

MASTER'S THESIS 2021

# Efficiency and planning in the Swedish healthcare system – *and design of a digital scheduling tool*

Mia Cicovic, Sanna Nordberg

DIVISION OF ERGONOMICS & AEROSOLTECHNOLOGY |  
DEPARTMENT OF DESIGN SCIENCES |  
FACULTY OF ENGINEERING LTH | LUND UNIVERSITY



UPPSALA  
UNIVERSITET



Efficiency and planning in the Swedish  
healthcare system  
– *and design of a digital scheduling tool*

Effektivisering och planering i det svenska  
sjukvårdssystemet  
– *och design av ett digitalt schemalägnings-  
verktyg*

Mia Cicovic, Sanna Nordberg



**LUND**  
UNIVERSITY

---

# Efficiency and planning in the Swedish healthcare system – *and design of a digital scheduling tool*

---

Mia Cicovic  
mi0454-s@student.lu.se

Sanna Nordberg  
bmp15sno@student.lu.se

September 10, 2021

Copyright © 2021 Mia Cicovic, Sanna Nordberg

*Published by*

Department of Design Sciences Faculty of Engineering LTH, Lund  
University P.O. Box 118, SE-221 00 Lund, Sweden

Master's thesis work on subject Interaction Design (MAMM01) carried out  
at Division of Ergonomics and Aerosol technology, Department of Design  
Sciences, Lund University.

Supervisor:

Christofer Rydenfält, [christofer.rydenfalt@design.lth.se](mailto:christofer.rydenfalt@design.lth.se)

Co-supervisors:

Gustaf Hedström, [gustaf.hedstrom@igp.uu.se](mailto:gustaf.hedstrom@igp.uu.se)  
Mikael Laaksoharju, [mikael.laaksoharju@it.uu.se](mailto:mikael.laaksoharju@it.uu.se)

Examiner:

Johanna Persson, [johanna.persson@design.lth.se](mailto:johanna.persson@design.lth.se)

## Abstract

The Swedish regions struggle with resource utilization issues that threaten the ability to provide timely and efficient healthcare to the citizens. This study aims to investigate and map the current production, planning, and scheduling processes within the Swedish healthcare, as well as develop a digital solution.

This is done through a user-centered design process, with the goal of designing a digital solution that will assist hospital staff in their everyday work. An extensive user study was performed where 23 subjects from five different hospitals around Sweden were interviewed. The data from these interviews was analyzed with a thematic analysis to find and understand the needs and requirements of the users. Based on the results of the user study, four personas were created that conveyed the different needs. In addition, nine conceptual models of possible solutions were created, incorporating the mentioned personas. After evaluation of the concepts it was decided to go forward with a model of a digital support for schedulers and personnel within healthcare, that aims to aid in making functional schedules more efficiently.

From the final concept, three iterations of prototyping were performed; two lo-fi prototypes mainly sketched on paper, and one digital hi-fi prototype. All iterations included designing, testing and evaluating the prototype on 3-5 test subjects, and applying the feedback in the next iteration. A final model was created based on the feedback from the hi-fi iteration. Throughout the process an effort was made to incorporate and meet as many of the found needs as possible.

The final model is a prototype of a website for schedulers and personnel at hospitals, aiding them in making functional, healthy schedules. The next steps are to further develop the prototype, test it more widely on hospital personnel, and implement the software.

With this thesis, we have established some of the main needs in the Swedish healthcare sector relating to production, planning and scheduling. The extensive user study has shed light on several areas within this scope with a need for improvement. These include scheduling of staff, organizational workflow, organizational structure and coordination, work procedures, work environment, and communication. The prototype presented succeeds in meeting some of these needs. In order to meet all needs further research and a closer collaboration with healthcare professionals is necessary.

**Keywords:** Healthcare, production, scheduling, planning, UX



## Sammanfattning

Regionerna i Sverige kämpar med frågor om resursutnyttjande som hotar möjligheten att kunna ge medborgarna en snabb och effektiv vård. Denna studie syftar till att undersöka och kartlägga de nuvarande produktions-, planerings- och schemalägningsprocesserna inom den svenska sjukvården samt att utveckla en digital lösning.

Detta görs med hjälp av en användarcentrerad designprocess, där målet är att designa en digital lösning som ska hjälpa sjukhuspersonalen i deras dagliga arbete. En omfattande användarstudie utfördes där 23 personer från fem olika sjukhus runt om i Sverige intervjuades. Data från dessa intervjuer analyserades med en tematisk analys för att hitta och förstå användarnas behov och krav. Från resultatet av användarstudien skapades fyra personor som lyfte fram de olika behoven. Vidare skapades nio konceptuella modeller med möjliga lösningar som innefattade de nämnda personorna. Efter utvärdering av koncepten bestämdes det för att gå vidare med en modell av ett digitalt stöd för schemaläggare och personal inom vården, för att på ett effektivare sätt kunna skapa funktionella scheman.

Från det slutliga konceptet utfördes tre iterationer av prototyper; två lo-fi prototyper huvudsakligen skissade på papper, och en digital hi-fi prototyp. Alla iterationer bestod av att designa, testa samt utvärdera prototypen på 3-5 testpersoner, och applicera den mottagna feedbacken på nästa iteration. En slutgiltig modell skapades utifrån feedbacken från hi-fi iterationen. Under processens gång lades stor vikt vid att få med och möta så många av dem funna behoven som möjligt.

Den slutliga modellen är en prototyp av en webbplats för schemaläggare och personal på sjukhusen, som ska hjälpa dem att göra funktionella, hälsosamma scheman. Nästa steg är att vidare utveckla prototypen, testa den på fler anställda inom sjukvården och implementera programvaran.

Detta examensarbete har lyft fram de mest centrala behoven inom den svenska sjukvården kopplat till produktion, planering och schemaläggning. Den omfattande användarstudien har belyst flera områden med behov av förbättring. Dessa innefattar schemaläggning av personal, verksamhets- och patientflöden, verksamhetsstruktur samt koordinering, arbetssätt, arbetsmiljö och kommunikation. Prototypen som presenteras i rapporten möter några av dessa behov. För att möta alla behov krävs det däremot mer forskning och närmare samarbete med sjukvårdspersonal.

**Keywords:** Healthcare, production, scheduling, planning, UX



# Acknowledgements

---

In this section we would like to express our gratitude toward the people who have helped in making this Master's thesis possible.

To our supervisor from the department of Design Sciences at LTH, Christofer Rydenfält, we would like to say thank you for all your support and guidance. It has helped us throughout the process of completing our work and writing this thesis. Thanks for all your input and feedback. To our co-supervisors at Uppsala University, Gustaf Hedström and Mikael Laaksoharju, we extend our thanks for your useful insights and well-rounded advice. Your experience and knowledge in design and healthcare have been of great help all through the process of working with this Master's thesis. Gustaf, we would like to give a special thank you to you for providing us with the contacts to the five hospitals. These contacts have been invaluable, and constitute the very base of the study. Without your help this thesis would have looked very different.

Furthermore, we would like to express our gratitude to the initial contact persons at the five hospitals who efficiently and helpfully provided us with contact information to their staff. We also want to thank all the employees who took the time to participate in our study without hesitation. Thank you for you sharing your thoughts, your honesty and your patience.

In addition, we extend a great thanks to all the people who participated in the testing of our prototypes. The feedback received was of great value, and has had fundamental impact on the iterations and final model of the prototype. Thank you for your honesty, enthusiasm, creative ideas, and new ways of looking at the concept.

Lastly, we want to thank our families and friends for their support throughout this project.



# Contents

---

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Introduction</b>                     | <b>1</b>  |
| 1.1      | Background . . . . .                    | 1         |
| 1.2      | Aim . . . . .                           | 2         |
| 1.3      | Delimitations . . . . .                 | 3         |
| <b>2</b> | <b>Theory</b>                           | <b>5</b>  |
| 2.1      | Job strain and stress . . . . .         | 5         |
| 2.2      | Complexity within healthcare . . . . .  | 5         |
| 2.3      | Design theory . . . . .                 | 6         |
| 2.3.1    | Interaction Design . . . . .            | 6         |
| 2.3.2    | User Centered Design . . . . .          | 6         |
| 2.3.3    | Usability and User Experience . . . . . | 7         |
| 2.3.4    | Design principles . . . . .             | 7         |
| 2.3.5    | Gestalt Principles . . . . .            | 8         |
| 2.3.6    | F-shaped reading pattern . . . . .      | 9         |
| 2.3.7    | Fitts' law . . . . .                    | 9         |
| 2.3.8    | Hick's law . . . . .                    | 10        |
| <b>3</b> | <b>Process overview</b>                 | <b>11</b> |
| 3.1      | Design processes . . . . .              | 11        |
| 3.2      | Thesis process . . . . .                | 12        |
| <b>4</b> | <b>User study</b>                       | <b>15</b> |
| 4.1      | Interviews . . . . .                    | 15        |
| 4.1.1    | Preparation . . . . .                   | 15        |
| 4.1.2    | Pilot study . . . . .                   | 16        |
| 4.1.3    | Consent agreement . . . . .             | 16        |
| 4.1.4    | Conducting the interviews . . . . .     | 17        |
| 4.2      | Data analysis . . . . .                 | 18        |
| 4.2.1    | Thematic analysis . . . . .             | 18        |
| 4.2.2    | Final themes . . . . .                  | 20        |
| 4.3      | Requirement elicitation . . . . .       | 24        |

|           |  |           |
|-----------|--|-----------|
| <b>5</b>  | <b>Conceptual design</b>                                   | <b>27</b> |
| 5.1       | Personas and scenarios . . . . .                           | 27        |
| 5.2       | Conceptual models . . . . .                                | 30        |
| 5.2.1     | The nine concepts . . . . .                                | 30        |
| 5.2.2     | Evaluating the concepts . . . . .                          | 32        |
| 5.3       | The two final conceptual models . . . . .                  | 36        |
| 5.3.1     | The scheduling concept . . . . .                           | 36        |
| 5.3.2     | The production and flow concept . . . . .                  | 37        |
| <b>6</b>  | <b>Low fidelity prototyping</b>                            | <b>41</b> |
| 6.1       | First iteration . . . . .                                  | 41        |
| 6.1.1     | MyPage . . . . .   | 43        |
| 6.1.2     | The Scheduler . . . . .                                    | 44        |
| 6.2       | Testing and evaluating 1 <sup>st</sup> iteration . . . . . | 46        |
| 6.3       | Findings from the 1 <sup>st</sup> iteration . . . . .      | 46        |
| 6.4       | Second iteration . . . . .                                 | 48        |
| 6.4.1     | MyPage . . . . .   | 48        |
| 6.4.2     | The Scheduler . . . . .                                    | 51        |
| 6.5       | Testing and evaluating 2 <sup>nd</sup> iteration . . . . . | 53        |
| 6.6       | Findings from the 2 <sup>nd</sup> iteration . . . . .      | 53        |
| <b>7</b>  | <b>High fidelity prototyping</b>                           | <b>55</b> |
| 7.1       | Third iteration . . . . .                                  | 55        |
| 7.1.1     | MyPage . . . . .   | 56        |
| 7.1.2     | The Scheduler . . . . .                                    | 59        |
| 7.2       | Testing and evaluating 3 <sup>rd</sup> iteration . . . . . | 61        |
| 7.3       | Findings from the 3 <sup>rd</sup> iteration . . . . .      | 61        |
| <b>8</b>  | <b>Final model</b>   | <b>65</b> |
| 8.1       | Changes . . . . .  | 65        |
| 8.2       | Slides from the final model . . . . .                      | 66        |
| 8.2.1     | MyPage . . . . .   | 66        |
| 8.2.2     | The Scheduler . . . . .                                    | 70        |
| <b>9</b>  | <b>Discussion</b>  | <b>75</b> |
| 9.1       | Final model . . . . .                                      | 75        |
| 9.2       | Process and framework . . . . .                            | 75        |
| 9.3       | Delimitations and scope . . . . .                          | 76        |
| 9.4       | User Study . . . . .                                       | 77        |
| 9.5       | Conceptual design . . . . .                                | 78        |
| 9.6       | Prototyping . . . . .                                      | 78        |
| 9.7       | Next steps . . . . .                                       | 79        |
| <b>10</b> | <b>Conclusion</b>  | <b>81</b> |
|           | <b>References</b>  | <b>83</b> |

|                   |                                      |            |
|-------------------|--------------------------------------|------------|
| <b>Appendix A</b> | <b>Consent agreement</b>             | <b>89</b>  |
| <b>Appendix B</b> | <b>Interview questions</b>           | <b>95</b>  |
| <b>Appendix C</b> | <b>Themes and Codes</b>              | <b>99</b>  |
| <b>Appendix D</b> | <b>Discovering requirements</b>      | <b>101</b> |
| <b>Appendix E</b> | <b>User test 1</b>                   | <b>103</b> |
| E.1               | Instructions - User test 1 . . . . . | 103        |
| E.2               | Survey Questions . . . . .           | 103        |
| <b>Appendix F</b> | <b>User test 2</b>                   | <b>107</b> |
| F.1               | Instructions - User test 2 . . . . . | 107        |
| F.2               | Interview questions . . . . .        | 108        |
| <b>Appendix G</b> | <b>User test 3</b>                   | <b>109</b> |

# 1. Introduction

---

The Swedish regions struggle with resource utilization issues that threaten the ability to provide timely and efficient healthcare to the citizens. This study aims to investigate and map the current production, planning, and scheduling processes within the Swedish healthcare, as well as to develop a digital tool that aids in these processes. A short background introduces the incentives of the study, followed by the aim formulation and delimitations.

## 1.1 Background

In Sweden there is a statutory right called *Health care guarantee* (Swe. Vårdgaranti). It implies that citizens have the right to reach different instances of the healthcare system within a certain time frame [1]. Despite this, data from the Swedish Association of Local Authorities and Regions (Swe. Sveriges Kommuner och Regioner) show that 27 % of all regions do not reach the goal regarding first contact with the specialized care instance. Moreover, 44 % of the regions do not reach the goal regarding appropriate measures taken following diagnosis by the specialized care instances [1].

A comprehensive study called *Effektiv Vård* [2] was completed in 2016 by the Swedish Government on the topic of resource efficiency and planning within the healthcare sector. The report shows that the current workflow and procedures within the healthcare sector in the regions did not result in efficient resource utilization. This included resources such as personnel, instruments, machines, and premises. It was found that a comprehensive and thorough understanding of what should be done, how it should be done and by whom, often was missing. This understanding will further on be referred to as production and capacity planning, (Swe. Produktion och kapacitetsplanering, POK). In many regions production and capacity planning is implemented locally in some parts of the organization. However, this leads to sub-optimization and capacity issues in the next unit in the care pathway, since the patient flow and throughput is only improved locally. Although there is ongoing effort to implement POK in many regions the results are not yet showing [2] [3].

