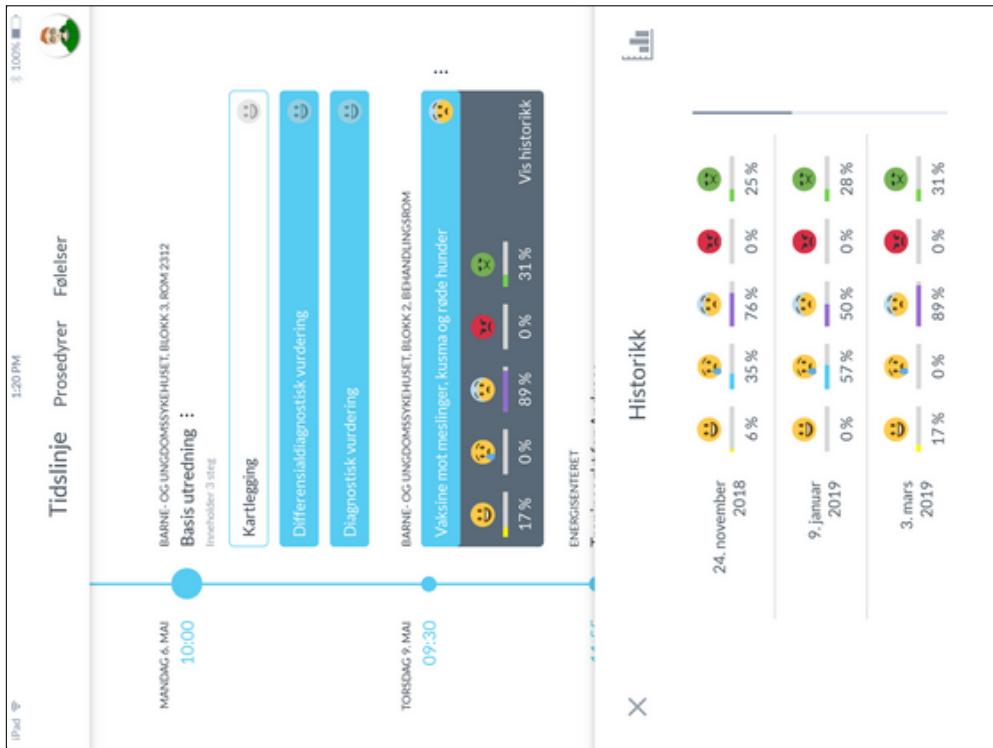
The rather standard layout for the procedures page has in this iteration been swapped out with a more complementary layout. The search bar, previously put aside, is now the main focus. Having one column instead of two is more efficient as the left-hand side was mostly empty. The procedure elements have also changed; instead of having the labels laying at the bottom, they are hovering above the rectangular preview area such that the dropdown element is closer to the emoji. The labels would be in the way and obstruct the flow otherwise. The page for feelings still contains the last given rating, but now with the associated procedure.

New to the application is a page named *Summary*, which is based on showing the average of each feeling that has been expressed in the last week, month and year. This can be used to convey a general 'mood' or a tendency that lasts for a specific period. The epicrisis has also been put here as it technically is a summary of a hospital stay. A new part of the procedure page is now the addition of thumbnails that show the current and nearby pages, aiming to make each page more recognizable.

Concerning the issues raised about the feedback screen, it was apparent that the screen could be made more intuitive. Several alternatives were made; the first one had an extra information label (*not happy, not sad etc.*) in addition to the right-hand label which was made static. It has the disadvantage of requiring extra space, and without the removal of the informative label, it looked too crammed. The second alternative involved using a line of which its thickness was increasing as you move right, indicating a more intense feeling. The shape is based on the current feedback method used in the hospital and although unconventional, it could work to a certain degree. The third and best alternative involves using colours to determine how intense each feeling is. Now that the sliders are coloured on one side only, the initial state is intuitive for the user. The labels have been placed underneath the dots and move together with them, indicating the current value rather than the maximum value.

The profile icon reveals an updated popup element rather than a sidebar (Figure 5.21). This makes sure that unnecessary screen space is not wasted. The aforementioned requested feature, to show a history of ratings, was also experimented with in this iteration. Two alternatives, one being a graph representation and the other a list, were designed for this purpose as illustrated in Figure 5.16.

For the purpose of illustrating the flow of the application for readers, a flowchart is shown in Figure 5.24. The arrows indicate the flow and the labels describe their actions. The feelings page may appear both



(b) History as list



(a) History as graph

Figure 5.16: Timeline with two alternatives for showing rating history

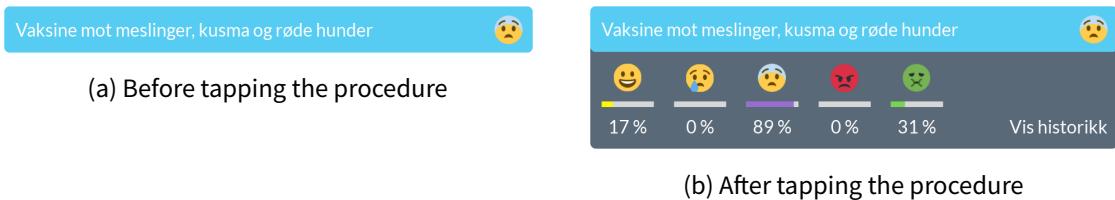


Figure 5.17: Dropdown element

inside a procedure and afterwards, when tapping on an emoji. The procedure page acts as an overlay, where exiting it leads the user to the previous screen. Although not explicitly indicated here, the user may freely navigate between related pages such as timeline/procedures/feelings and the procedure pages.

5.5.1 Analysis

The reception for these changes were mixed, some changes were seen as positive while others were negative. The blue coloured procedures in Figure 5.16 were confusing and did not provide the intended meaning for the supervisor.

The new layout for the procedure page was not really clear either. It was pointed out that this functionality would suit better for the staff and not for the patient. In fact, there is no particular use case for this and it has fallen short in terms of functionality ever since replacing the page with the new home page.

There seemed to be little gain for the procedure thumbnails as shown in Figure 5.18. They were often too small, making it difficult to depict what is happening in each thumbnail, not to mention the thumbnail looks very similar. The focus has been put on something that is hardly visible and takes away from the main purpose of this element; to visualize the user's progress.

As the design has evolved, there are some differences in the designs across the various pages. Some procedures are shown as narrow buttons (Figure 5.16) while others have a preview window (Figure 5.18). The design should aim for consistency across all pages, but this case in particular lacks consistency. It would be preferable to stick to one way of representing procedures, something that would fulfil Nielsen (1994)'s fourth heuristic, 'consistency and standards'.

5.6 Iteration 6: Redesign

A complete redesign of the application has been performed in the sixth iteration. Layouts have changed, fonts have been swapped and there is a bigger focus on a common theme. The aim is to make the interface cleaner while making the prototype look more like a final product than the previous, more loosely defined screens.

The initial idea was to make a prototype using the intended software and architecture and start developing the basis of the application (see chapter 7). This was an idea that turned out to be too time consuming given the time restrictions. Instead, the current approach continues as this iteration also makes use of a graphical prototyping tool.

Contrary to the previous few iterations, the new design has been made using a different prototyping tool. As the previous tool is pretty restrictive when it comes to exporting, the screens had to be made from scratch. Following this change, it made sense to rebuild the design as well, aiming for a more modern and uniform look. It is worth noting that some of the features of the previous iterations, while perfectly suitable, have not been ported over to the new platform yet.

The theme is centered around the timeline, a red line with circles acting as the pathway to follow. A