The Swedish Agency for Health and Care Services Analysis (Swe. Myndigheten för vård- och omsorgsanalys) [3] has identified the three constraining factors:

- Traditions and habits impede changing old behaviors and routines, despite the fact that a need could be identified.
- Strong professions bring a fear of losing personnel if the freedom to choose working hours freely is restricted.
- Many regions lack adequate IT-systems that support the production- and capacity planning in a suitable way.



The regular description of planning and scheduling within the Swedish healthcare system is usually based on the available personnel and individual preferences. This means that the scheduling is the primary focus, and how to meet the needs of the unit is secondary. Patients' needs are thus not leading when deciding on how the unit is to be organized, planned and staffed. An in-depth analysis of the healthcare needs and duties (POK) is often missing, as well as planning and scheduling based on those needs. There are many consequences of this, but the most important one is that the scheduling does not meet the present needs in the most efficient way [2]. Furthermore, the current scheduling is not integrated between the staff groups. The Swedish Agency for Health and Care Services Analysis (Swe. Myndigheten för vård- och omsorgsanalys) has found that the doctors make the doctor schedule, the nurses make the nurse schedule, and the assistant nurses make the assistant nurse schedule. This in turn sometimes leads to situations where there are too many doctors in relation to available rooms and nurses, days when there are no doctors but many nurses without tasks, or other similar situations [2][4].

That many regions lack adequate IT-systems has been well documented and pointed out in multiple settings [2][3]. The systems in use have many problems with design and functionality [5]. Additionally, there are issues with uniformity and structure related to terms and concepts used in the medical settings. This results in poor utility that makes it difficult to do things such as gaining an overview of the patient journal and having to use many different passwords in separate, non-integrated systems and therefore combined information about the patient cannot be provided. Furthermore, follow-up administration is not done automatically but needs to be done manually and automatic systems are not widely used. This gives rise to a substantial amount of manual labor and administrative work. The study *Effektiv vård* [2] concludes that there is a frustration among the medical staff concerning the increasing administrative burden within the healthcare sector. This is not solely based on increased administrative demands but also lies within the mentioned outdated and non-integrated digital supporting systems. The lacking continuity leads to double documentation and further administrative work when reporting between staff, partly due to the design of the digital journal with many long-answer, free-text boxes. The National Board of Health and Welfare (Swe. Socialstyrelsen) approximates about 70 percent of the information in the journal to be a recurrence of earlier inputs [6].

The *Effektiv vård* study [2], also concluded that the Swedish healthcare system has a proportionately low productivity. At the same time, the number of employees within healthcare is increasing fast, especially among high academic professions. Decreasing productivity and an increasing number of employees could imply a well-staffed healthcare system with a good working environment and plenty of time for the patient. Yet, employees share the opposite story according to the mentioned study above. They are running faster, they do not have enough time for each patient, and they are drowning in disparate, administrative tasks.

## 1.2 Aim

The current resource utilization and planning within the Swedish healthcare sector is inefficient. Digital support systems are experienced as difficult to manage, time consuming, and non-integrated, lacking in both design and functions [2, 1, 3, 6]. Thus, the aim of this

Master's thesis is to develop and deliver a digital concept that can aid in the process of optimizing and streamlining planning and scheduling. This can be broken down into:

- Investigating and mapping the current production, planning, and scheduling processes within the Swedish health sector.
- Designing a prototype of a digital solution that could meet some of the needs that are presently not met in a competitive and efficient way.

## **1.3 Delimitations**

This thesis is focused on the design process. In particular it is concerned with the user study, concept and prototype development parts of the design process. It will not cover implementation and programming the software. The study is delimited to procedures regarding production, planning and scheduling within the Swedish healthcare sector, mainly directed toward nurses and assistant nurses with typical 3-shift-days. The interaction between healthcare staff and patients will not be covered by the study, and the impact on Swedish healthcare operations caused by the Covid-19 pandemic will not be further analyzed.



## 2. Theory

---

This chapter aims to give a deeper understanding of how stress can affect the mental strain of healthcare personnel, how the healthcare system can be seen as a complex system along with an introduction to complexity theory and the FRAM-method which can be used to investigate complex systems. Finally, design theory is presented, with principles and different design processes, to give insight to the thought process while designing.

### 2.1 Job strain and stress

Stress is the body's natural response to emotional, physical, or mental pressure [7]. Stress for short periods can have a positive effect, such as giving the person more energy to be able to reach a certain goal, an increase of physical strength or endurance [7]. However, long periods of stress can negatively affect a person's health and job performance [7].

Working as a healthcare professional, one is subdued to substantial levels of mental and physical stress, such as work overload, excessive working hours, sleep deprivation, repeated exposure to emotionally charged situations, dealing with difficult patients and conflicts with others [7]. It is therefore important that the personnel is given the tools that they need to be able to keep a healthy work environment. Several provisions are already implemented in the Swedish Working Hours Act (Swe. Arbetstidslagen, ATL) [8], such as the need of a daily- and weekly rest. The act says that "all workers must have at least eleven consecutive hours of leave during each period of twenty-four hours (daily rest), and workers must have at least thirty-six consecutive hours of leave during each seven-day period (weekly rest)" [8].

### 2.2 Complexity within healthcare

A complex system is an organization or a group which is made up of many interacting parts [9]. The individual parts of a complex system are called "agents" or "components", and the interactions between these parts can largely affect other parts of the system, which are difficult to predict by only observing a certain part of the system [9]. In other words, the actions of one agent may affect the context for other agents, which in hand will lead to changes in the system at other places than observed [10].

Plsek and Greenhalgh [10] argue that healthcare can be seen as a complex system. Thus, it can be difficult to model, as there are many individual parts to take into account, such as the patients, the personnel, the varying in- and out flow of patients, machines, unpredictable events, and so on. Analyzing the healthcare system therefore becomes a complex and time demanding job. Plsek and Greenhalgh [10] state that the challenges in

healthcare today require a new framework on how to respond to them, that includes a dynamic, emergent, creative, and intuitive view of the world.

A method that is used for risk assessment and that can model complex systems is the Functional Resonance Analysis Method (FRAM) [11]. FRAM is described by Erik Hollnagel as "a method for modelling non-trivial socio-technical systems" [12]. Socio-technical referring to people and technology interaction at workplaces. It is a method that makes it possible to describe work-as-done rather than work-as-imagined, which in turn allows for safety analyses without decomposing systems into components.

A complex system also involves many gaps between people, stages, and processes, as described by Cook et al. [13]. Gaps are defined as discontinuity in care, and may appear as loss of information, or interruptions in the delivery of care [13]. They further on address the problem of organizational and/or technological change in a complex system, which may lead to unintended side effects [13]. As the system already is complex, where every agent affects another, a change in this that is not correctly applied, can lead to problems further on.

## 2.3 Design theory

This section covers design theory including interaction design, user centered design and design frameworks. Additionally, usability, user experience and design principles are introduced.

### 2.3.1 Interaction Design

Preece et al. [14] define interaction design as the following: "*Designing interactive products to support the way people communicate and interact in their everyday and working lives*". It contains activities focused on discovering requirements and understanding the problem space, designing something to fulfill those requirements, and producing prototypes that are then evaluated. It also focuses attention on users and their goals throughout the design process, for instance through a user-centered approach. It involves non-linear processes and is of iterative nature [14].

### 2.3.2 User Centered Design

User Centered Design (UCD) is a broad term to describe design processes in which end-users influence how a design takes shape. The extent to which users are involved can vary; at specific times during the design process (typically during requirements gathering and usability testing) or throughout the entire design process (involved as partners) [15]. Their opinions and reactions are sought and their concerns direct the development [14].

In order to involve users the designs and potential solutions need to be captured and expressed in forms that allow review, revision, and improvement, based on the users input. This can be done in many ways such as using sketches, written descriptions, or by building prototypes that the user can interact with. These formats allow for fast and cost efficient collection of insights [14].

Three principles that constitute the basis of a user centered approach were laid down by Gould and Lewis [16], and are as follows:

1. **Early focus on users and tasks.** Understanding who the users will be. This is done by studying their characteristics as well as the nature of the work expected to be accomplished.
2. **Empirical measurement.** Early in the design process, intended users should interact with prototypes to carry out real work, while their performances and reactions are being observed, recorded, and analyzed.
3. **Iterative design.** When problems are found in user testing, they will be fixed. This means design must be iterative - there must be a cycle of design, test and measure, and redesign, repeated as often as necessary.

### 2.3.3 Usability and User Experience

The two terms usability and user experience are closely linked, since usability is often fundamental to the quality of the user experience and, conversely, aspects of the user experience are related to how usable the product is [14].

The ISO definition of user experience is a "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" [17]. This can be connected to how the product looks, how it feels to use and how aesthetically pleasing the product is. A good user experience can be expressed by desirable user experience goals such as *satisfying*, *fun*, or *helpful*, while a bad user experience give rise to feelings like *boring*, *unpleasant*, or *patronizing*. Important to note is that one cannot design a user experience, one can only design *for* a user experience [14].

Usability on the other hand, is defined as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [17]. It refers to things such as ensuring that the product is easy to learn, effective to use, and enjoyable from the user's perspective. It involves optimizing the user's interactions with the product in different environments. Usability can be broken down into six goals [14]:

- **Effectiveness:** The product should be able to perform the tasks that it is intended for.
- **Efficiency:** Helping the user to carry out their tasks in an efficient way.
- **Safety:** Protecting the user from dangerous conditions, unwanted actions and undesirable situations, as well as providing possible recovery.
- **Utility:** Providing the correct functions for the intended use.
- **Learnability:** Refers to how easy the product is to learn to use.
- **Memorability:** Once learned, the user should be able to remember how to use the product without having to relearn how to use it every time.

### 2.3.4 Design principles

When designing the interface of a product and its prototypes, there are many factors to take into account. Norman's design principles [18] aid designers in their process with focus

on functionality and user experience. The principles are a mix of theory-based knowledge, experience, and common sense [14][18]. They are defined as following:

- **Visibility:** The actions and functions that the user can do should be highly visible, making it easier for the user to understand what to do. This principle also refers to the overview of a system. A good visibility should give the user an easy overview of what they are working with.
- **Feedback:** When the user is carrying out an action, the system should provide a response to said action. Feedback can be provided as sounds, change of colour, or the visible action of clicking a button. Feedback is important since it is a natural element of the user's everyday life. If not provided, the user might try to do the same thing over and over.
- **Constraints:** Constraints are used in the design to restrict the user from making mistakes. Constraints are an easy way to help the user understand what actions are possible, and which are not, in that particular moment. This can be achieved by deactivating choices by shading them gray, or by applying physical constraints on the product.
- **Consistency:** The design should be kept consistent. Consistency can be upheld through the use of the same type of actions for the same type of function, and the same theme throughout the design. This makes it easier for the user to learn and use the product, and it will be experienced as more comfortable for the user.
- **Affordance:** Giving the user a clue on how to interact with the product and what actions are possible[18]. The attributes should invite the user to perform the intended actions. An example is the graphical element buttons. The design should mediate that it is clickable.
- **Signifiers:** Signs, or perceptible signals, of what can be done and where the action should take place. The signifiers helps the user understand where there are actions to be performed. For example, the word "Push" on a door.
- **Mapping:** The relationship between controls and their effects. Mapping can be used to specify which device is controlled by what control. Natural mapping is when the mapping comes natural to the user, e.g. moving up on the device is performed by an arrow pointing upwards.

### 2.3.5 Gestalt Principles

Gestalt theory describes how human perception can be altered when single objects are arranged in certain patterns and ways [19]. It is part of Gestalt psychology and relates to how and what we perceive when looking at an image. There are multiple Gestalt principles and several are elaborated on below. These principles are useful in design to create good cognitive ergonomics [19].

- **Figure-ground:** An easy way to distinguish an object from the background. It automatically generates the illusion that the figure is something that stands out from the background.
- **Similarity:** Objects that look the same, or alike, are grouped together by the user. This can be used by giving objects that belong together the same colours, sizes or apply different shades of brightness to the objects.
- **Proximity:** Objects that are placed close to each other, are more likely to be perceived as objects of the same type, or group. This can be achieved by placing objects in the same row, column, or in the close proximity of each other. Objects that are placed on the same row or column can be grouped differently by inserting space between the objects that do not belong to the same group. By doing so, another level of proximity is applied.
- **Common region:** Objects that are situated within the same boundary are grouped together by the user.
- **Continuity:** Objects that are lined up continuously, even with space in between, can be perceived as belonging together. The mind of the user can find patterns that do not actually exist, but can be imagined.
- **Closure:** Elements are paired together if they seem to belong to a closed figure. This principle is an elongation of the continuity principle, and works in the same way.
- **Focal point:** Whatever stands out from the rest will capture the viewers attention. By using different properties of the important element or object, than the rest of the elements/objects, the designers can make it easier for the user to find the important feature.

## 2.3.6 F-shaped reading pattern

In an eyetracking study [20] that was performed on users who visited web pages, it was found that the dominant reading pattern of the users was in the shape of an 'F'. First the users scan horizontally, covering two top sections from left to right. Then they scan the left side in a vertical manner from top to bottom, giving the F-shaped pattern. This can be applied when designing an interface, placing important objects in the top left corner.

## 2.3.7 Fitts' law

The distance between an object and the time it takes to click on it with a pointing device, can be described with Fitts' law [14], shown in equation 2.1.  $T$  is the time it takes to move the pointer to the target,  $D$  is the distance between the pointer and the target,  $S$  is the size of the target, and  $k$  is a constant of approximately 200 ms/bit.

$$T = kx \log_2\left(\frac{D}{S} + 1\right) \quad (2.1)$$

In other words, the bigger the target is, the easier and faster it is to reach it [14].



### **2.3.8 Hick's law**

Hick's law states that there is a linear relationship between the reaction time of the user and the task complexity measured in bits of information [21]. A user that is given a lot of options will take more time to finish the task, or make a decision, as there are too many choices that has to be interpreted, which leads to extra work and time for the user. Consequently, the less options the user has, the faster she/he can make a decision on what to do.

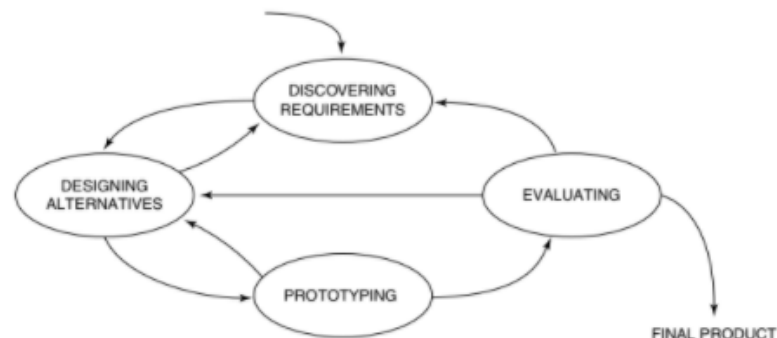
## 3. Process overview

---

This chapter aims to give a short description of what a design process is, followed by an overview of what the design process for this project has looked like.

### 3.1 Design processes

Design processes are iterative, non-linear and explorative. Working with a design process is about learning, and applying the knowledge into the process. There are many different frameworks proposed in the field of interaction design. Preece et al. [14] divide it into four activities of interaction design: 1) Discovering requirements, 2) Designing alternatives that meet those requirements, 3) Prototyping alternatives, and 4) Evaluating the product. This can be seen in Figure 3.1.



**Figure 3.1:** A visualization of Preece et al.'s design process [14].

Another framework to describe the non-linear process was developed by the British organization Design Council, called the Double Diamond [22]. The two diamonds represent a process of exploring an issue more widely (diverging) and then taking focused action (converging). The framework is divided into four different phases and is visualized in Figure 3.2:

- Discover – identify, research and understand the initial problem.
- Define – limit and define a clear problem to be solved.
- Develop – focus on and develop a solution.
- Deliver – test and evaluate, ready the concept for production and launch.

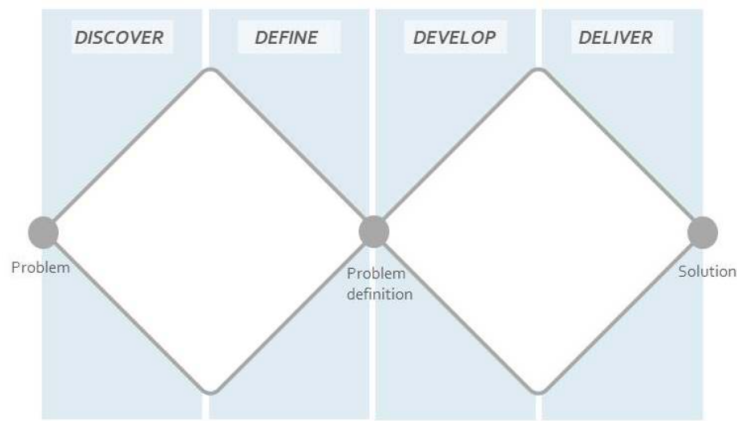


Figure 3.2: Visualization of the Double Diamond framework [23].

In this thesis the Preece et al. framework is primarily used, with the diverging and converging thinking of the Double Diamond. The general principles found in both frameworks are applied throughout the study and will be described in greater detail below.

## 3.2 Thesis process

The project is of an explorative type, which implies that the project is expanding the perspective. To achieve a diverging perspective, the main focus has been conducting an extensive user study. A considerable amount of time has been assigned to mapping, understanding and defining the problems and needs of Swedish hospitals associated with planning. The second part of the project has been spent creating concepts from the findings of the user study, creating prototypes in three iterations, to end in a final prototype. The overview of the process can be seen in Figure 3.3.

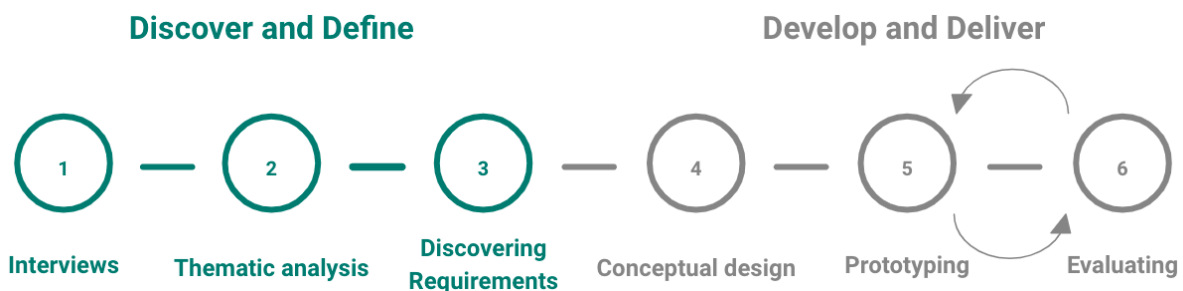


Figure 3.3: Process overview

The user study was composed of interviews conducted with 23 different employees from five different hospitals within the Swedish healthcare system. The interviews were analyzed using thematic analysis. Based on the obtained themes and codes, user requirements were found. Thereafter, multiple conceptual designs were created with the help of personas and storyboards. These were then evaluated with a Pugh matrix and the

mentioned personas. The concepts were refined further and it was decided which one to go forward with when stepping into the prototyping process. Two iterations of lo-fi prototypes were created and tested on smaller test groups of three people. The insights gained from the lo-fi iterations were taken into account when creating the final hi-fi prototype, which was tested on five people. Thus, there were 11 testers total, evaluating the prototypes. Lastly, the final model was created based on feedback from the hi-fi prototype testing.

The next chapters will give a deeper description of the user study, followed by the generation of concepts, and prototyping of the product. In every chapter there will be a description of the methods that were used, followed by the result. The methods and results from these chapters will then be discussed in the chapter "Discussion". Finally, a concluding chapter "Conclusion" can be found at the end of the report.



## 4. User study

---

To understand where the problems lie, and what solution is desirable for the users, an extensive user study was performed. The goal of the user study was to discover and define the user needs and requirements for the solution. The user study included semi-structured interviews, a thematic analysis and requirements elicitation, which is described further in this chapter and is highlighted in Figure 4.1 below.

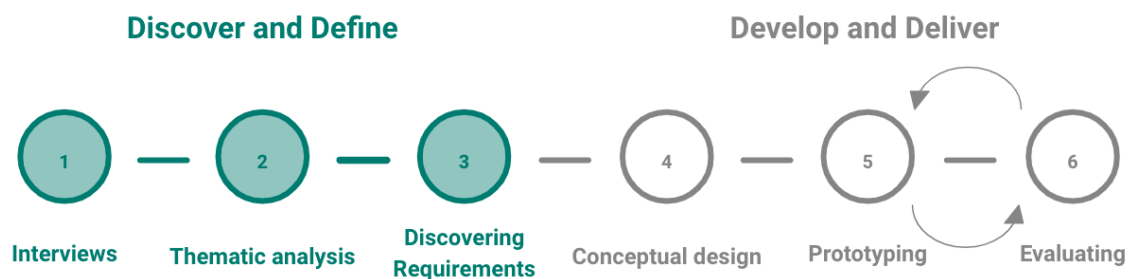


Figure 4.1: Process overview

### 4.1 Interviews

This section describes the preparation and the conduction of the interviews.

#### 4.1.1 Preparation

The goal of the interviews was to explore what problems exist in today's healthcare, in the area of production, planning and scheduling. The chosen target group was personnel of all ages actively working within the Swedish healthcare sector, with tasks relating to this area.

In order to explore, semi-structured interviews were used during the study. In a semi-structured interview the interviewer follows a basic script of questions to ensure that the same topics are discussed with all the interviewees, but also has the opportunity to go deeper into answers that an interviewee provides [14]. This way, the interviewee is allowed to speak freely, without the interviewer pushing for a specific answer.

The preparation of questions for the interviews was an iterative process. Creating the questions for the interview guide was inspired by Arvola's method "5 W's & 1 H" [24] as well as the Functional Resonance Analysis Method (FRAM) [11]. Both methods contained frameworks with a number of questions designed to capture dynamics and provide a good overall understanding of the systems at hand. These questions were analyzed and used to create comprehensive interview questions capturing the dynamics of the workplace. A

brainstorm session was held aiding in the recognition of important areas that were ought to be covered during the interviews.

Identified areas were:

1. Information about the interviewee
2. Organizational structure at workplace
3. Scheduling/planning routines
4. Current and recent improvements in planning, scheduling and production processes at the workplace
5. Desired improvements and dream tools

From these areas, questions were formulated. The first four areas generated questions of descriptive manner, in order to gain a better understanding of the structure of the organization, the position of the employee and the hospital operations. Questions were formulated in a way that had the interviewee answer with examples, such as *what happens before a certain situation?*, *what happens during?*, *what happens after?*, and *what were the consequences?*. For example, "What happens if someone in the staff calls in sick?", and "Tell me about your work day, yesterday", or "When was the last time this happened and who was affected?".

The last area was used to let the interviewee think about the future and come up with their own dream tools to help them in their everyday work at the hospital. They were asked to elaborate on features or functions that they felt like they were lacking and what the biggest challenges would be to implement the new tools or features they dream of having.

The interviews were conducted with subjects that held different positions and functions at the hospitals. Thus, the underlying interview guide used during each semi-structured interview was altered slightly in order to apply for each interviewee. The complete interview guide can be found in Appendix B.

### **4.1.2 Pilot study**

Before interviewing the subjects, a pilot study [14] was performed by evaluating the questions with a person that was not included in the main study. The interview in the pilot study was conducted as a real interview in order to make sure the structure was easy to follow and the questions were clear and easy to understand. After the pilot interview, the questions were revised. Some questions were excluded due to low significance, and others were rephrased so that they were easier to understand.

### **4.1.3 Consent agreement**

Before each interview a consent agreement was collected from each interviewee in order to be able to store and use the information shared during the interview. The agreement consisted of a short summary of background and purpose of the study, involved parties, and how the data collection was to be conducted and managed. Furthermore, details on storage locations, access, publishing and contact information was provided. The consent agreement can be found in appendices A.

#### 4.1.4 Conducting the interviews

The interview subjects were selected via convenience sampling and the interviews were conducted online, via Zoom and Microsoft Teams, due to the on-going pandemic. The contacts were provided by Co-supervisor Gustaf Hedström, Uppsala University, and were located at five different hospitals around Sweden; three smaller hospitals (hospitals 1, 2 and 3) and two large university hospitals (hospitals 4 and 5). In two out of the five hospitals, the interviews were conducted with staff from the emergency unit, where the majority of the patients are non-elective, i.e. need urgent or emergency care, as opposed to elective patients that can be planned in advance [25]. At the other three hospitals, employees at units with both non-elective and elective patients, were interviewed. The first round of interviews were conducted with the five contacts provided by Gustaf Hedström to get a broad overview and an overall understanding of the hospitals and their operations. Further interviews were conducted with contacts mediated by the first five interviewees, to get a more detailed understanding of the organizations and the problems that they were faced with.

The average duration of each interview was 50 minutes and varied between 40 minutes and 60 minutes. The interviews were recorded, with a written and oral consent of the interviewee that the data could be used for research purposes. The interviews were later transcribed manually, word by word. Long pauses, rephrasing of sentences and sounds such as "um", "eh" and "hm" were not noted.

A total of 18 interviews were conducted during a period of three weeks. In these 18 interviews, 23 subjects were interviewed. 13 interviews were conducted with a single subject. The other five interviews were conducted with two subjects at the same time, as these interviewees had been paired up in advance because of their specialties in the same area of expertise. The interviewee subjects held different positions in the organizations, which is presented in Table 4.1. They were chosen to gain a broad understanding of the organizations and the perceived problems from different points of view. It was ensured that both an overview and more detailed perspectives were gained by interviewing roles at different levels in the hospital business structure. Due to convenience sampling of the interviewees not all roles were interviewed at each hospital as seen in Table 4.1. However, it was made sure that the same areas were covered at each hospital.



**Table 4.1:** The interviewees positions/roles at the hospitals.

| Hospital | Role  | Number of interviewees |
|----------|---|------------------------|
| 1        | Operations manager (Swe. Verksamhetschef)                       | 1                      |
| 2        | Operations manager (Swe. Verksamhetschef)                       | 1                      |
|          | Scheduler (Swe. Schemaläggare/chefsstöd)                        | 1                      |
|          | Unit head (Swe. Avdelnings-/Enhetschef)                         | 1                      |
| 3        | Operations manager (Swe. Verksamhetschef)                       | 1                      |
|          | Scheduler (Swe. Schemaläggare/chefsstöd)                        | 1                      |
|          | Unit head (Swe. Avdelnings-/Enhetschef)                         | 5                      |
|          | Business developer (Swe. Verksamhetsutvecklare)                 | 1                      |
| 4        | Overall insight/Business developer (Swe. Verksamhetsutvecklare) | 1                      |
|          | Scheduler (Swe. Schemaläggare/chefsstöd)                        | 3                      |
|          | Unit head (Swe. Avdelnings-/Enhetschef)                         | 2                      |
|          | Area manager (Swe. Områdeschef)                                 | 1                      |
| 5        | Operations deputy manager (Swe. Bitr. Verksamhetschef)          | 1                      |
|          | Scheduler (Swe. Schemaläggare/chefsstöd)                        | 1                      |
|          | Unit head (Swe. Avdelnings-/Enhetschef)                         | 1                      |
|          | Medical director (Swe. Medicinskt ledningsansvarig läkare)      | 1                      |

## 4.2 Data analysis

In this section, the analysis of the data retrieved from the interviews will be described as well as a description of the final themes that were found in the data set.

### 4.2.1 Thematic analysis

As the interviews resulted in qualitative data the method thematic analysis [26] was applied in the analysis process. A thematic analysis is a method for identifying, analyzing and reporting patterns within data. The goal is to create themes that capture the essence of the data, relating to the research question. There are several phases in a thematic analysis described by Braun and Clarke [26]:

1. **Familiarize with the data.** Get to know the content by reading and re-reading the data and annotate initial thoughts and ideas.
2. **Generate initial coding.** Give full and equal attention to each data file, and work systematically through them all. Sections can be coded once or multiple times to different codes.
3. **Searching for themes.** Collect codes and group them together, and try to find potential themes.
4. **Reviewing themes.** Analyze the potential themes, look over the coding to ensure it is performed correctly.

5. **Define the themes.** When the final hierarchy of codes is in place the essence of what each theme is about and what aspect of the data each theme captures can be defined. Themes should not be overlapping and should together cover all data relevant to the research question. They should be internally coherent, consistent and distinctive.