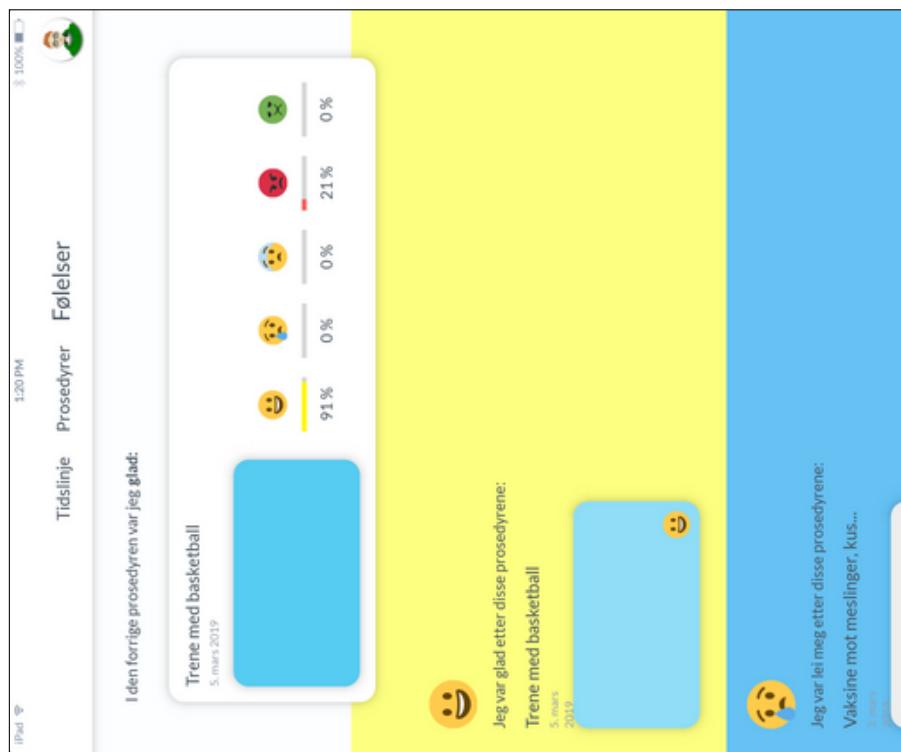


Figure 5.19: Updated feelings page

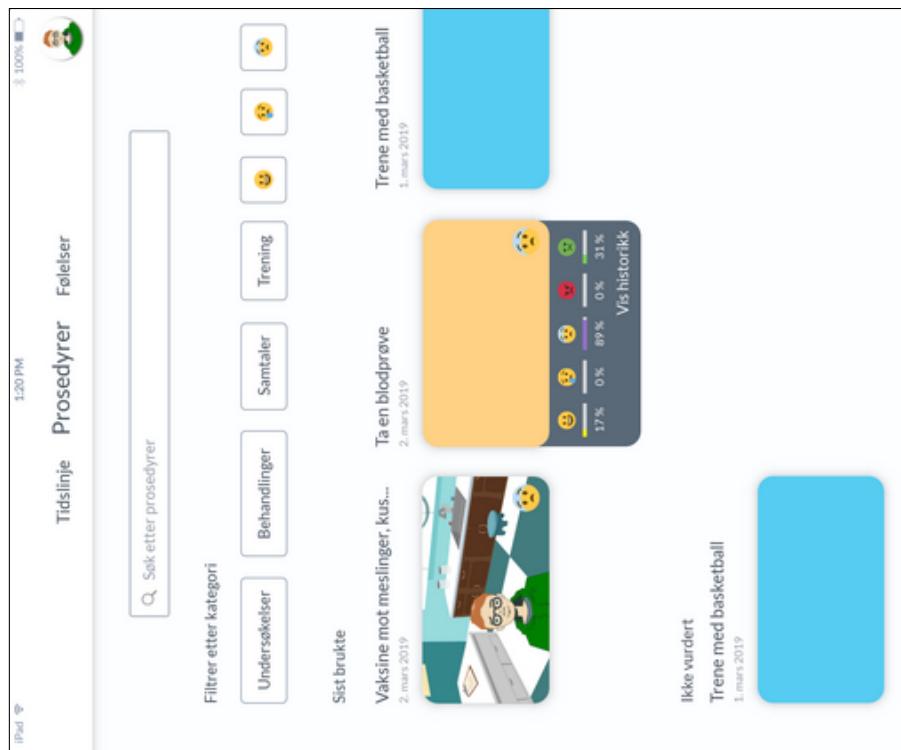


Figure 5.18: Procedures page with new layout

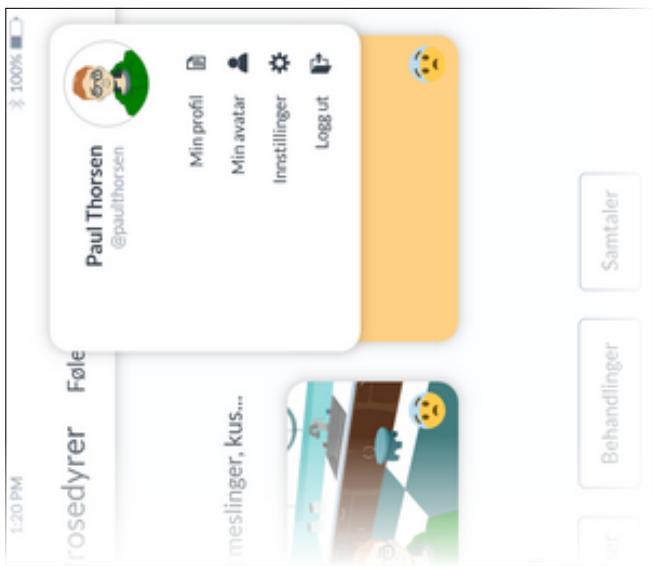


Figure 5.21: Snapshot of popup element when tapping on the avatar icon

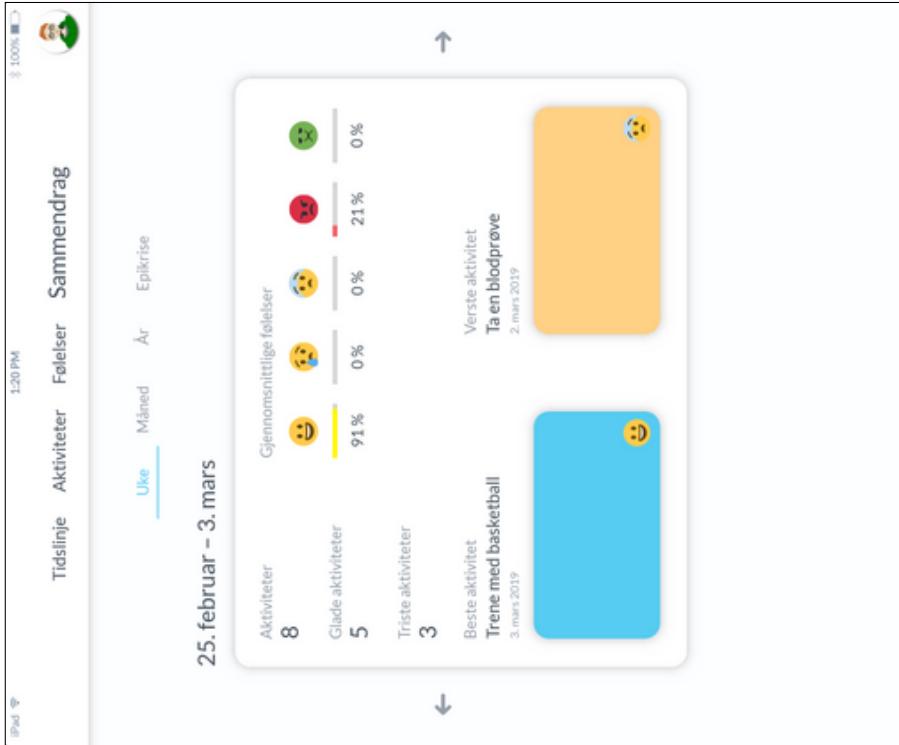


Figure 5.20: Summary page showing an overview of the last week



Figure 5.23: Ratings with coloured sliders



Figure 5.22: Procedure page with thumbnails

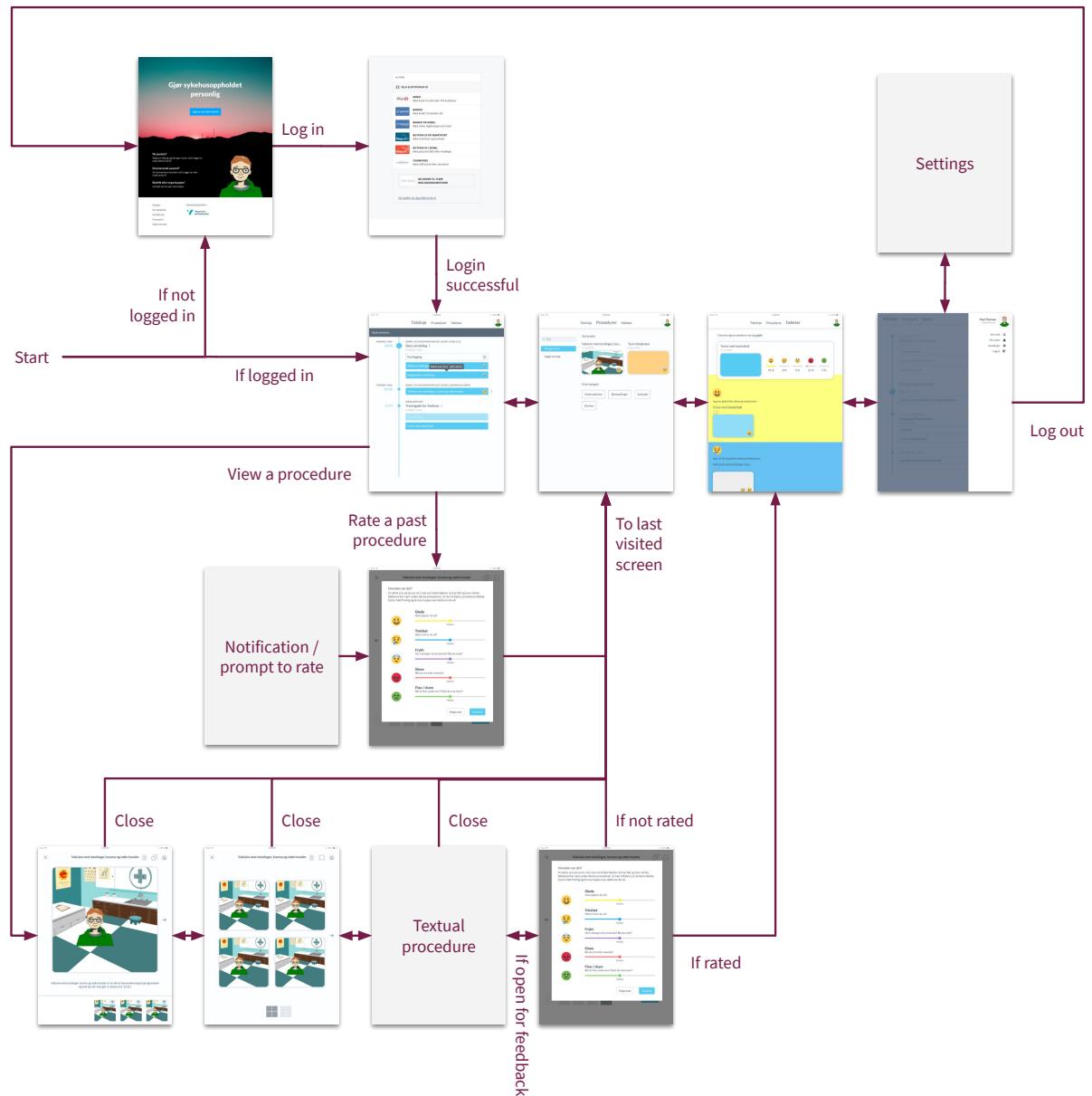


Figure 5.24: Flowchart of the application as of iteration 5

new primary colour, a crimson-like variant, has been chosen for the design. The colour fits well for both light and dark backgrounds and can be seen as a reference to the previous PictogramApp which used similar colours. The previous primary colour, which was more of an electric blue, was prone to be problematic when dealing with contrast against light backgrounds.