6. **Produce report.**

In this study, an inductive approach was used as the study was explorative. This means that no pre-existing coding frame was used to fit the data during the analysis [26]. Instead, codes were created based on the data, in order to capture the essence, resulting in a more data-driven analysis. For the same reason, a rich description of the data (i.e. detailed transcripts from the interviews) was retained in the analysis, ensuring codes and themes were an accurate reflection of the content in the data set. Themes were chosen such that each theme should be relevant to the research question of the study, mentioned in a majority of the interviews, and have a substantial amount of code references.

The first steps made were to get to know the content of the interviews, as described by Braun and Clarke [26] in phase 1. The interview transcripts were re-read and commented on individually by the authors. Initial thoughts for possible codes were annotated individually. The transcripts were then imported into the qualitative data analysis software NVivo (c) QSR International [27], where the coding was performed. The comments and annotation were compared and lay ground for the initial coding. The data was gone through file by file and sections related to the research question were coded once or multiple times to the initial codes, as mentioned in phase 2 of the thematic analysis. The extracts were coded inclusively, i.e. a little of the surrounding data was kept for context, and to as many codes as possible.

With all relevant data coded and collated phase 3 was initiated and an analysis of how different codes could be combined to form overarching themes and sub-themes was conducted. Potential themes were found using the help of visual representations such as post-it notes, whiteboards and mind maps, creating affinity diagrams [14]. This can be seen in Figure 4.2. Some initial codes were refined, removed, split or merged with other codes in order to create a collection of candidate themes.

Following this, phase 4 was commenced and the candidate themes were reviewed. It was ensured that each theme had enough supporting data, that they did not overlap, that each theme had a connection to a majority of the interviews, and relevance to the aim of the study. Similarly, sub-themes were created, arranged and rearranged in appropriate hierarchy to give structure to the overarching themes. This was mainly done by one of the authors while the other author was responsible for validating the restructured themes and codes. The validation included verifying consistency in way of coding and ensuring that each code reference was coded and mapped accurately to themes and sub-themes. Throughout the coding process any inconsistencies in the coding were re-coded or added to additional codes. Reaching phase 5 the themes were defined, which will be described in the next section.



Figure 4.2: The process of creating themes.

## 4.2.2 Final themes

The final six themes were; *Staffing* (Swe. *Bemanning*), *Work procedures* (Swe. *Arbetsätt*), *Organization* (Swe. *Verksamhet*), *Change and Improvement* (Swe. *Förändring och Förbättring*), *Work environment* (Swe. *Arbetsmiljö*), *Communication* (Swe. *Kommunikation*). Each theme had above 100 aggregated references, with an exception for the theme "Communication" that only had 78. All themes were mentioned in a majority of interviews (from 16-18 of the interviews). A seventh candidate theme was named *Covid-19*. However, it was deemed to be out of scope since it did not relate to the research question and was thus not included in further analysis.

Below, a description of each theme can be found:

- **Staffing:** Involves employees and staff, staff scheduling, and issues concerning these matters.
- **Work procedures:** Routines, planning of operations and production, tools used, and issues concerning all of these matters.
- **Organization:** Organizational structure, economics, patient flow, cooperation with other units.
- **Change and Improvement:** Current improvement and undergoing change at the work place. Desired improvements and changes, dream tools and desired functions, along with expected obstacles that may impede these.

- **Work environment:** Physical and psychological burden on staff, human resources, varying strain on units, and attitudes found among the employees.
- **Communication:** Way of communicating within a unit and between units, along with issues connected to this matter.

A visual representation of the final six themes can be found in Figure 4.3. The intensity of the colour represents the number of interviews in which the codes were mentioned. The same intensity of colour as the overarching theme implies that it was mentioned in 16-18 interviews. A lighter shade indicates that it was mentioned in less than 16 of the interviews. The detailed list of themes, sub-themes and codes can be found in appendix C.

In Table 4.2 examples of references that capture the essence of some of the themes and codes are shown. The extracts from the interviews have been translated from Swedish to English.

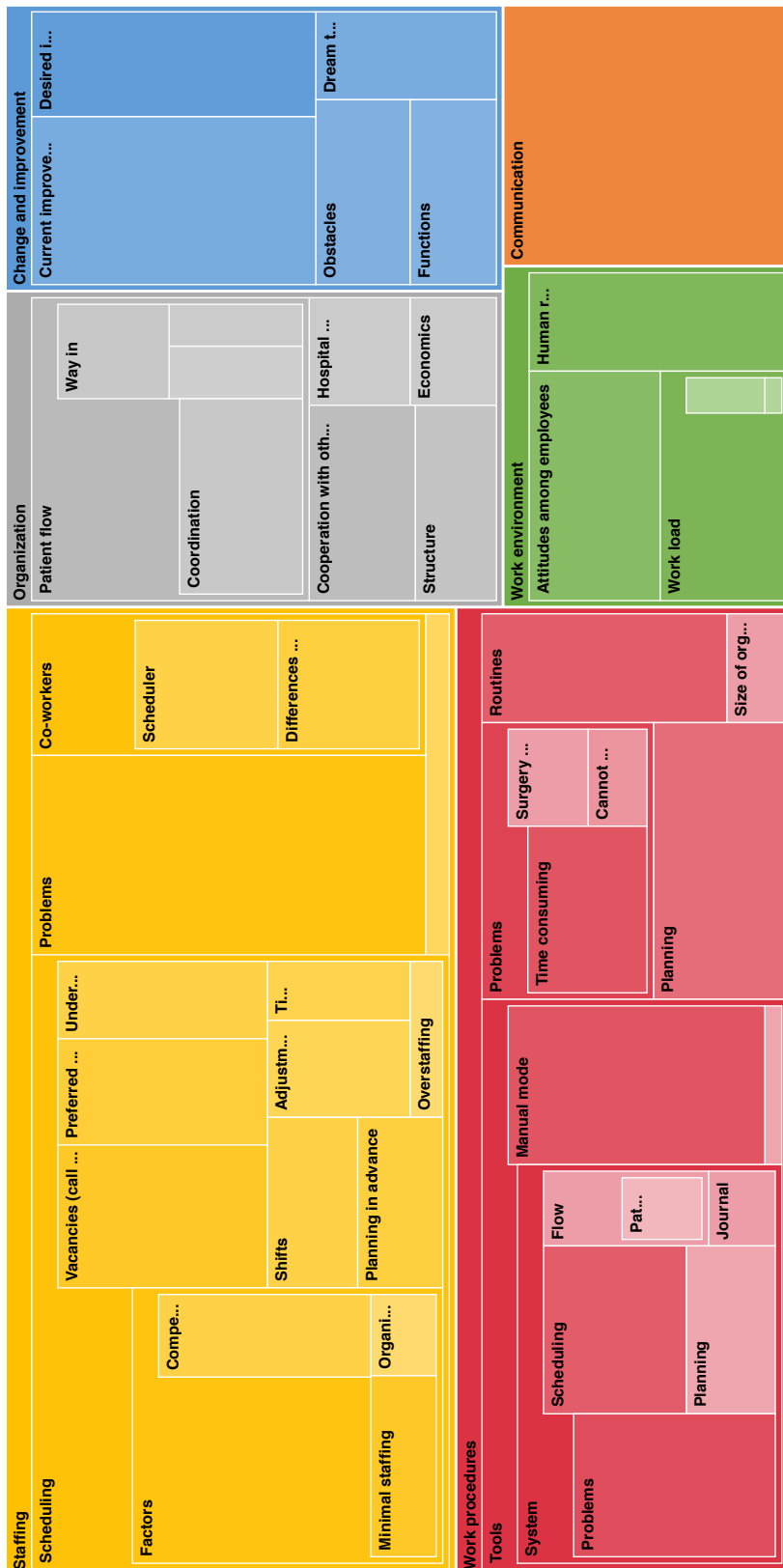


Figure 4.3: Final themes and codes.

**Table 4.2:** Examples of codes.

| Theme                         | Code                         | Extract from interviews   |
|-------------------------------|------------------------------|---|
| <i>Staffing</i>               | Competences                  | There are two issues. First one is how to place the co-workers on the current shift. The second one is long term and relates to how we make sure they are placed at each function and thus retain the competence. We don't have a good way of keeping track, it's done manually.  |
| <i>Staffing</i>               | Problems                     | It's about keeping their competences for the co-workers. That you don't get put at the same place each shift, and then it's Saturday night and no one around to ask.  |
| <i>Staffing</i>               | Difference between employees | There's no coordination with the doctors. We coordinate nurses and assistant nurses when scheduling to try and make sure there are not two inexperienced scheduled at the same station.   |
| <i>Work procedures</i>        | Manual mode                  | It is a little tragic. I have an Excel sheet that isn't connected to anything. I make an individual schedule, where you can see each person, and then I make an overall schedule based on the unit. The two aren't connected which means that I have to add everything twice. If I make a mistake it won't add up. It's a disaster. |
| <i>Work procedures</i>        | Manual mode                  | In the system you can colour each skill. Our problem is that many of our nurses have multiple skills, as ear or plaster. Then it's very hard to tell just how many I have in the schedule and I have to count manually.   |
| <i>Work procedures</i>        | Problems                     | I think it's often that people do not really understand each others' assignments. That one does not have full insight to what my job means to the next person. If I don't complete my part, how does that affect the next person that then can't do their part.   |
| <i>Work environment</i>       | Human resources              | It's difficult because it's up to the staff to act responsibly and make a healthy schedule, while we as employers are the ones that have the work environment responsibility.   |
| <i>Change and improvement</i> | Functions                    | There are different agreements, e.g. my staff works 5h less a week than surgery, since they have a different agreement there. So some of the features that I'd like, cannot be used on their schedule, because it won't work in the system. The small details have to be taken into account and need to add up.                     |
| <i>Communication</i>          |                              | It might take 15 min before the nurse sees that we have a spot free in the system, but then she can't get a hold of the receiving nurse when calling. She's off to other duties and misses the call from the department nurse, and just like that; it has been a whole hour.  |
| <i>Organization</i>           | Patient flow                 | We are not happy with it. I think that the workflow is too uneven at the departments.   |
| <i>Organization</i>           | Patient flow                 | There is a lot of computer work since we work in 3 different systems, which costs a lot of staffing.  |

## 4.3 Requirement elicitation

From these themes, problems and needs were found. This was done by going through codes and their corresponding references related to problems, such as *Staffing*→*scheduling*→*problems*, *Dream tools* and *Desired improvement*. The underlying issues found were noted and clustered. Problems that were out of scope were removed. An affinity diagram was created with the found and grouped issues, as can be seen in Appendix D. The five largest groups (*Competences*, *Work procedure*, *Schedule*, *Systems*, and *Strain on healthcare*) were chosen to go forward with, shown in Figure 4.4. The issues in each group were further clustered and rephrased. For each refined problem description an underlying need was identified. Separately, both authors came up with functions that could solve each need. Each need was rated based on importance from 1 to 3, and clusters with low ratings were removed. Needs with significance to the research question and with high prevalence in the interviews were deemed as important. The five final clusters and what needs they included can be seen in the Table below.

**Table 4.3:** Five final clusters of needs

| Competences | Work flow/impact                       | Schedule     | Health         | Analysis                         |
|-------------|--|--------------|----------------|----------------------------------|
| - Retention | - Different agreements                 | - Integrated | - Restrictions | - Varying workload               |
| - Overview  | - Co-planning                          | - Updated    | - Laws         | - Production & capacity planning |
| - History   | - How actions impact & change workflow | - Available  | - Preferences  |                                  |

From these five clusters one final split was made resulting in two main tracks:

- **Scheduling:** competences, schedule, health
- **Production and flow:** analysis, work flow/impact

These two tracks, as well as the created functions, were kept in mind when going forward into the next part of the project; the conceptual design.

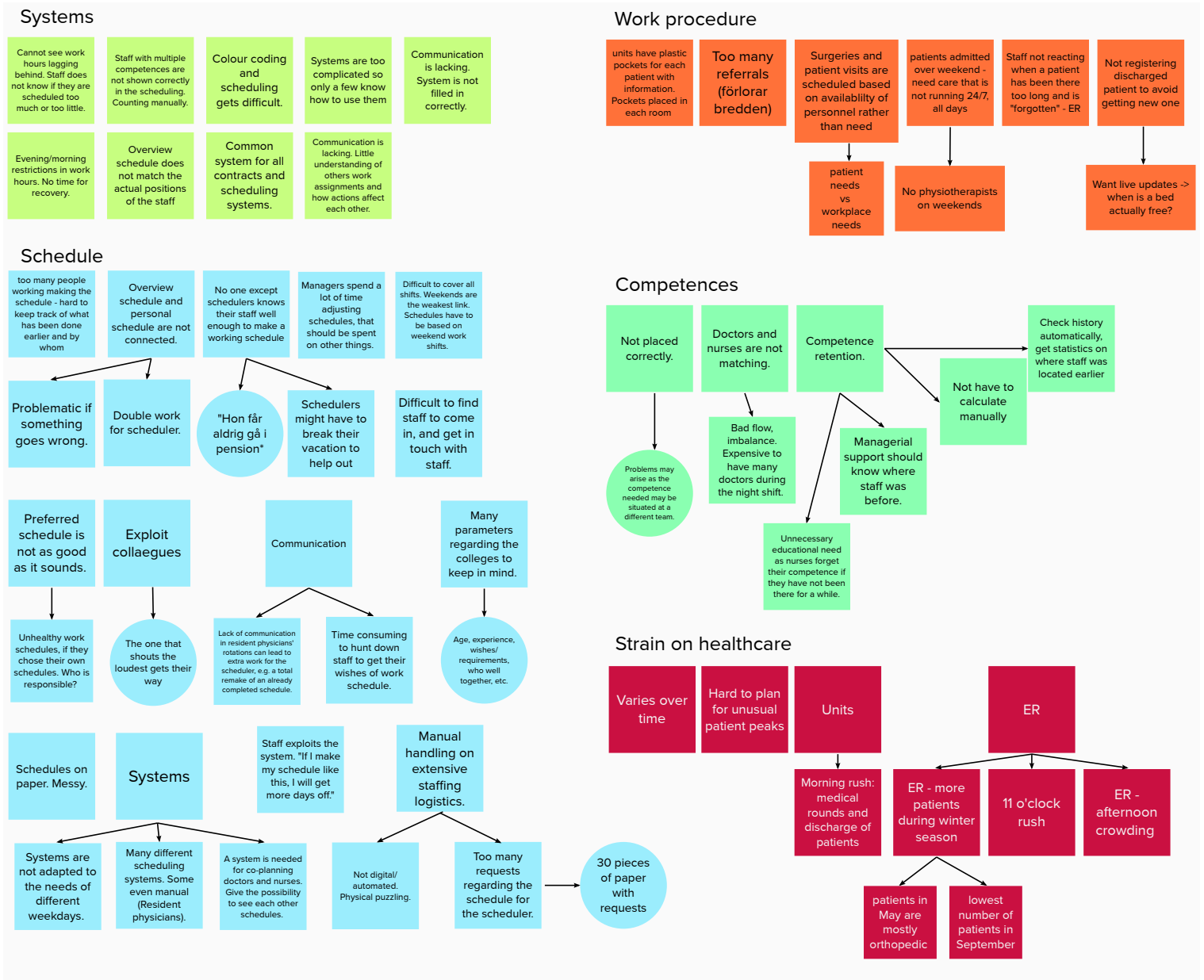


Figure 4.4: Affinity diagram over the found issues, in the five final clusters.