What previously was a navigation header has now been transformed into a navigation bar while the name of the current page remains at the top. The nature of the application—with illustrations and feelings—makes it sensible for the navigation bar to use icons instead of text. Following the theme, buttons and other highlights may have coloured backgrounds that are based on the timeline circles, but are wider and stadium-shaped in order to distinguish them.

The procedure labels have been adjusted once more; this time the procedure's title and location are implemented inside the preview area. This poses a challenge regarding contrast as the background may be of any colour. To prevent this, the background is made to have a darker tint and thus a background with the same colour as the text will not prevent the text from being visible. The dropdown element from Figure 5.17 is included as well.

As a step in integrating guideline pathways into the application, a new element *veivalg* (path selection) has been introduced. This is displayed whenever the guideline pathway's trajectory splits into several paths and it is uncertain which set of procedures should come up next.

The feelings page takes the functionality of section 5.5's summary page, allowing to view a summary of the user's feelings given in the last day, week or month. Procedures yet to be rated will be displayed here as well.

A new page being introduced in this iteration is the profile page. Instead of being encapsulated in a profile icon in the top right corner, the profile now has a dedicated page for the purposes of editing one's avatar, profile info and their login session. If desired, this page may be extended to include contact information, user statistics, information about associated practitioners *et cetera* – without being restricted by space. Accessing the profile now requires only one tap instead of two and as such, this is considered a better alternative to the previous popup element.

Although not too different, the procedure pages have gotten a new look as well. At the bottom is a themed progress indicator, replacing the former thumbnails that were not too good. It still allows for quick navigation with tappable buttons, in case the procedure contains many pages.

Another step in the redesign is the home page in Figure 5.29, which is redesigned to feature the timeline as both a decorative element and as a cue to the application itself. While mostly an exemplification, the application logo and name is displayed at the top with infographics shown below. The logo depicts an avatar being cast into two shades by a half-moon background. It is made to indicate how an avatar is connected, yet differs from the person using it. Inspiration comes from *Åpen II*, a sculpture by Gunnar Torvund which depicts a silhouette of the Norwegian composer Edvard Grieg (Vaage, 2014).

As the design has developed, it makes more sense to have an administrator application alongside the application shown here. Instead of building extra functionality into the tablet application to cover the extra needs that health professionals and other members of the staff have, a desktop application is considered. This way, there is no need to access a tablet that one otherwise might not need. The design proposed in Figure 5.30 covers most, if not all, the use cases that are connected to the medical staff.

5.6.1 Analysis

One of the first things that was noticed was the choice of wording of the path selection element in Figure 5.25a. Roughly translated, it becomes the following:

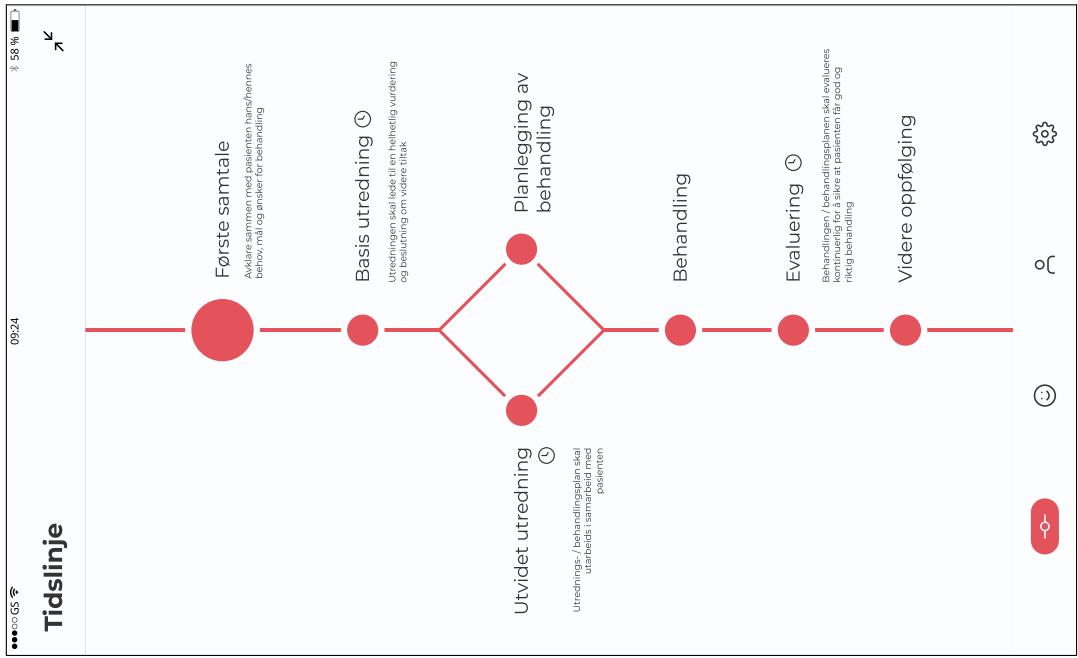
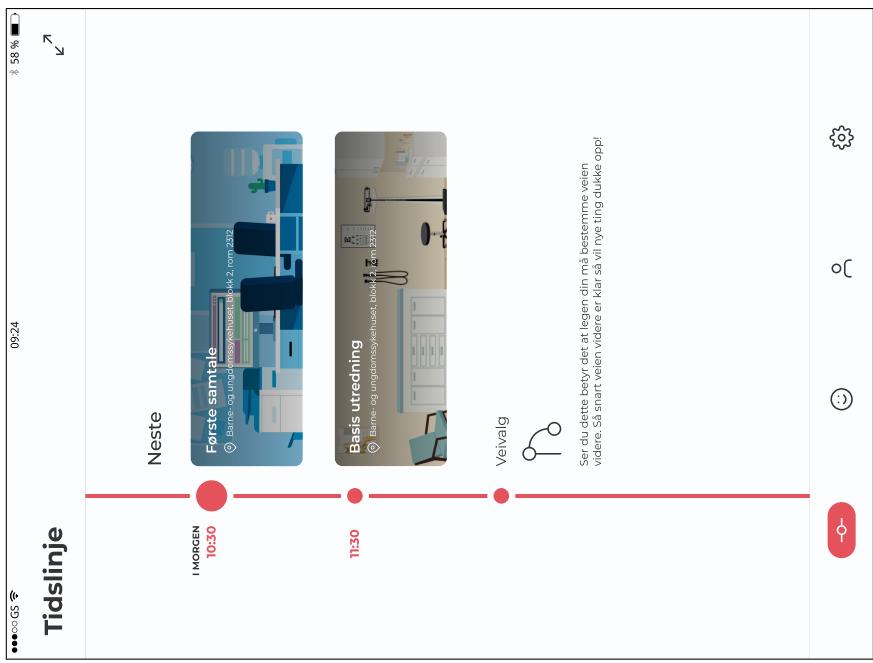


Figure 5.25: Redesigned timeline

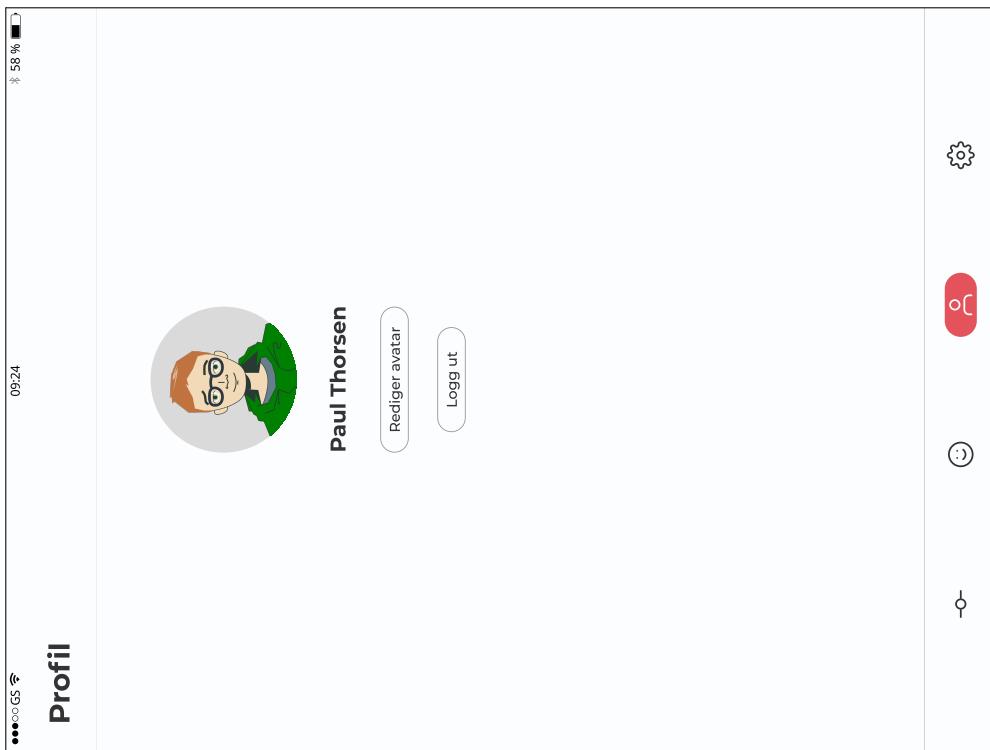


Figure 5.27: Profile page showing the user's avatar

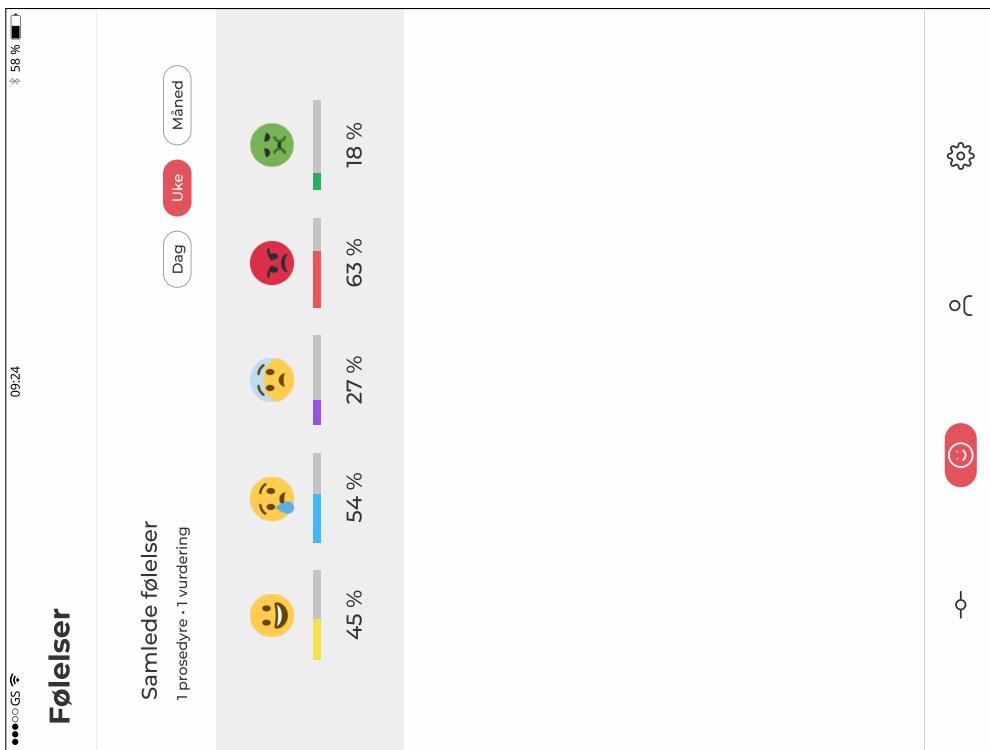


Figure 5.26: Redesigned feelings page



Figure 5.29: Redesigned home page

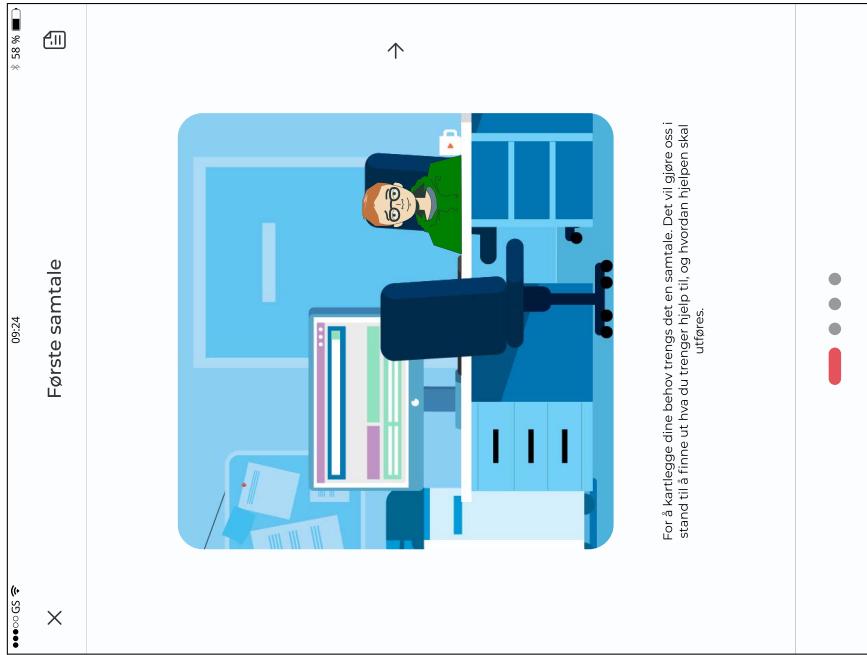
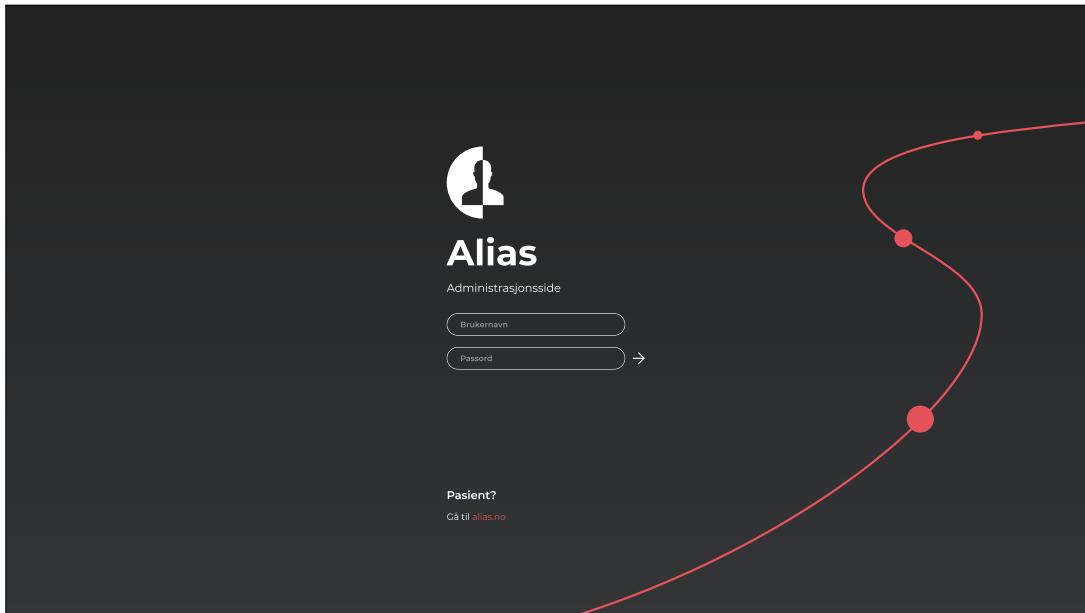
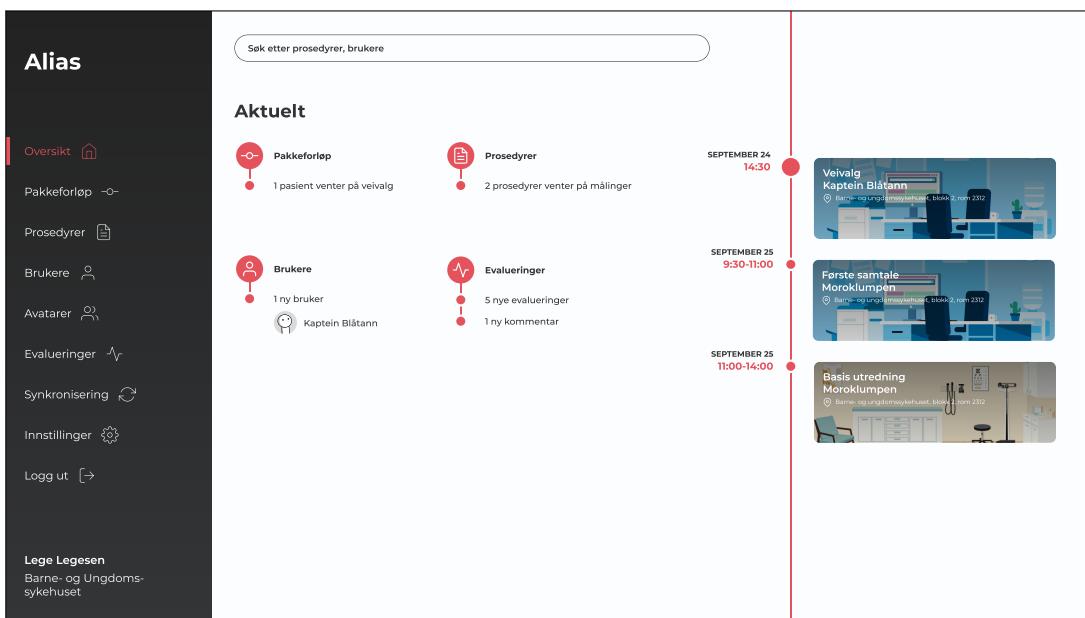


Figure 5.28: Redesigned procedure page



(a) The login page



(b) The dashboard showing recent events and a timeline-themed calendar

Figure 5.30: Administrator application

If you see this, then your physician has to decide which way to go forward. New things will appear once the road ahead is clear!

The problem is that this is not how it works; the patient should be the one to decide the approach in collaboration with their physician. Part of the communication and treatment at the hospital is to make sure that the patient is put at the front seat; choosing and affecting their treatment if they wish to. A rewording is necessary to reflect the actual situation.

Some new functionalities have been requested for the upcoming iteration:

- So far, measurements made during a procedure (see section 4.4) have not been taken into consideration yet. While the dropdown element has worked well since its integration, there is a request for adding information about measurements to it. The hospital staff may perform various measurements such as blood pressure and body temperature, and the dropdown element seems like a suitable place for these measurements.
- The rating overlay should include a comment section where the user may give their opinion of a procedure through text. This would enable more extensive feedback from patients. The overlay has remained unchanged since Figure 5.23.
- Lastly, another set of customization is wanted; namely to change the order of procedures within a phase. If one phase contains two procedures *A* and *B*, then the user should be able to reorder these such that *B* appears before *A*. This has the potential to put the focus on the procedures that matter the most for each patient.

Apart from that, something that is missing so far is an onboarding sequence. Currently there is nothing that is welcoming the user to the application, something which is important considering the circumstances. The user should also be invited to create an avatar as one of the first tasks to be performed.

5.7 Iteration 7: Final prototype

The seventh and last iteration leads us to the final prototype used in the evaluation. It keeps the visual style similar as of iteration 6, but with a few key changes that add up to the overall experience.

Starting with the onboarding in Figure 5.31, this sequence is centered around the task of getting the user up and running for the application. During the sequence, the user may choose their avatar and be given an introduction to the elements of the timeline page. This introduction is done on the timeline page itself, explaining the various elements to the user as they appear. This is also a good place for making sure the user agrees to the usage of their personal and sensitive data.

The comment section request for the rating page has been met as shown in Figure 5.32. To accommodate for the space needed for the comment section, the explanatory text previously shown on the top of the overlay has been hidden, only to be shown when tapping an information icon on the top right. This comment is reflected in the dropdown element in Figure 5.34, which now also contains eventual measurements made by a physician.