# 5. Conceptual design

---

In this chapter the creation of conceptual models is described, based on the requirements covered by the two main tracks found in the previous chapter. This is followed by a detailed description of the evaluation of the conceptual models as well as the creation of the final two models. This is the first step of the Develop and Deliver part of the process overview, as seen in 5.1.

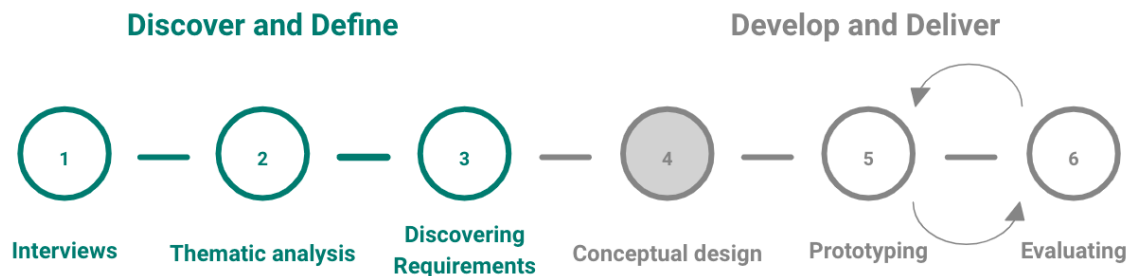


Figure 5.1: Process overview

## 5.1 Personas and scenarios

In order to create a better understanding of the requirements and the users needs, the two techniques *personas* and *scenarios* were applied.

A persona is a rich description of a typical user of the product, for whom you design. A persona is not a real person, but a creation built upon the requirements and gathered data. It is created with the general characteristics, needs and goals of the interviewees. It becomes a general user, aiding in creation of a broad solution that is applicable to many users [14].

Scenarios are stories with fictional characters, events, products, and environments. They can be created as storyboards, written stories, acted outplays, or full scale movies. Moreover, they allow for exploration and discussion of contexts, needs and requirements in an engaging way that makes us think about many levels of interaction at once. The use of scenarios keeps us connected to a range of users and user needs in a hands on way [14, 28].

Together, personas and scenarios can help the developer bring the requirements of the users to life when developing a product. The persona is the general main character with goals, frustrations, activities and ideal experiences. The scenario describes when, where and how the story of the persona takes place along with the difficulties it faces and overcomes.

Four personas were created with both main tracks in mind: Charlotte, Anneli, Lena, and Lisa. They are general but highlight different aspects met during the interviews. The personas were created based on templates from JustInMind [29] and can be found in Figures 5.2-5.3.



### CHARLOTTE

*"When I schedule these two together, work goes fast. If I put those two together it takes years."*

#### PERSONALITY

- 64 years old
- Scheduler
- Tech savviness: Low

#### BIO

Charlotte has worked at the hospital unit for many years and knows the staff well. Previously to being in charge of schedules she worked as an assistant nurse at the unit. With many years of experience, she knows who works well together and how to make the most efficient schedule.

#### Ideal experience

Make a schedule without having to alter it later on when someone realizes they need the evening off. A system that is easy to understand.

#### Goals

- Making a functioning schedule that takes all needed factors into account, as well as meeting the staff's preferences
- To be able to do her job more time efficiently
- Collaborate with doctors for better use of resources to achieve a better workflow

#### Frustrations

- Scheduling is very time consuming, especially having to ask staff multiple times about their schedule preferences
- Last minute changes in staff availability that break up a made schedule
- Manual counting to make sure there are enough people to cover the shift
- A lot of work goes into remembering who works well with whom



### Anneli

*"Sometimes there is too much to do, other times there is not enough."*

#### PERSONALITY

- 36 years old
- Nurse
- Tech savviness: Medium

#### BIO

Anneli has worked at the hospital for a couple of years. She is a problem solver that goes above and beyond for the patients. She thinks things could be done more efficiently, as there often are hiccups in the day-to-day work.

#### Ideal experience

Everyone knows what has been done, what to do, and when to do it – for the operations to be most efficient.

#### Goals

- That the patients receive the best possible care
- Better understanding of each others' tasks
- Be able to rotate between different positions to improve and keep her expertise

#### Frustrations

- The workflow is very uneven - sometimes due to unbalance between the number of doctors vs nurses
- When earlier tasks are not completed correctly, she cannot start/complete her own tasks properly
- Often scheduled at same positions, no possibility of improving other skills

Figure 5.2: Charlotte and Anneli



LENA

*"I want my staff to feel appreciated, but we must focus on the patients."*

#### PERSONALITY

- 51 years old
- Unit manager
- Tech savviness: High

#### BIO

Lena is a specialist nurse that has advanced to unit manager. She puts a lot of effort into improving routines and workflows. She wants to make sure production is as high as possible, while keeping the focus on the patient.

#### Ideal experience

Integrated systems that simplify overview of the needs to enable a corresponding level of production.

#### Goals

- Increase production in order to meet the regional demand
- Understand the strain on the unit to optimize its resources over the week (e.g. scheduled staff)
- Improve collaboration and patient flow between units and doctors/nurses

#### Frustrations

- Lacking communication and cooperation between units results in reduced production
- Different agreements for employees (e.g. doctors/nurses or staff at different units) interfere with efficient co-planning of staff
- Scheduling not based on unit needs
- Preferred schedules do not reflect a healthy schedule



LISA

*"When making a schedule I often receive up to 30 paper notes with preferences that I need to take into account."*

#### PERSONALITY

- 31 years old
- Scheduler/Nurse
- Tech savviness: High

#### BIO

Lisa is a nurse and in charge of scheduling. She has worked at other hospitals previously to this one, giving her experience with different digital systems. She feels that the systems are outdated with many missing functions, creating unnecessary manual work, and does not meet the needs of the unit or staff.

#### Ideal experience

A schedule that is automatically created based on hospital and staff needs.

#### Goals

- Have a digital and integrated scheduling system that updates all schedules, so that she does not have to do it herself
- Gain a better overview of staff competences and recent placements
- Make healthy long term schedules for the employees
- To improve efficiency at the workplace by digitizing and automizing

#### Frustrations

- Schedules are not integrated which means that changes must be manually updated in all places
- Staff competences are not maintained due to lacking staff statistics and work history
- Scheduling is not based on the unit needs

Figure 5.3: Lena and Lisa

## 5.2 Conceptual models

With personas created, one can continue the design to create a conceptual model. According to Preece et al. [14], "a conceptual model is a simplified description of a system or process that helps describe how it works". Further on, Johnson and Hendersen [30] describe a conceptual model as "A high-level description of how a system is organized and operates". The model should give the user an understanding of how the system is supposed to work, without designing the actual interface. A conceptual model should include metaphors and analogies that convey how a product is used, as well as the concepts the user is exposed to through the product when creating objects and performing operations. Additionally, it should cover the relationships and mappings between concepts and the intended user experience [14].

Based on the two main tracks found in Section 4.3 and the four personas created above, nine conceptual models were created. Three out of the nine concepts were related to the main track *Scheduling*, and the other six were related to the main track *Production and flow*. Each conceptual model is described in greater detail below.

### 5.2.1 The nine concepts

1. **MyPage** (*Scheduling*): An individual page for each employee where all their information is gathered. Here they can find personal statistics over previous schedules, placements, competences, their career development, and how healthy their schedule has been. There is also information on their current work hours as well as a possibility to input personal preferences regarding who they would rather work with, which days, or what shifts they would prefer to work. This information is also available to the scheduler through the system and can thus help them make a more optimal schedule. A tree is used as a symbol for the personnel to visualize how healthy their schedules are. The more green and growing the tree is, the healthier the schedule is. The tree is also used for competence development. The more competences one possesses, the more branches the tree has.
2. **The bracelet** (*Production and flow*): Each patient who comes to the hospital receives a bracelet with a chip in it. The chip holds all information about the patient and contains a tracker. The chip is connected to a main system that is located throughout the hospital, which is a support to get statistics. Every time a patient arrives to a new station or unit, the bracelet is scanned with a device that shows everything that has been done before, and what is planned to be done in the care pathway of the patient. Before the patient leaves the station, the bracelet is scanned again to ensure that all tasks are completed. If not, a warning pops up.
3. **The patient journey** (*Production and flow*): When a patient arrives at the hospital, they get added into the main system, with their whole patient journey pathway drawn up and they get a tracker. This way, it is easy to follow the patient to see what is next and where they are at. This is visualized on displays on the walls in all units. Patients that are scheduled to arrive to a unit will show up on their display. The unit gets an overview of all the patients who are currently at the unit. For more detailed

information about a patient, such as scheduled medical tests and future plan, it is simply to click the patient of interest on the display. Doctors and nurses can go to different pages and get more detailed information on the patient, e.g. a scheduled transport is closing up, test results from MR have arrived, or a blood sample is to be taken.

4. **Statistics** (*Production and flow*): A live-updated software that gives information on and the whereabouts of all the patients and staff in the hospital. Statistics from the previous year, month, week, etc. are saved to generate a forecast of what the future periods may look like as well as to see how the production has looked like in the past. The software performs an optimization of what the upcoming period should look like, and sends this to an integrated scheduling software as support to the scheduler for a better use of the resources. It should also be possible to add how many surgeries, new visits, revisits, etc. that are planned for the upcoming period, and a suggestion over how these should be planned most efficiently for a higher production.
5. **Team board** (*Scheduling*): A live-updated schedule displayed on the wall. Similar to a mind map or ski resort map, all teams and team members on the current work shift are visualized on the display. If an adjustment is made in the daily plan, it is updated directly on each display at the unit and the latest update is saved. The scheduler has access to a library of all the previous schedules, where she/he can look at history and statistics for better future scheduling. All the changes and adjustments that have been made in the schedules are available to the scheduler as well as the final schedules that were actually used.
6. **Schedule** (*Scheduling*): A scheduling software that takes all parameters of importance into account and automatically generates a suggested schedule for the scheduler. The staff have their own page where they can find information about themselves, and add their own preferences on how they would like to work the upcoming scheduling period. All staff members and their profiles are saved in a data base. The scheduler has access to the whole data base and can see information about all the staff. The scheduler can use the suggested schedule, or adjust it manually. She/he can also see a history over previous periods, and statistics about the staff, such as where they have been located and to what extent, in terms of competence retention.
7. **Understanding each other - VR** (*Production and flow*): The staff's everyday work is recorded and recreated in a virtual reality to be experienced by another staff member. By experiencing a day in a coworker's shoes, every member of the staff can learn and understand each other assignments and the patient care pathway. This can also be recreated through video or movie format.
8. **Production & capacity planning** (*Production and flow*): A system that helps the managers gain a better understanding of the production and capacity efficiency, in order to optimize scheduling and planning. Mapping of the resources and work flow in order to determine what parameters (resources in terms of equipment, beds at next unit, staff, etc) are needed to increase the production and meet the needs. The scheduling and planning will then be based on these findings.

9. **Step counter/pedometer - AI (Production and flow):** Each staff member is equipped with a pedometer (counts steps) during their shifts, in order to see during what time of the day/week/month/year that they walk the most. This pattern can be connected to when the employees are the busiest and have a lot to do. An AI can be trained based on the data from the pedometers and thus a pattern of the unit strain over time can be obtained. This will in turn create a better understanding of how the resources in terms of staff are matching the unit needs. The scheduling can then be adjusted in order to optimize operations.

## 5.2.2 Evaluating the concepts

To evaluate which concepts to continue the process with, two methods were used; a Pugh matrix analysis and a personas evaluation, created by the authors.

### Pugh matrix analysis

The first method used is called Pugh matrix analysis and is a useful method in situations with more than one possible option and multiple factors that need to be taken into account [31]. It helps the team select the best option and highlights priorities at hand. The method involves seven steps as described by Cervone [31]:

1. Developing criteria for comparison, e.g. the different conceptual models.
2. Selecting the factors to be compared against.
3. Draw the matrix.
4. Assigning weights to factors.
5. Define a baseline.
6. Generating factor scores.
7. Computing criteria scores, e.g. weighted factor scores.

According to Cervone [31] the criteria for comparison were the different conceptual concepts. Each concept was evaluated based on factors constituted of the different needs found in Section 4.3. The matrix was drawn and weights were assigned to each need in line with the prioritization applied in 4.3, from 1-3 based on importance. The concept MyPage was chosen as the baseline concept. The other concepts were evaluated in respect to the baseline as performing better (+1), the same (0), or worse (-1) in terms of meeting the need in question. The weighted score was added to the matrix. Finally, a summation for each concept was calculated. A distinction was also made for the two main tracks and a summation for the weighted factor scores relating to each need was calculated. This is shown in Figure 5.4. The highlighted scores show the two best concepts in each track.

| Concept:  | 1 - MyPage | 2 - Bracelet | 3 - Patient journa | 4 - Statistics | 5 - Team board | 6 - Schedule | 7 - VR | 8 - POK | 9 - Step counter, AI |
|---|------------|--------------|--------------------|----------------|----------------|--------------|--------|---------|----------------------|
| <b>Needs:</b>   |            |              |                    |                |                |              |        |         |                      |
| Support for competence retention, and the ability to see the history and automated hourly summation of where the employee has been positioned.          | 3          | 0            | -3                 | 0              | 0              | 0            | 3      | -3      | -3                   |
| Compile all parameters of every co-worker for easy access, such as age, competences, experience, special wishes etc.                                    | 3          | 0            | -3                 | -3             | -3             | -3           | 0      | -3      | -3                   |
| Overview of all competences and their positions, as well as where they are designated during the creation of a new schedule.                            | 2          | 0            | -2                 | 0              | 0              | 0            | 2      | -2      | 2                    |
| History over WHO made WHAT changes and WHY.   | 2          | 0            | 0                  | 0              | 0              | 2            | 2      | 0       | 0                    |
| Automated system that supports requirements and wishes being sent digitally from the employees, as well as minimizes the time spent on the work process | 3          | 0            | -3                 | -3             | -3             | -3           | 0      | -3      | -3                   |
| Simpler means of getting in touch with the employees and receive their wishes. Get the employees to send their wishes and desires in time.              | 1          | 0            | -1                 | -1             | -1             | -1           | 0      | -1      | -1                   |
| Digital solution that is easy accessible to everyone and updated at all time.   | 2          | 0            | 0                  | 0              | 0              | 0            | 0      | 0       | 0                    |
| Integrated system that updates all schedules.   | 3          | 0            | -3                 | 0              | 3              | 3            | 3      | -3      | 0                    |
| Integrated systems that handles both salaries and schedules. Overview of the work hours completed shown for each employee.                              | 3          | 0            | -3                 | -3             | 0              | 0            | 0      | -3      | -3                   |
| Requirements from the organization and Swedish laws implemented into the system. These should be guidelines on how the schedule should be formatted.    | 2          | 0            | -2                 | -2             | -2             | -2           | 0      | -2      | -2                   |
| A schedule that is both healthy, in the aspect of the work environment laws, and takes the personnel's wishes into account.                             | 3          | 0            | -3                 | -3             | -3             | -3           | 0      | -3      | -3                   |
| Better understanding of the different assignments in the care pathway, and how they affect each other.  | 2          | 0            | 2                  | 2              | 2              | 0            | 0      | 2       | 2                    |
| Plan the doctors/nurses/assistant nurses together, or at the same time in order to improve the nurse/doctor balance.                                    | 3          | 0            | 0                  | 0              | 3              | 3            | 0      | 0       | 3                    |
| Possibility of having employees with different work agreements in the same system, as well as managing different work agreements in different units.    | 3          | 0            | 0                  | 0              | 0              | 0            | 0      | 0       | 0                    |
| Possibility to schedule more or less personnel, depending on the needs of the hospital and analyze how they vary.                                       | 3          | 0            | 3                  | 3              | 3              | 3            | 0      | 0       | 3                    |
| Support that automatically creates a functioning schedule.  | 3          | 0            | 0                  | 0              | 3              | 0            | 3      | 0       | 3                    |
| <b>Sum:</b>   | 0          | -18          | -18                | -4             | -1             | 13           | -5     | -19     | -19                  |
| Main track 1 - Scheduling   | 0          | -6           | -6                 | -3             | -3             | 3            | 0      | -6      | -6                   |
| Main track 2 - Production   | 0          | 5            | 5                  | 11             | 6              | 3            | 2      | 11      | 6                    |

Figure 5.4: Pugh matrix



## Personas evaluation

The second evaluation method consisted of the personas created in Section 5.1. For each concept a fraction of the fulfilled needs and solved frustrations was noted. If all the goals were fulfilled, e.g. 4 out of 4, a score of 1.00 was noted. If only 3/4 of the goals were fulfilled 0.75 was noted. A percentage in fraction form was also noted based on how well the concept helped the personas reach their ideal experience. A score of 1.00 was noted if they reached their ideal experience, 0.50 was noted if they partially did. A summation of the three criteria was then calculated giving an idea of how well each concept resonated with the different personas. This can be seen in Figure 5.5. The light blue highlights show concepts that resonate well with each persona, receiving a score higher than 1.

The results showed that six out of the nine concepts got a higher score than 1 on two or more personas, as indicated in dark blue in Figure 5.5. Four out of these overlapped with the four best concepts (two for each main track) from the Pugh matrix analysis, validating the results. These were:

- MyPage (*Scheduling*)
- Schedule (*Scheduling*)
- Statistics (*Production and flow*)
- Production & capacity planning (*Production and flow*)

After the analysis of the four concepts it was clear that concepts in the same main track were closely connected and could be merged. Therefore, two new final concepts were developed containing a combination of the two concepts in each track. They will be further described and developed in the next section.

| Personas:          | Concept: | 1 - MyPage  | 2 - Bracelet | 3 - Patient journa 4 - Statistics | 5 - Team board | 6 - Schedule | 7 - VR      | 8 - POK     | 9 - Step counter, AI |
|--------------------|----------|-------------|--------------|-----------------------------------|----------------|--------------|-------------|-------------|----------------------|
| Charlotte          |          |             |              |                                   |                |              |             |             |                      |
| - Goals            |          | 0.67        | 0.00         | 0.00                              | 0.00           | 0.33         | 0.67        | 0.33        | 0.00                 |
| - Frustrations     |          | 0.50        | 0.00         | 0.00                              | 0.00           | 0.00         | 0.75        | 0.00        | 0.00                 |
| - Ideal experience |          | 0.00        | 0.00         | 0.00                              | 0.00           | 0.00         | 0.00        | 0.00        | 0.00                 |
|                    |          | <b>1.17</b> | <b>0.00</b>  | <b>0.00</b>                       | <b>0.00</b>    | <b>0.33</b>  | <b>1.42</b> | <b>0.33</b> | <b>0.00</b>          |
| Lisa               |          |             |              |                                   |                |              |             |             |                      |
| - Goals            |          | 0.75        | 0.25         | 0.25                              | 0.25           | 0.75         | 0.75        | 0.00        | 0.25                 |
| - Frustrations     |          | 1.00        | 0.33         | 0.33                              | 0.33           | 0.67         | 0.67        | 0.00        | 0.33                 |
| - Ideal experience |          | 0.00        | 0.00         | 0.00                              | 0.50           | 0.00         | 1.00        | 0.00        | 0.00                 |
|                    |          | <b>1.75</b> | <b>0.58</b>  | <b>1.08</b>                       | <b>1.42</b>    | <b>1.42</b>  | <b>2.42</b> | <b>0.00</b> | <b>1.08</b>          |
| Lena               |          |             |              |                                   |                |              |             |             |                      |
| - Goals            |          | 0.33        | 1.00         | 0.67                              | 0.83           | 0.33         | 0.00        | 0.33        | 1.00                 |
| - Frustrations     |          | 0.50        | 0.50         | 0.25                              | 0.25           | 0.25         | 0.25        | 0.00        | 0.25                 |
| - Ideal experience |          | 0.50        | 1.00         | 0.50                              | 1.00           | 0.00         | 0.00        | 0.00        | 0.50                 |
|                    |          | <b>1.33</b> | <b>2.50</b>  | <b>1.42</b>                       | <b>2.08</b>    | <b>0.58</b>  | <b>0.25</b> | <b>0.33</b> | <b>2.25</b>          |
| Anneli             |          |             |              |                                   |                |              |             |             |                      |
| - Goals            |          | 0.33        | 0.67         | 0.67                              | 0.33           | 0.33         | 0.67        | 0.67        | 0.33                 |
| - Frustrations     |          | 0.33        | 0.67         | 0.67                              | 0.33           | 0.00         | 0.67        | 0.00        | 0.33                 |
| - Ideal experience |          | 0.00        | 1.00         | 1.00                              | 0.00           | 0.00         | 0.00        | 0.00        | 0.50                 |
|                    |          | <b>0.67</b> | <b>2.33</b>  | <b>2.33</b>                       | <b>0.67</b>    | <b>0.33</b>  | <b>1.33</b> | <b>0.67</b> | <b>1.17</b>          |
| <b>Total sum</b>   |          | <b>4.92</b> | <b>5.42</b>  | <b>4.33</b>                       | <b>3.83</b>    | <b>2.67</b>  | <b>5.42</b> | <b>1.33</b> | <b>4.50</b>          |
|                    |          |             |              |                                   |                |              |             |             | <b>1.75</b>          |

Figure 5.5: Evaluation of the personas

## 5.3 The two final conceptual models

Below the two final concepts are described in greater detail. Both showed potential, however, the production and flow concept constituted a greater challenge in terms of accessing statistics and data as well as the coming hi-fi prototyping. Due to time and resource constraints, the scheduling concept was chosen to go forward with.

### 5.3.1 The scheduling concept

This concept was created with the persona Lisa, (Figure 5.3) in mind, as she had the highest scores on the two merged scheduling concepts. A story board with Lisa and the persona Anneli (Figures 5.2-5.3) is attached below, in Figure 5.6.

Lisa is in need of a better digital support for scheduling. It should be integrated with already made schedules, allowing them to auto-update if a change is made later on. She needs support for ensuring competence retention among the staff, by making sure they rotate and thus use all their competences frequently. By visualizing the history over the scheduled staff she would like to get a better overview of where each person has been positioned, so that she then can make the next schedule with this in mind.

To meet her needs, as well as some of the needs of the three other personas, this concept aims to simplify and streamline the process of making schedules. The concept has two parts; one directed towards the scheduler, the other directed towards employees. When signing in, the system will automatically detect which of the two the user is and present the corresponding part of the system. The scheduler part of the system will contain an overview and information on all employees, as well as functions including creating a schedule and viewing scheduling history. The staff part of the system will show their own page with personal information and statistics, such as competences, experience and preferences. Information added by the employees will be visible for the scheduler and vice versa. The system is of an instructing and responding interaction type [14]. Metaphors included are calendars for planning, green trees for healthy schedules, search and filtering functions when looking for specific data. Below are more detailed descriptions of the two parts of the system.

#### MyPage

This is the personal page of each employee. All their information is gathered here and they have the possibility to add or change preferences, such as 'I would like to work at this position', 'I work very well together with Carl' and 'I cannot work before 7 am on Mondays'. Furthermore, they will be able to get an overview of their competences and how much they have been at each position as well as plan future career steps by adding competences they want to attain. A calendar is used to show history over shifts previous months and used in a similar way for adding a preferred schedule for the upcoming scheduling period. When adding a preferred schedule the function "Where am I needed?" will be available allowing the staff to easily see which shifts are not covered that match their competence profile. A function showing the current work hour balance is present as well as how these hours will change when adding a new preferred schedule period. Another function will calculate how healthy an employee's schedule is, with warnings popping up if it becomes too unhealthy, as

well as general information about healthy schedules. Reminders will also go out to employees when the preferred schedule deadline is coming up.

## **Scheduler**

The scheduler part of the system contains a database with all the staff and their information from each employees' MyPage. It can be sorted and filtered. A search function is also available for easy access. Furthermore, a library of old schedules, both overall and personal, will be available with information on which employee has been where and to what extent. Additionally, there will be a record of all changes made; what, why and by whom. Apart history, there will be a function of creating a new schedule for the upcoming period. The system will give the scheduler a calculated suggestion taking different aspects into account. It will optimize staff and their profiles, with different competences and preferences to fit the organization's needs, as well as laws and work environment requirements. Warnings will show inconsistencies such as missing competences, too few employees, and enable an easy overview and possibility for manual adjustment for the scheduler. When adding staff to a work shift a drop down list of suggested personnel will show, listing those who have been at the competence the least at the top. If a person is new to a position and needs to be there more often to finalize the training, a mark will show this and they will be at the top of the drop down list. When creating a new schedule there will also be an overview section summarizing which competences are covered and which are not for each shift. If a staff member holds more than one competence, only the competence that has been scheduled will be counted.

### **5.3.2 The production and flow concept**

This concept was created with the persona Lena in mind, shown in Figure 5.3. She had the highest scores on the two production and flow concepts and was therefore a good candidate. A storyboard that exemplifies the concept and process can be found in Figure 5.7.

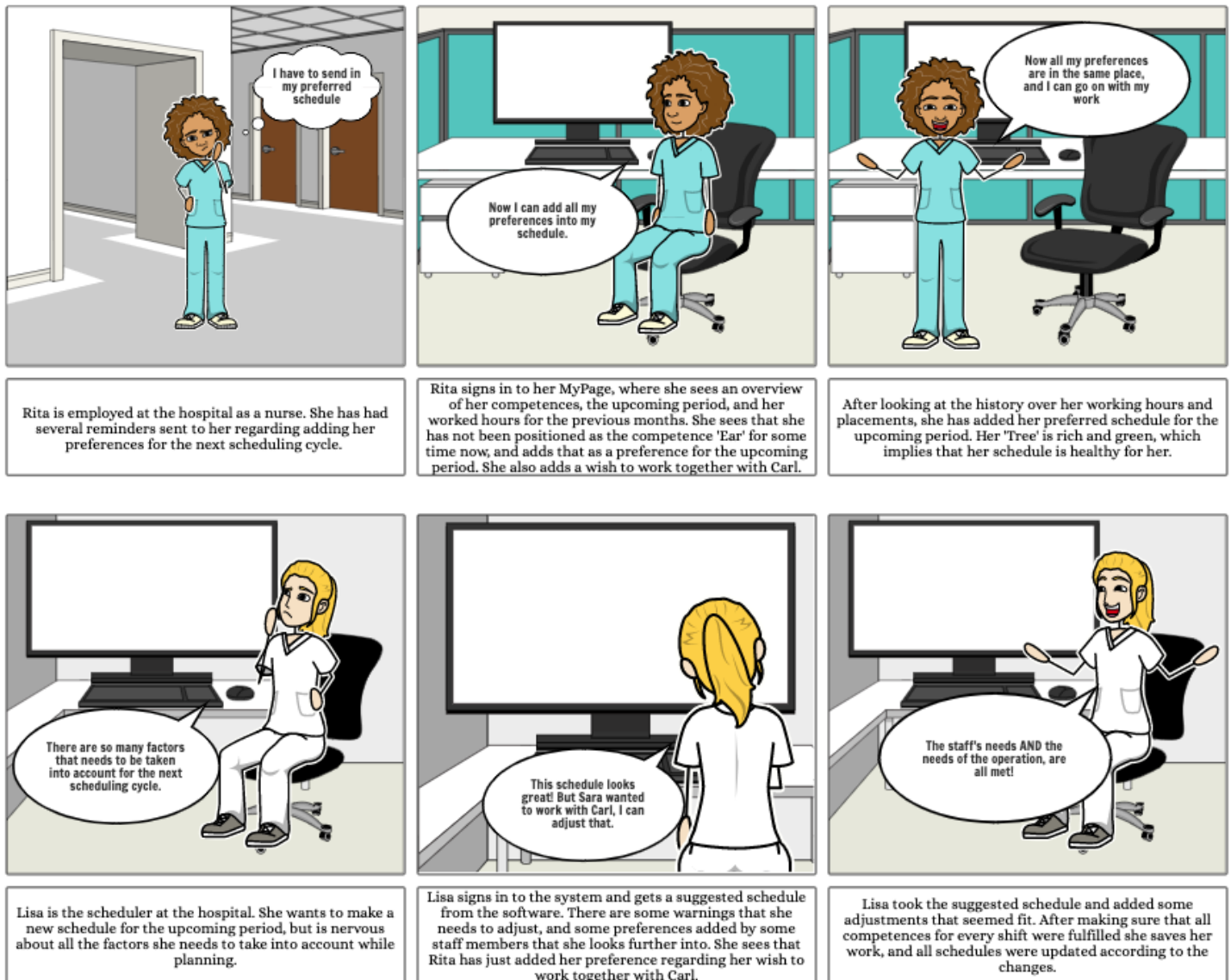
Lena needs a better overview of production and unit needs. She needs a tool that can help her with the mapping of production and operations in order to take active charge of production and not only base it on how things usually are run. By gaining a better overview of production she will then base unit scheduling on this data and thus, match the production to the actual needs.