A new overlay (Figure 5.33) has been made for procedure groups as mentioned above. When tapped, it expands to cover the screen, listing its procedures. These procedures may be rearranged as the user sees fit. Though, this functionality is not interactive in the prototype made in this iteration.

5.7.1 Analysis

When working on the final prototype, it was discovered that every case was not considered for the rating system; that is, which emojis to display on a procedure after rating it. The idea is to show feelings that have been measured to be greater than 50 % and hide the others. If there is no rating, then a

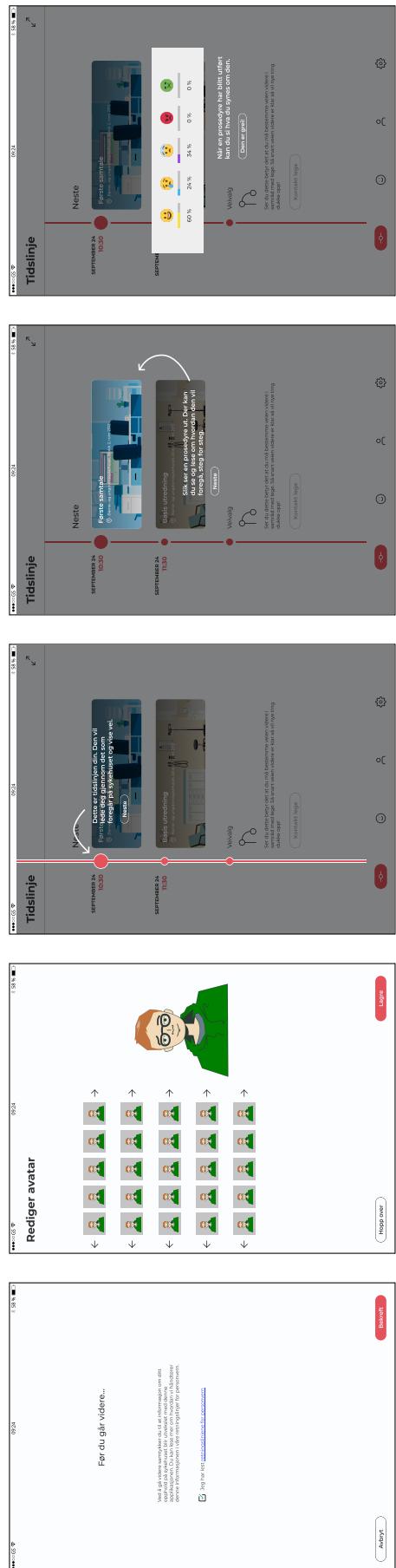
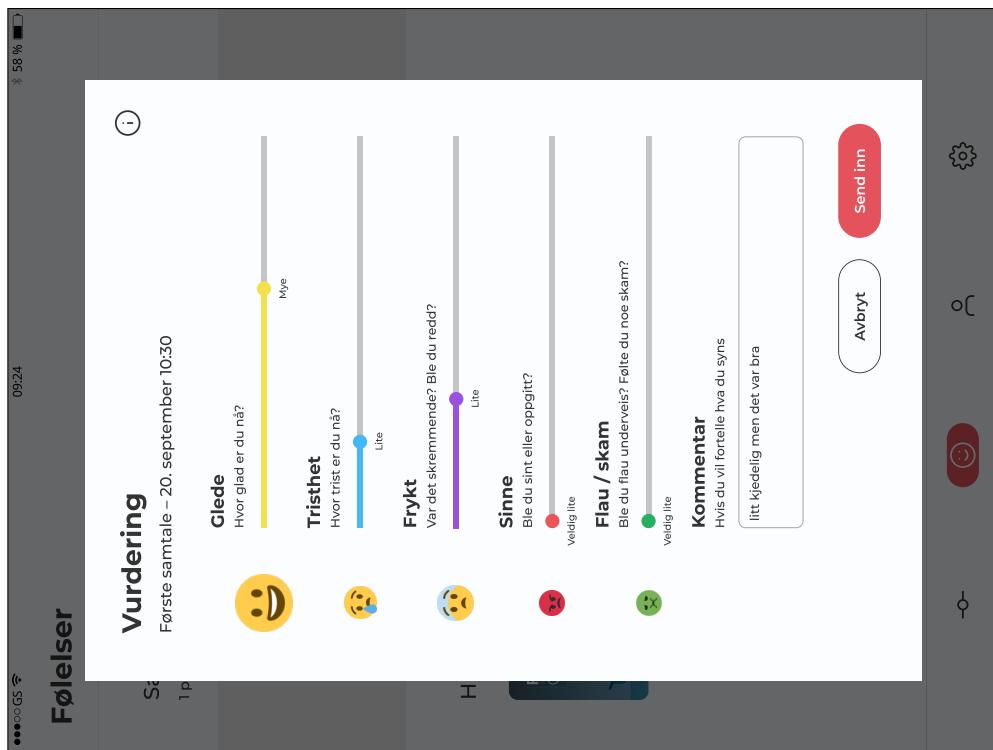


Figure 5.31: Onboarding sequence



(b) Explanatory text when expanded

Figure 5.32: Updated rating overlay

(a) Rating overlay with a comment section

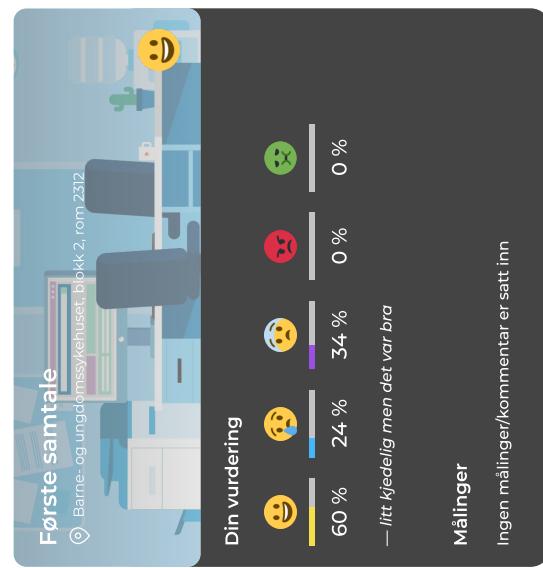


Figure 5.34: The new dropdown element



Figure 5.33: A group containing several procedures that can be rearranged

semi-transparent emoji is shown instead. Something that was not thought about was the fact that the user could rate every feeling below 50 %, resulting in no emojis being shown. It was therefore decided to reflect this situation with a neutral emoji. In that way, it symbolizes the fact that a rating—despite it lacking feelings—has been given.

Chapter 6

Evaluation

To verify that the design works as intended, a more extensive evaluation of the final prototype has been made.

6.1 The test group

While it would be beneficial to let the patients—the primary target group—use the final prototype for evaluation purposes, there are some reasons why this is not a good idea:

- Firstly, the prototype is not fully functional and some actions and gestures are not supported, which could lead to awkward or even harmful moments when something that is not interactive is anticipated to be.
- Secondly, the low age of the patients induce a high risk of misunderstandings when it comes to the testing; the prototype can easily mistaken for a final product and a patient may not necessarily understand that the situation is a general case and not tailored to their current situation, possibly leading to further misunderstandings.

Therefore, a different test group has been sought for. At Haukeland University Hospital, a youth council has been set up to represent and voice for the younger patients. The youth council is an advisory body with a mission to help the hospital to reach goals that children and youth have. A member of this council will, together with senior consultant psychiatrist Thorsen, form the test group for this evaluation. Although the group is quite small and consists of ages significantly higher than the intended target group, both subjects have ample knowledge about treatment of children in hospitals.

6.2 Performing the evaluation

The evaluation took place in a meeting room at the Children and Youth Clinic. The interaction with the application was done through an Apple iPad as the test subjects were observed. During the evaluation, the subjects were free to use the prototype as they wanted and intervention was kept to a minimum; in other words, they were not directed into making choices. Still, both subjects were informed that they could initiate questions and give comments at any time. Some questions, if not already answered, were given afterwards as a form of semi-structured interviews. Notes were written on a laptop by the side together with a stopwatch for measuring the time spent with the prototype.

Some elements had to be clarified as they were not part of the prototype themselves:

- The first detail was a skip button placed on the lower right corner of the screen that was used to skip ahead in time. Normally the user would have to wait until each procedure has passed until

they can rate it, so instead of waiting, the subjects could skip to the next point.

- Another detail being that procedures in Figure 5.33 can not be rearranged although that is the intention.
- A third detail is the aforementioned rating screen where the sliders can not be properly interacted with, and the most predictable solution for the prototype is to show a pre-defined scoring after one tap.
- Lastly, the prototype was restricted to the first two phases only, and some functionalities were not made interactive.

The prototype was split up into 'states' in order to prevent accidental backtracking. The initial state is before skipping time; the second state being after. A third state is introduced after rating the procedure as to not lose said rating. Errors in the prototype were commented and corrected during the evaluations, with the subject being immediately redirected to the intended screen.

6.3 Results

Both test subjects had a positive perception of the prototype. They reported it to be easy to use, informative and self explanatory. Comments were mostly positive although some suggestions were given for further development.

The subjects found the visual style to be simple, clear and visually attracting. Despite the simplicity, the subjects had few problems finding out where to navigate and which buttons to tap. The onboarding sequence was followed with ease, each step bringing the subject to the next one. Some buttons, or rather tappable areas, were a bit small and did not activate despite the user tapping said buttons.

The timeline pages were understood by the subjects, although one of them assumed that the elements of the guideline pathway (see Figure 5.25b) were tappable, which they were not and probably should have been, considering the subject had a pretty disappointed reaction. However, what was not anticipated was that the subject also tapped the circles of the timeline, expecting to enter a guideline pathway phase or to open a procedure.

The subjects found the procedure pages to be straightforward, one of them finding it to be a better alternative to a textual representation. One of the subjects had the following comment:

I like how there is little text for each picture. I find it difficult to read if there is too much text.

which is interesting to hear. Not only does a graphical illustration make it more clear and engaging for the user, but the corresponding reduction of text is also beneficial, putting this approach in significant favour for this specific subject compared to documents filled with text. On the other side, the other subject appreciated the ability to view the textual representation of the procedure, underlining the importance of having choices.

The subjects had mixed impressions of the procedure group overlay; it seemed unnecessarily confusing and one of the subjects had problems navigating out of it. This is probably better left off as part of the initial timeline page and such procedure groups may be separated by headers.

When arriving at the ratings page, both users seemed to be engaged and treated it well despite not having the intended functionality. One of the subjects tried to recall this rating system to a different one, but said that the use of colours was different. Neither subject tapped the information icon and accessed the extra info text that can be revealed.

One of the subjects commented that the application could be used to explain medical terms for the user. The subject stated that not everyone knows what a procedure means, considering the low target

group age. Meanwhile, the other subject suggested having a small popup window explaining these terms when tapping them.

The subjects spent 11.5 minutes and 12.5 minutes fiddling with the prototype. The first subject investigated each screen before moving on (similar to a breadth-first search), however the second subject followed the flow in a depth-first manner and proceeded to rating the procedure before discovering other pages of the application. Opinions regarding performance and responsiveness were of less importance as the prototype was not made with the intended architecture; i.e. it was not built upon a codebase. The prototype tool had some issues transitioning between pages at the intended speed, and unresponsiveness made the subjects confused at some points.

An area that was yet to be inquired is one of ‘trustability’; of which degree the user would trust the application and let it process their data. Therefore, the following question was asked: ‘Would you trust this application?’ The subjects were positive to it, although one of them had a slight concern regarding the risk of data loss as a result of hacking. The issue of security is mentioned as an anticipated challenge in section 7.4.

Another concern was about visibility of their personal data – who would have access to their journal? The journal should be restricted to certain members of the staff who have a reason to look into the data. The journal system at Helse Bergen currently uses an *access log* of which the user can see who have accessed their journal. Investigating the possibility to use and display this log is an idea for future development.

Chapter 7

Application outline

Throughout this project, an implementation of the application has been planned. This chapter outlines how such an implementation may look like.

7.1 Implementation details

Following the reasoning in section 5.6 and section 8.1, the current approach is to split the application in two; an web application for patients (optimized for tablets) and a web application for the staff (optimized for desktop). The avatar generation system is to be integrated into both applications. An extended use case diagram is shown in Figure 7.1 to reflect these changes.

A revised and more detailed domain model is shown in Figure 7.2. Here, the concepts of the domain are further analysed and made more concrete. A procedure is now made up of several *pages* and a textual *document*. Each page may include a drawing, a video or an image depending on its source. The user's avatar is only displayed in a DrawingPage. The concepts of PictogramApp (stories and scenes) are carried over to the application as well, although named as *procedures* and *steps* respectively.

7.2 Architecture

The architecture follows a similar pattern to many production-scale web applications, being based on web- and application servers. These servers are exposed through a firewall, making them accessible through a web browser. For extra security, the application may be exposed only to the networks used at the relevant hospitals.

7.2.1 Backend

The planned application involves a .NET Core backend.

7.2.2 Frontend

(...)

7.3 Integration with existing systems

When viewing this application together with existing systems, it (...). The application can be used in many steps of a particular guideline pathway. The application's flow of information can be seen in light of a guideline pathway, and the model seen in figure 7.3 takes the guideline pathway of mental disorders for children and youth (Haugland and Landsholt, 2018) as an example.