This tool will help her collect statistics over things such as the current wait lists (patients in line), the planned surgeries, duration of different kinds of surgeries, how long new visits and re-visits take as well as how the patient flow can be improved. This is done by extracting data from current digital systems, as well as mapping the patient journey and finding the bottlenecks in the process. Furthermore, a mapping of the available resources should be done in order to know where the current constraints are located. One method to do this is tracking each patient and thereby getting an overview of where crowding is present. This could give an indication to where the bottlenecks are based. Another method is to equip staff with pedometers (counting steps) in order to see during what time of the day they walk the most. An AI can be trained based on the data from the pedometers and thus a pattern of the unit strain over time can be obtained. This will in turn create a better

understanding of how the resources in terms of staff are matching the unit needs. They can then be adjusted in order to optimize operations.

All this collected data will result in a forecast of how the next period should be planned and scheduled, taking other units into account as well as the production goals.

The tool is of both an instructing and responding type [14]. It is instructing when data, goals and resources are inserted manually. On the other hand it is of a responding type when the forecast is presented. Metaphors such as forecasts are used, as well as time indicators to visualize duration of operations.



**Figure 5.6:** The storyboard of the scheduling concept. The top three boxes visualize the persona Anneli (nurse), and her way of using the product, while the three bottom boxes shows the persona Lisa's (scheduler) point of view.



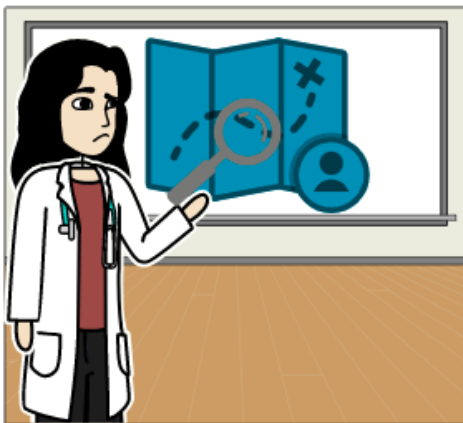
Lena's unit does not meet the Swedish Vårdgaranti and there are many people waiting. The unit is always full.



She has a feeling that things could be done more efficiently.



She implements the tool and adds different kinds of statistics.



She searches through the patient care pathway to find bottlenecks, and maps the patient's journey along with the available resources.



A forecast of how she should plan and schedule is obtained. Now she knows how other units will be affected and how she can meet the demands in the best possible way.



The forecast is sent to the scheduler, so that the scheduler can base the schedules on the production and the needs of the hospital.

**Figure 5.7:** The storyboard of the production concept visualizes the persona Lena (unit manager) in her thoughts of streamlining the productivity.



## 6. Low fidelity prototyping

---

This chapter describes the process of creating the first and second iteration of lo-fi prototyping of the scheduling concept described in Section 5.3.1. This constitutes two iterations in the prototyping and evaluating part of the process overview as seen in Figure 6.1. For every iteration a description of the design is presented along with the testing and evaluation of the prototype. The test group consisted of three test subjects in each iteration.

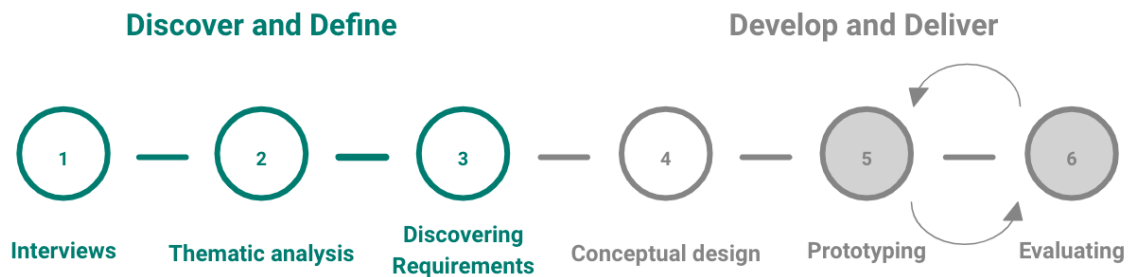


Figure 6.1: Process overview

### 6.1 First iteration

Low fidelity prototyping is used to explore alternatives and ideas, early on in the design process [14]. The lo-fi prototype does not have to look like, or even have the same functions, as the final product. It is simply a mean to visualize one's ideas and is often simple, cheap, and quick to produce.

In this study lo-fi paper prototypes were created, with each screen drawn on a different piece of paper. Pop-up alerts were simulated by placing cut outs on top of the current screen. Photos were taken of each sheet of paper and uploaded to the digital software Marvel App [32]. The platform allows to make connections between screens allowing users to maneuver in the prototype digitally. The interface designs and layouts in the prototypes were based on the design theory covered in Section 2.3.

The interfaces of the two parts in the scheduling concept (MyPage and Scheduler) had several things in common. Screens in both parts all had a menu bar at the top with several elements. This was done in order to maintain consistency and visibility, as well as comply with the F-shaped reading pattern [20]. The elements in the menu bar were separated from the other components on the screen by a line and thus helping the user navigate using the common region Gestalt principle [19]. The buttons representing shortcuts to the main pages were based on the Gestalt principles proximity and similarity [19]. The design principle signifiers and metaphors [18] were used in terms of icons in the menu bar



(notifications→ bell icon, E-mail→ letter icon and home→ house icon) to convey the actions that could be performed when clicking on those elements and increase familiarity. Three lines in the top right corner also indicated a collapsed menu. Furthermore, feedback was used when performing an action throughout both parts of the prototype, such as with pop-up alerts. Continuity [19] was applied by using informative headlines on all screens. Screens that needed a *Save* button had one placed in the bottom, right corner, in line with the F-shaped reading pattern, as this was an action aimed to be performed at the end. Figures 6.2 and 6.3 show the home pages for staff (MyPage) and scheduler. The design of the two parts will be further elaborated on below.

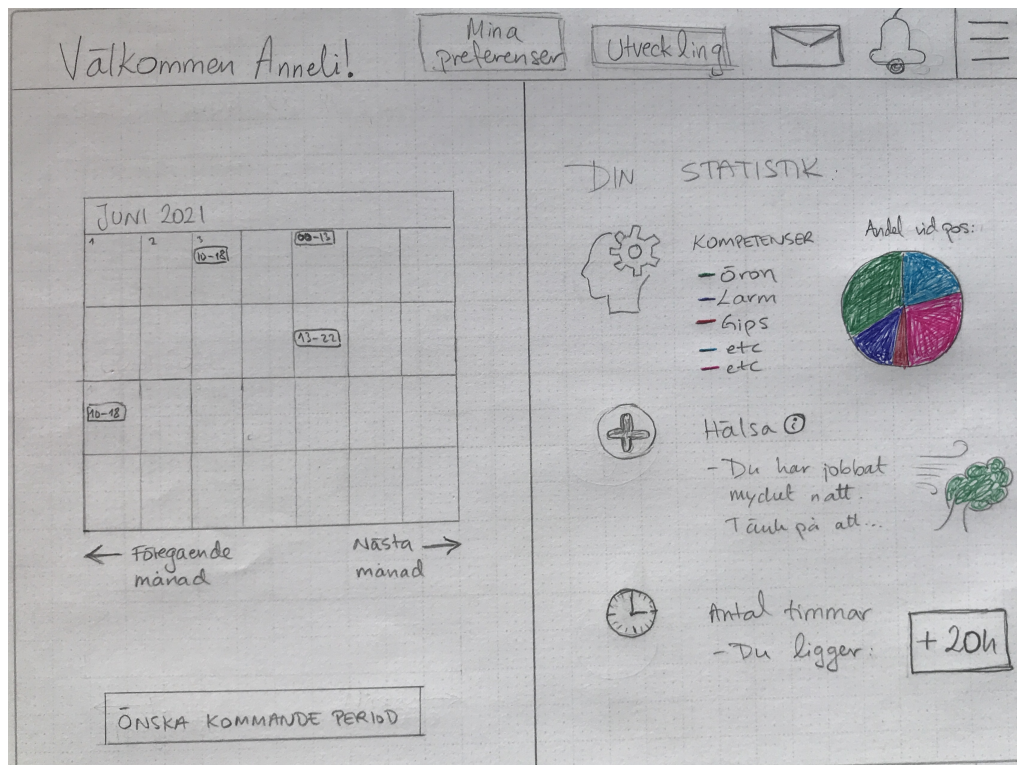


Figure 6.2: The home page of the MyPage in the first iteration.

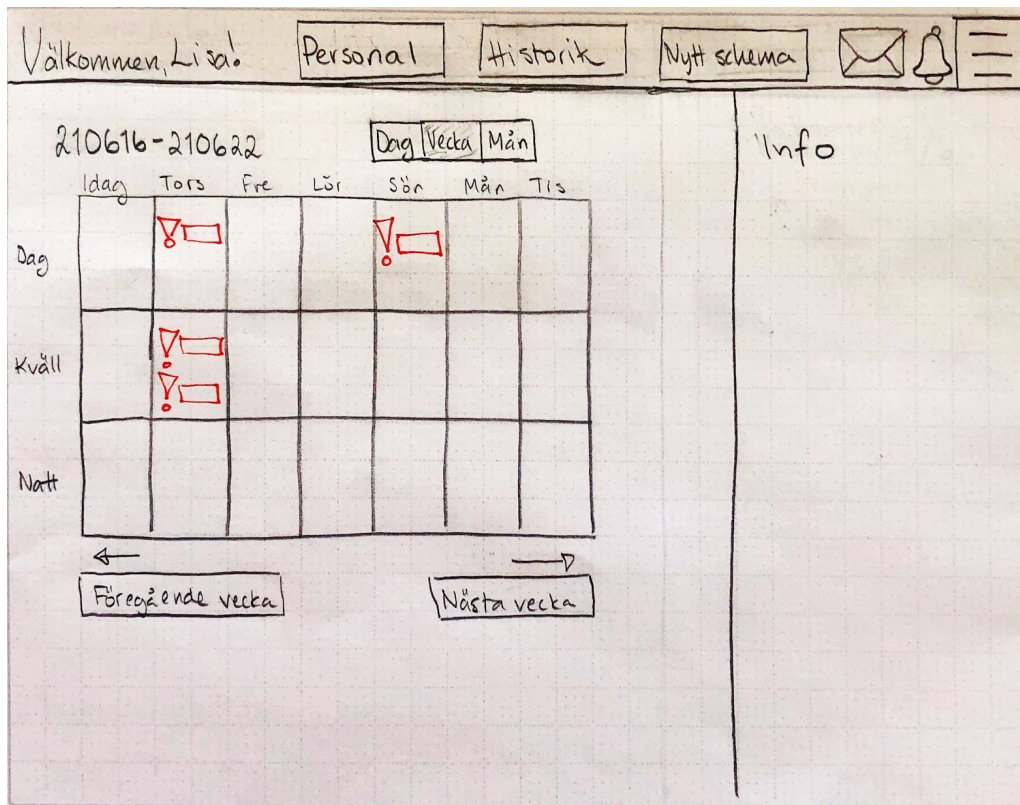


Figure 6.3: The home page of the scheduler in the first iteration.

### 6.1.1 MyPage

This part was created for the staff and had three main sections apart from the first page, *My preferences* (Swe. Mina preferenser), *Development* (Swe. Utveckling), and *Schedule*, since they were found to be important for the staff. The first two sections could be reached through the menu bar, while the third section was reached when pressing the *Plan next period* button (Swe. Önska kommande period) on the first page. The three sections will be elaborated on below:

- **Home page** - The screen was divided into two sections, one for the person's current work schedule and upcoming/earlier shifts, and the second for work statistic and information. The sections were deemed as equally important and thus were the same size. A monthly calendar was used as a metaphor to facilitate grasping the current schedule and icons were used to complement the headlines of statistics and information. The pie chart showed how much a person had been positioned at their different competences over time. Clicking the competence icon would direct the user to the *Development* page. The information icon next to the *Health* (Swe. Hälsa) headline would direct the user to a page with information on healthy schedules. The tree was used as a metaphor for health.
- **My preferences** - When clicking on *My preferences* in the menu bar a drop down list appeared on top of the current page showing a preview of the preferences entered, for an easy overview access, as well as a *Manage my preferences* button. The button lead to

the *My preferences* page where the user could indicate what shift they preferred to work and who they preferred to work with, in drop-down lists. Furthermore, there were text fields where they could input information themselves.

- **Development** - This page contained information about the person's competences, the last time they were at a function where they used them, and how these competences were distributed over time. Additionally, there were drop-down lists with other competences the person could ask to be trained in. Further down, there was a summary of formulated goals and notes from staff appraisal.
- **Schedule** - This page was divided into two sections. One smaller to the right with the number of hours scheduled, a tree showing how healthy the schedule was and a prognosis over what competences have been scheduled. The bigger section to the right had a headline at the top indicating what period was to be planned, along with a text-box underneath for preferences. The most part of this section was however constituted of a calendar. There were two buttons below the calendar: *Where am I needed?* and *Save*. The first button was to show what shifts yet needed to be covered, and was placed to the left, thus seen first, in line with the F-shaped reading pattern.

## 6.1.2 The Scheduler

This part had three main sections apart from the first page, *Staff* (Swe. Personal), *History* (Swe. Historik), and *New schedule* (Swe. Nytt schema), since they were found to contain all the actions needed by a scheduler. The sections will be elaborated on below.