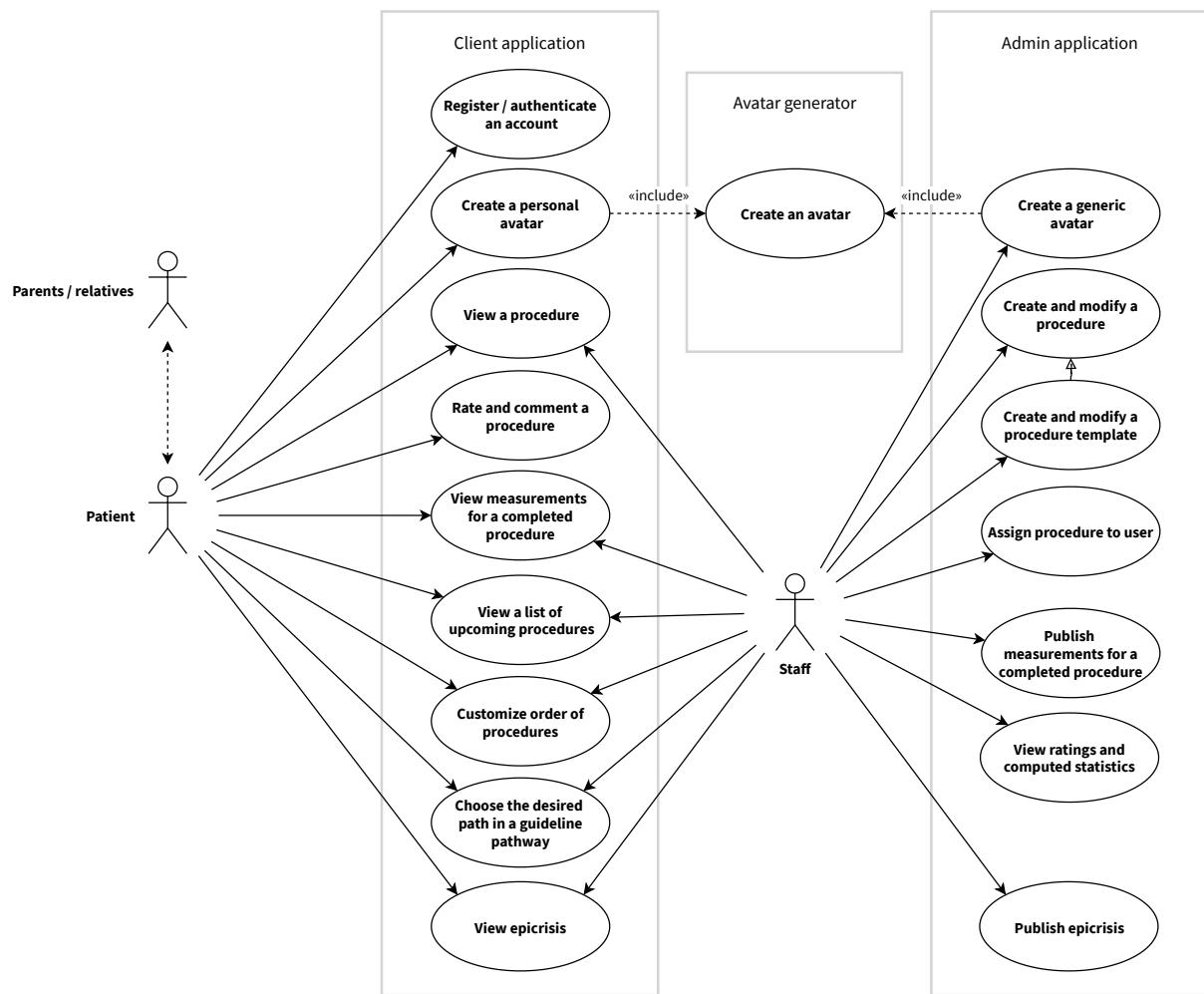


Figure 7.1: Extended use case diagram

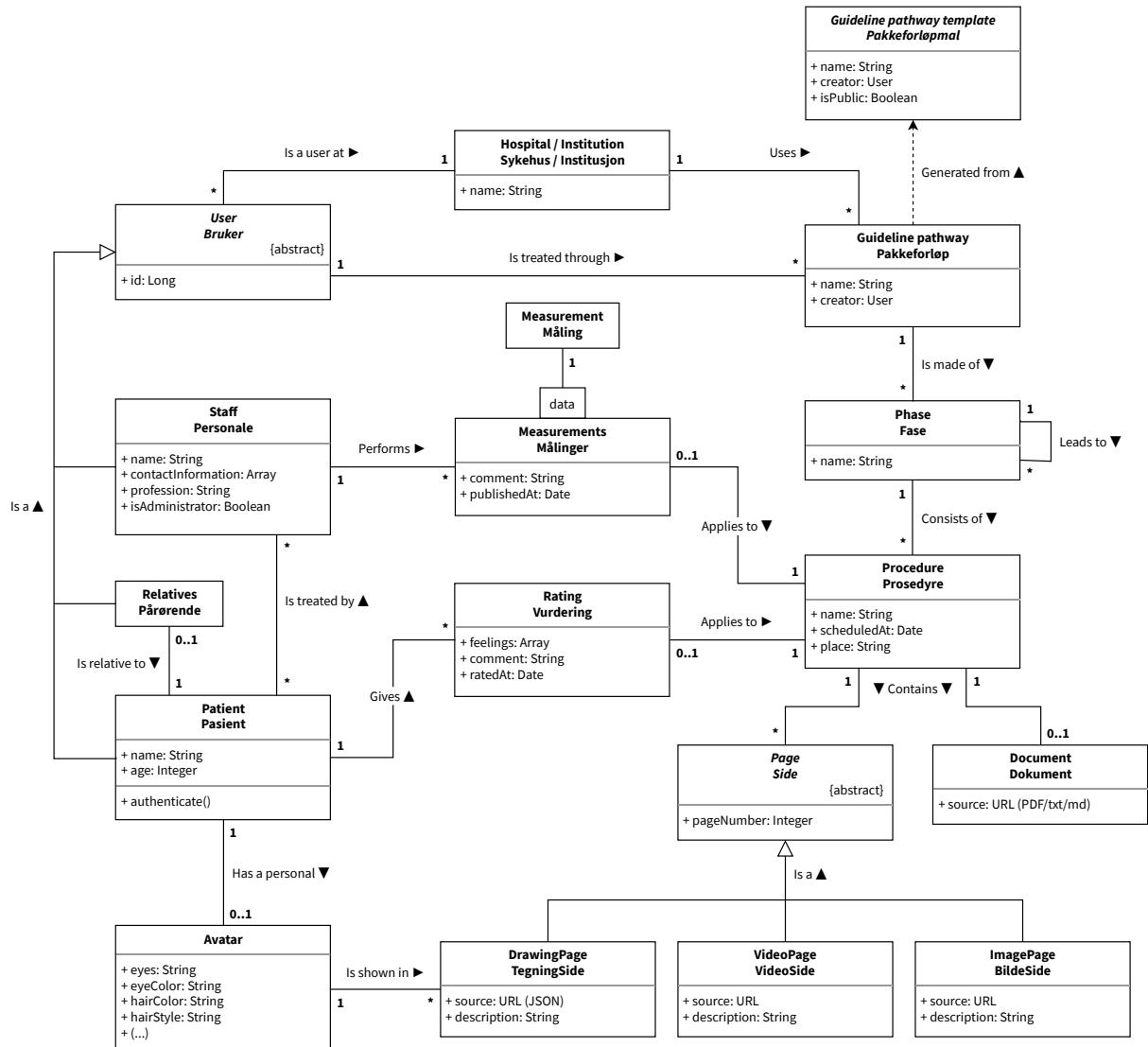


Figure 7.2: Extended domain model

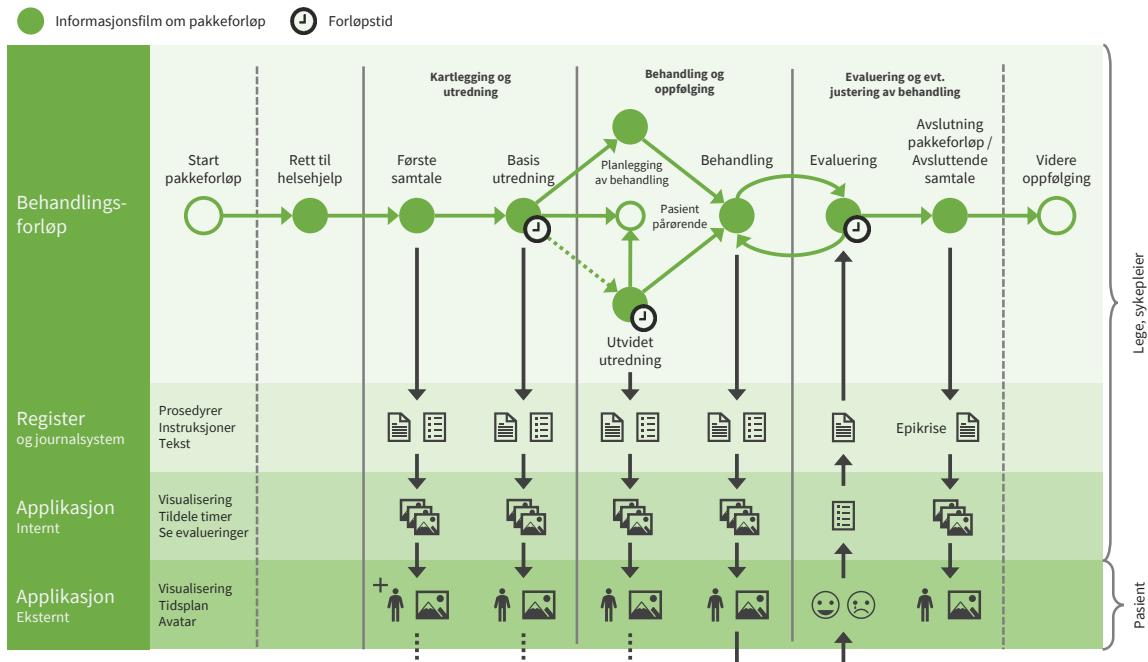


Figure 7.3: Application model as illustrated through a guideline pathway

This application is intended to be used together with the avatar generation system from E-LAN described in section 2.4. The software seems to run on Windows with support for a web client, and outputs two-dimensional portrait pictures.

7.4 Anticipated challenges and feasibility

The development tools chosen for an application should support the functionality of the application. The following subsections illustrate a few scenarios which the chosen development tools should support.

7.4.1 Personalised avatars

The avatar generation system created for E-LAN (from 2.4) can be used together with the application. This enables the user to view their avatar in procedures like they were participating themselves. A challenge lies in associating an avatar to each user while making it easy to modify it when needed. The system is based on a graphical user interface and does not present an API; it is very much a black box where the result is an exported PNG file.

7.4.2 Realistic avatar projections

The system outputs two-dimensional portrait images only, with the face and chest facing forward. The images are also limited to the top part of the body, leaving the lower body out. Concerns were raised about whether these images would look realistic in certain settings. For example, using a single 2D image, a person laying in the bed would look awkward unless viewed from above the bed. To deal with this, there are several approaches as seen in table 7.1.

It is shown that 2D images can be rotated in 3D pretty realistically. Rivers et al. (2010) carried out a project which showed that it is possible to view a figure from any angle when given three 2D projections of it.

Though, an alternative is to simply use such avatars in 2D-space.

	Realism	Processing power	Ease of use	Additional requirements
2D images	Lowest	Lowest	Highest	None
2D image sets with various poses	High	Low	High	Extra image sets
2D images rotated in 3D	Low	High	Low	Software framework which supports 3D rotations
3D models	Highest	Highest	Lowest	New 3D models; a 3D rendering engine; software framework which supports 3D rotations

Table 7.1: Different ways to project an avatar on a screen

The IACTA application shows that this can be used with similar effect as a 3D-application (Stålberg et al., 2018).

7.4.3 Visual art and template designs

This brings us to the next challenge. (...)

7.4.4 Connections between client and administrator applications

(...)

7.4.5 Integrations towards current healthcare systems

(...)

7.4.6 Security concerns

(...)

7.4.7 Service workers and offline content

(...)

7.4.8 Scaling

(...)

7.4.9 Costs

(...)

7.5 Handoff

The scope of this project involves minimal integration with existing healthcare and journal systems at the Children and Youth Clinic and Haukeland University Hospital. Given that Helse Vest IKT monitors

most of said systems, it would be sensible to develop an application that can be adapted, or even be developed further on, by them. It was pointed out that the developers of the avatar generation system used well-established web technologies such as HTML, CSS and JavaScript to develop it, and that similar technologies were preferred for the new application. This led to a new direction in choosing the most suitable software tools.

Attached to this thesis are Figma project files for the client and administrator applications. The former is interactive and the one used in this project's evaluation.

(...)

Chapter 8

Tools and technology

Different types of technology and kinds of application are reflected upon in this chapter. The following discusses reasons behind choices that were made in the implementation planning process.

8.1 Choice of application setup

As previously stated in section 4.4, the Children and Youth Clinic indicated the application to be used for tablets with medium to large screens. In Norway, most of such tablets either run a full-fledged operating system (OS) such as Windows or a mobile OS such as Android and iOS.

As with most applications, there is a choice between the following approaches:

- A *native application* is written in each operating system's native languages. For Android this is Java, and Swift and Objective-C for iOS. Native applications can access all features which each OS may offer.
- Another native application approach is to write the application in a different language and transpile it to native code. The resulting application is then very similar to a native one and has comparable performance.
- A *hybrid application* encapsulates a web page into a smartphone application. Such applications use a browser instance to render elements, although without the search bar and tools of the browser. This approach offers functionality that you don't get with web applications, but has usually worse performance compared to a native solution.
- A *mobile web application* is a responsive web page shown in the user's web browser. These do not appear in app stores but function just like an ordinary web page. Lately there have been increasing interest in Progressive Web Apps (PWAs) which aim to provide mobile web pages with app-like behaviour and functionality such as push-notifications. PWAs do, however, require a website which is capable of serving HTTPS.
- A *desktop application* is an application that can be installed on operating systems such as Windows, macOS and Linux. As some tablets run Windows, this is also an alternative to be considered. The immediate downside is that they will not run on mobile operating systems. These applications are not necessarily cross-platform, but may be if they are built with cross-platform tools and software (similarly to a hybrid application).

Progressive Web Applications are a relatively new kind of technology with increasing support in both Android and iOS. Some browsers also support adding an app icon to the user's app launcher, circumventing app stores in the process.

Determining which approach to use requires paying attention to several factors: requirements, anticipated challenges and stakeholder interests among others. The requirements suggest using a cross-platform application primarily aimed for tablet devices, while Helse Vest IKT suggest using web technologies when developing the application. General factors such as cost, ease of use, responsiveness, support for older devices and debugging also play a role.

Based on this, mobile and desktop applications are considered to be less suitable. Although mobile application frameworks make it possible to transpile JavaScript into native code, the syntaxes vary greatly and may not suit developers who are more familiar with web development. This leads us to two remaining approaches:

- The first approach is based on *hybrid applications*, using HTML, CSS and JavaScript. These are typically built upon using a WebView, a browser instance that can be used by the application. Some frameworks offer their own JS-like language, providing additional methods and native functionality, which are compiled into traditional JavaScript.
- The second approach is through web applications which run in web browsers. There is always the possibility to enhance a web application, turning it into a Progressive Web Application. The application must be run through a web browser or through an app shortcut if a PWA is made.

Given that both hybrid applications and web applications use web browsers (WebViews) to show content on the screen, their performances are assumed to be comparable. The main difference is how a hybrid application is dependent on an app store whereas a web application is dependent on a website. In this case, a self-running application will require less server and networking resources. Comparing hybrid applications and PWAs, both support offline content, although the technology used for this in PWAs are still in an experimental state.

8.2 Frameworks

Next to consider is frameworks. Frameworks allow developers to develop an application more efficiently by facilitating APIs, UI components, navigation, MVC patterns, utility methods or a combination of these. Some frameworks can also help deploying the application to app stores. Table 8.1 shows a few frameworks and what functionalities they offer.

The most common way to make a hybrid app is to use a Cordova-application. Apache Cordova is the original concept while Adobe PhoneGap is an extension to Cordova and acts much the same with some additional features.

It is unknown which frameworks the web developers of Helse Vest IKT have used previously, if any. A starting point is to assume that web developers have some prior experience with popular web frameworks. Any framework used for the project should therefore be easy to learn for any person skilled in HTML, CSS and JavaScript.

A framework worth explaining is React. React Native is a mobile version of React, able to transpile code to both Android and iOS.

Is it too difficult for a web developer to learn React and its adjacent technologies? Learning React most likely requires learning JSX, Redux and Flux as well. Although (...)

8.3 Database system

SQL vs NoSQL

Framework	Functionality	Description
Meteor	Native compiler	JavaScript
NativeScript	Native compiler	JavaScript
React Native	Native compiler	Mobile version of React. Supports hot reloading. Focuses on Single Page Applications (SPAs).
Apache Cordova	App wrapper	
Adobe PhoneGap	App wrapper	
Ionic Capacitor	App wrapper	
Angular	Navigation	
Framework7	Navigation & UI	
Ionic	Navigation & UI	
React (+ Flux)	Navigation & UI	JavaScript and JSX (HTML-like syntax represented as JavaScript objects). Supports hot reloading.
Vue.js	Navigation & UI	
Bootstrap	UI	
Onsen	UI	
Polymer	UI	
Semantic UI	UI	

Table 8.1: List of web developer friendly frameworks for mobile and web application development

8.4 Storage

JSON

Chapter 9

Conclusion

The conclusion is based on several factors, including the evaluation of the final prototype, the research question and the aims that were set. When taking these factors into consideration, the main conclusion is that this project is found to be successful.

9.1 Discussion

The biggest factor is the evaluation of the final prototype. It follows a methodology based on an iterative design process that is evaluated using a usability test combined with semi-structured interviews. This evaluation was positive as the subjects found the prototype to be easy to use, informative and self explanatory. There is quite a potential for the application as procedures can be illustrated graphically and, if suggestions from the evaluation are followed up, can explain medical terminology that is used in the handed-out information. In summary, the evaluation showed that both the design and the concept altogether are working well.

With this outcome, the research question can be considered as answered. Building upon national guideline pathways, the resulting prototype has the potential to offer a more personalized experience for children and youth. Despite guideline pathways being standardized, this project provides an insight in how they can be made more personal and engaging.

Looking at the aims that were set in section 1.3, the progress of the application needs to be considered. The first aim:

(...) to look at how the information from hospitals may be formed and the way it is given, and adjust this information flow such that it is more engaging and understandable for children and youth.

can be considered achieved as the design is a result of an iterative process, constantly improving upon the shape of how information about procedures are shown. The design was also shown to be engaging and understandable in the evaluation. The second aim:

(...) to facilitate how children and youth may participate in decision-making and give feedback about their treatment as a step in personalizing the treatment itself.

is rather doubtful as the application stands. Although the feedback part has been thoroughly explored, decision-making has been given less precedence. Apart from viewing procedures, there are only a few places in the application that encourage decision-making, one being procedures that can be rearranged (see Figure 5.33) and another being *veivalg* (path selection) (see section 5.6). Feedback can be considered a part of decision-making, but a small one at that. As it stands, this is an area of responsibility primarily left for health professionals and parents.

9.2 Reflections

The means of the evaluation could have been better, most notably the target group which has little resemblance to the actual target group. As previously stated (section 6.1), this was due to several risks combined with the prototype. However, as one of the subjects is a senior consultant psychiatrist and the other subject is a member of the hospital's youth council, the evaluation has a certain value. Looking back, a possible improvement would be to evaluate the prototype with a group of non-hospitalized children who are aware of the difference between an unfinished prototype and a finished product.

It would also have been preferred if a prototype built on the intended architecture was made. Only code-less prototypes were made, focusing on the design rather than the implementation. Time was the biggest factor as to why a software implementation was only planned but not attempted.

9.3 Further work

Due to the application being only a prototype, further work involves an implementation of the application. Though, there are also several parts of the design and planning that can be improved.

Some of the elements of the design have not been carried over since the earlier iterations, e.g. the graph and list representations of a procedure's rating history (Figure 5.16). These can be combined into the current design, enhancing it.

As stated in the evaluation, there are several wishes to the design. One would be to explain medical terminology, possibly with a popup element explaining each term when tapped. Another possible improvement would be to look into the procedure group overlay and integrate it into the timeline view or make the overlay easier to navigate.

A requested feature not mentioned yet is the ability to participate in several guideline pathways and have a unified view of them. This would involve viewing procedures from both pathways at the same time, scheduled along the timeline. That is, if this situation is technically feasible. That ultimately depends on the hospital systems, and the integration between them if that is an option.

As for the planning, the architecture does not take scaling into consideration, and making it scalable involves software and technology not mentioned in this thesis. The transparency of cloud solutions can alternatively be considered. Depending on whether the system must be hosted locally or not, this has to be thought of beforehand.

Other than a mere static web page built for testing purposes, there is currently no implementation of the application. The implementation and planning of it is described in chapter 7 and chapter 8 but the implementation itself is left for further work. That being said, the choice of tools is made on the basis of several aspects, including Helse Vest IKT's preference of languages and the requirements from the Children and Youth Clinic. If these change, the desired form of the application may change as well. This will remain for a later time.

Bibliography

- Coyne, I. (2006) Consultation with children in hospital: children, parents' and nurses' perspectives. **Journal of Clinical Nursing**, 15 (1), pp. 61–71.
- Coyne, I. (2008) Children's participation in consultations and decision-making at health service level: A review of the literature. **International Journal of Nursing Studies**, 45 (11), pp. 1682–1689.
- Coyne, I. and Gallagher, P. (2011) Participation in communication and decision-making: children and young people's experiences in a hospital setting: Participation in communication and decision-making. **Journal of Clinical Nursing**, 20 (15), pp. 2334–2343.
- Delp, C. and Jones, J. (1996) Communicating Information to Patients: The Use of Cartoon Illustrations to Improve Comprehension of Instructions. **Academic Emergency Medicine**, 3 (3), pp. 264–270.
- Design Council (2007) **Eleven lessons: managing design in eleven global brands**. London: Design Council. Available from: <<https://www.designcouncil.org.uk/resources/report/11-lessons-managing-design-global-brands>> [Accessed 2nd December 2019].
- Fure, M., Spinnangr, N. and Syslak, I. (2017) **PictogramApp: Digital staging of pictograms**. Bachelor thesis, Western Norway University of Applied Sciences.
- Haugland, K. K. and Landsholt, L. E. (2018) **Et løft for sterkere brukerinvolvering** [Presentation]. Nasjonal lanseringskonferanse – Pakkeforløp for psykisk helse og rus. Helsedirektoratet, Oslo. Available from: <<https://youtu.be/7wGD6hsjA4w>> [Accessed 27th November 2019].
- Helse Bergen (2018) **Suksess for ELAN i Energisenteret** [Internet]. Available from: <<https://helse-bergen.no/nyheter/suksess-for-elan-i-energisenteret>> [Accessed 20th November 2019].
- Helsedirektoratet (2018) **Pakkeforløp for utredning og behandling i psykisk helsevern, barn og unge** [Internet]. Available from: <<https://www.helsedirektoratet.no/pakkeforlop/psykiske-lidelser-barn-og-unge>> [Accessed 3rd December 2019].
- Helsedirektoratet (2019) **Om Helsedirektoratets normerende produkter** [Internet]. Available from: <<https://www.helsedirektoratet.no/produkter/om-helsedirektoratets-normerende-produkter>> [Accessed 27th November 2019].
- Kelly, M. M., Hoonakker, P. L. T. and Dean, S. M. (2017) Using an inpatient portal to engage families in pediatric hospital care. **Journal of the American Medical Informatics Association**, 24 (1) January, pp. 153–161.
- Lambert, V., Glacken, M. and McCarron, M. (2011) Communication between children and health professionals in a child hospital setting: a Child Transitional Communication Model: Communication between children and health professionals. **Journal of Advanced Nursing**, 67 (3), pp. 569–582.
- Lien, L. H. and Booth, A. (2018) **Pictogram-me** [Internet]. Research Catalogue. Available from: <<https://www.researchcatalogue.net/view/157238/157386>> [Accessed 17th February 2019].

Maher, M., Kaziunas, E., Ackerman, M., Derry, H., Forringer, R., Miller, K., O'Reilly, D., An, L. C., Tewari, M., Hanauer, D. A. and Choi, S. W. (2016) User-Centered Design Groups to Engage Patients and Caregivers with a Personalized Health Information Technology Tool. **Biology of Blood and Marrow Transplantation**, 22 (2), pp. 349–358.

Nielsen, J. (1994) Heuristic evaluation. In: Nielsen, J. and Mack, R. L. eds. **Usability Inspection Methods**. New York, John Wiley & Sons.

Norwegian Air Shuttle (2012) **Safety onboard (NO)** [Internet]. Available from: <<https://youtu.be/TEHa653fMyY>> [Accessed 28th November 2019].

Preece, J., Rogers, Y. and Sharp, H. (2015) **Interaction design: beyond human-computer interaction**. Fourth edition. Chichester, Wiley.

Rivers, A., Igarashi, T. and Durand, F. (2010) 2.5D cartoon models. **ACM Transactions on Graphics**, 29 (4) July, p. 1.

Stålberg, A., Sandberg, A., Larsson, T., Coyne, I. and Söderbäck, M. (2018) Curious, thoughtful and affirmative-Young children's meanings of participation in healthcare situations when using an interactive communication tool. **Journal of Clinical Nursing**, 27 (1-2) January, pp. 235–246.

Stålberg, A., Sandberg, A., Söderbäck, M. and Larsson, T. (2016) The child's perspective as a guiding principle: Young children as co-designers in the design of an interactive application meant to facilitate participation in healthcare situations. **Journal of Biomedical Informatics**, 61 June, pp. 149–158.

Vaage, N. S. (2014) **Like an Open Door** [Internet]. University of Bergen. Available from: <<https://www.uib.no/en/arts-and-gardens/77578/open-door>> [Accessed 21st November 2019].