- **Home page** - The screen was divided into two sections, one smaller to the right with the headline *Info* and one bigger to the left with a weekly calendar. The calendar had three boxes per day, indicating three-shift-days with labels *Day* (Swe. Dag), *Evening* (Swe. Kväll) and *Night* (Swe. Natt) on the left hand side. There were red icons indicating a warning in some of the boxes. These represented vacancies, i.e. last minute cancellations of shifts (such as calling in sick), that needed to be solved. When one of those icons was clicked, information about that vacancy was presented in the right hand section, along with available staff to call in. This was chosen as the main page since interviewees had emphasised that solving vacancies was one of their main tasks.
- **Staff** - A search bar and filter options were at the top of the screen followed by a list of panels with short information about each person. A scroll bar was added to the left hand side to indicate that you could move down through the panels, involving the affordance principle [18]. The proximity and common region principles [19] were used to separate information about each employee as well as the consistency principle since each panel contained the same type of information, such as a picture of the employee to the left.
- **History** - This screen was added to meet the need of knowing who made what changes to the schedule and why. Furthermore, employee history and statistics over time were available to aid the scheduler in creating schedules that helped staff retain their competences through rotation on different positions. A search bar was placed at the

top. Beneath it there were two buttons indicating a time span, and a filter button. The remaining  $\frac{2}{3}$  of the screen was covered by a sheet with the schedule and information about that chosen day/period, as well as sorting possibilities. When clicking on a name of an employee in the sheet, statistics and employee history were shown in a new screen.

- **New schedule** - When clicking this section in the menu bar a question would appear asking if a new blank schedule was to be made or if a suggested schedule was to be edited. The suggested schedule was generated by the software and based on the staff database, unit requirements, and work environment laws. Choosing the generated schedule a screen appeared with one big section to the left and a smaller panel to the right with four different sections, as seen in Figure 6.4. The left section contained a sheet with the schedule for one day with suggested staff on each work shift and information about the competences needed. Clicking on a person, a drop-down list of staff would appear. It contained staff that all had the right profile and could be scheduled instead of the person, as seen in the figure when clicking on Jonna. The last column in the sheet showed alerts, with a legend in the panel to the right. Different colours indicated severity. The first section in the right panel showed a monthly overview and the current date, the second showed how many competences have been filled, and the bottom one was a button for locking the finished schedule. There was a *Save* button below the sheet that saved the changes made without locking the schedule.

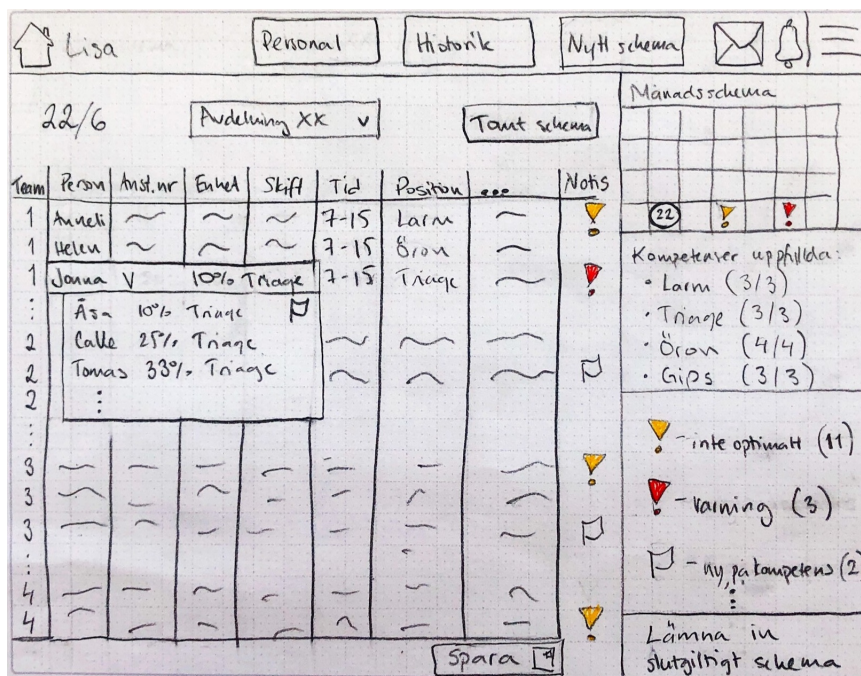


Figure 6.4: The *New schedule* screen for the Scheduler in the first iteration.



## 6.2 Testing and evaluating 1<sup>st</sup> iteration

The lo-fi prototype was tested and evaluated by a group of three people. This number was chosen since it is found that a majority of usability problems can be detected with a test group of three to five people [33]. Two of the test subjects had extensive knowledge on design methodology and one had vast experience within the Swedish healthcare sector. The Think Aloud test method [14] was used, as it gave good insight to how the different levels of the prototype were experienced. When a person tests a prototype using this method she/he is asked to speak out loud and communicate what they are feeling or thinking when interacting with the prototype. All feelings, thoughts, first impressions, or ideas are encouraged to be shared. The developers do not interact with the tester during the test apart from giving instructions, but note what she/he is sharing when carrying out the test. This feedback can then be used in the next iteration.

Due to the ongoing pandemic the Marvel App [32] was used for testing the prototype. The built-in test feature allowed testers to record sound, video, and the test subject's screen while following written instructions and completing tasks. These included testing all of the main features and can be found in Appendix E.1. The test subjects spoke while conducting the test, in line with the Think Aloud method. Upon completion the recording was uploaded to Marvel, making it available to the developers. Next, the subjects were asked to participate in a survey with six short evaluating questions. The survey can be found in Appendix E.2.

## 6.3 Findings from the 1<sup>st</sup> iteration

The first user test resulted in many findings, some of them found in Figure 6.5. The overall design was received well, as the testers understood how to maneuver without much trouble. The menu bar was intuitive, and they all were able to reach the correct page for each task. However, the *Development* section in the menu bar was not used by any of the testers when completing the competence task. The house icon worked well as a metaphor for the home page, and they all knew how to log out by entering the collapsed menu. The home pages were well received but there were wishes of additional and clearer signifiers, such as more descriptive titles and drop-shadows on buttons. The *My preferences* page in the MyPage part and *Staff* page in the Scheduler part were easily found and understood. All users managed to solve the tasks associated with these pages. Feedback on the remaining sections and their corresponding tasks can be found in Table 6.1.

Furthermore, feedback regarding the test itself was received. The box where the instructions were shown was experienced as too small and hard to manage. Showing all tasks at the same time caused some confusion and one of the testers forgot to complete one task because of this. The feedback was to give one task at a time, making sure that the tester focused on and finished each task. The test questions were experienced as somewhat inconsistent and the scenarios were perceived as unfinished. The feedback was to formulate questions that encouraged the tester to finish a whole scenario. Such as making a final correction and saving a schedule without any warnings or alerts. Lastly, there was feedback suggesting a short interview instead of the survey, since it was experienced as difficult to give objective feedback while answering the questions in text.



Figure 6.5: Feedback received in the first iteration.

Table 6.1: Findings from user test 1.

| Section                           | Key findings  | Quote   |
|-----------------------------------|---|---|
| MyPage - Competences/ Development | There was some confusion regarding the competences and the personal development screen. None of the subjects reached this page through the menu bar and a majority did not grasp the difference between competences wanted and had.   | - Confusion around actual competences and competences I would like to get better at. Separate these two.  |
| MyPage - Schedule                 | There were comments received regarding the way of choosing shifts and specifying times. More signifiers were wished for. Furthermore, there was some confusion about the scheduling process and a clarification of it was wished for. | - I want to make my preferred schedule without taking anyone else into account but also see what my colleagues wished for.<br><br>- There should be a headline called "Schedule" for clarity. |
| Scheduler - New schedule          | The percentages, annotations and competences were not completely understood. Some more feedback was wished for.   | - What is team 1?<br>- I thought I only made an suggestion. How do I unlock it?   |
| Scheduler - History               | This segment of the prototype was not well received by the users, as none of the three subjects understood how the History-part was meant to work, and thereby could not complete the task that regarded this section.                | - I can't solve the task.   |

## 6.4 Second iteration

For the second iteration the feedback from the first was taken into account and the prototype was remade accordingly, as will be described in the two following subsections. The first step was to revisit the scheduling process and clarify the concept, as seen in Figure 6.6. This was visualized in the new prototype by adding a timeline below the menu bar in screens connected to scheduling, for both the MyPage part as well as the Scheduler part. Furthermore, a mark showed today's date in that timeline, giving insight to where in the scheduling process one was. The prototype was again created on paper with each screen on a different sheet. Photos of the sheets were taken and uploaded to the Marvel App [32], where connections between the images could be made. This time, Marvel was used further by adding colours to the calendars with the help of the software, and by creating some of the pop-ups digitally. It was done to simplify and expedite the creation of very similar screens. Below, a description of changes made when creating the second lo-fi prototype will be presented.

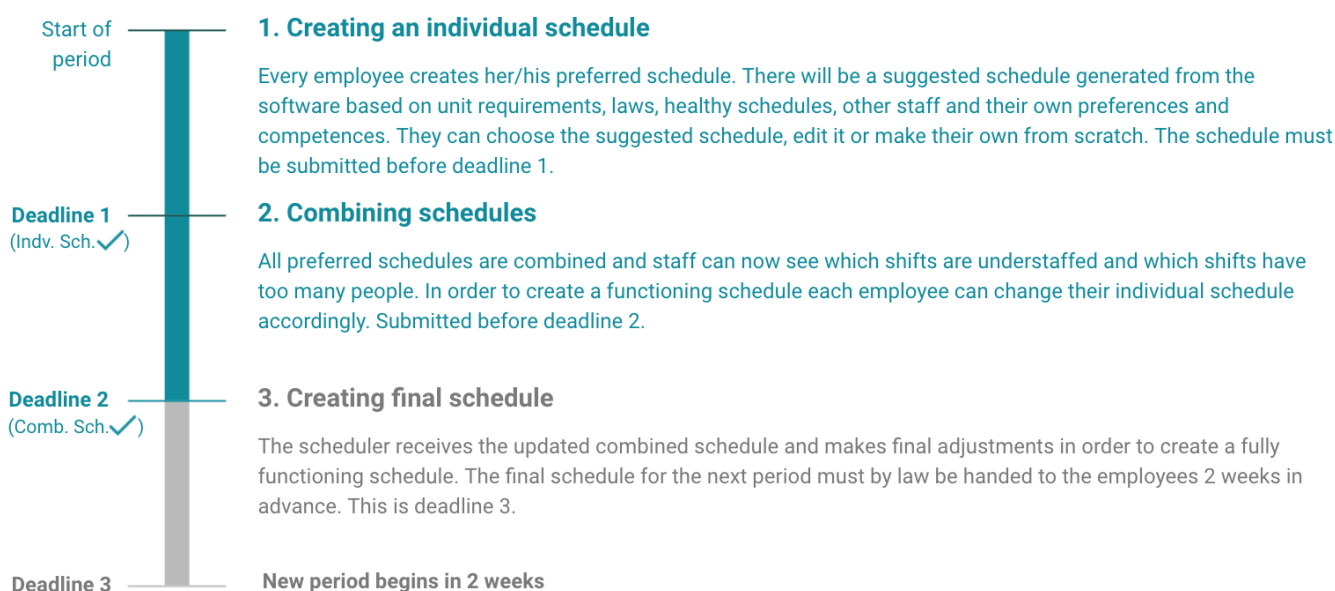


Figure 6.6: The clarified scheduling process.

### 6.4.1 MyPage

After redefining the scheduling process, it was clear that scheduling was one of the central parts for staff. Due to this, a third section was added in the menu bar called *Schedule* (Swe. Schema), so that it could be reached from all pages increasing visibility. In line with the similarity and continuity principle [19] it followed the design of the other two sections in the menu bar. Furthermore, the section *Development* was renamed to *Competences and development* (Swe. Kompetenser och utveckling) in order to clarify the contents on that page, since none of the testers reached that page through the menu bar, while completing the competence task. Feedback was added throughout the prototype, with the use of pop-ups. Further changes made are listed below.

- **Home page** - The previous design of the home page was kept intact, as the feedback from the testers implied that it gave a good overview. Colours were incorporated in the calendar instead of boxes with times in them, in order to create focal points that are easier to grasp [19]. A three-shift-day was assumed, with a different colour for each shift. A headline was added above the calendar, as an additional signifier [18]. Additionally, an information button was added by the headline that contained information about the schedule. When clicked, a pop-up alert appeared, as seen in Figure 6.7.
- **My preferences** - Similarly, the *My preferences* page did not change significantly, other than adding extra drop-down lists to enable stating multiple co-workers that the employee worked well with.
- **Development** - In this section headlines were adjusted to clarify the difference between *wanted* and *possessed* competences. An information button was added by the *wanted* competences for more information. Furthermore, the notes and goals from staff appraisals were moved to the right hand side in a separate box in line with the common region and figure-ground principle [19], since it was separate from the two other sections on this page. A shortcut to *Healthy schedule* was added, within this box.
- **Schedule** - This page would look somewhat different depending on the current phase of the scheduling process. The two different phases where staff are involved (phase 1 and 2) are elaborated on below. The overall layout was the same but with slight differences, such as signifying headlines, colours and buttons. The page was again divided into two sections, one to the left for a calendar, the other to the right, as a side panel. An information button was added by the calendar signifying additional information. One could scroll in the calendar to reach different months, as indicated by the scroll bar to its right, separating it from the side panel. The text box above the calendar was removed. The two scheduling phases are described:
  1. When making their preferred schedule, the calendar had highlighted shifts showing the generated suggested schedule. Above the calendar there were three choices: *Choose shifts*, *Cannot work* and *Vacation*. When marking the first choice, one could add work shifts to the schedule. Those would appear as bright boxes with the corresponding shift colour. When marking the second choice, one could mark shifts as *Cannot work* and they would appear bright red. Similarly, when marking *Vacation* one could apply for vacation. When choosing shifts to work there was a possibility to choose all suggested shifts. This was shown as a checkbox in the lower right corner, below the calendar. When checked, all highlighted shifts would become bright and full-coloured, indicating that they were chosen. Another option was to select shifts manually by pressing the top, middle, or lower part of that day. This shift would then be coloured brightly to indicate that it was chosen. In the side panel a summary of hours scheduled was shown, along with the competence pie-chart and a *Save* and *Send* button.
  2. When combining the schedules, the side panel remained the same, apart from just having one button: *Save*. In the other section, there was only a headline, a calendar with one's preferred schedule (created in the previous phase) and a



button called *Where am I needed?* in the bottom left corner. Upon clicking that button, all understaffed shifts got a negative number in their left corner. The understaffed shifts that were not a part of the employee's schedule were marked as bright green, to indicate that they were "available". At the same time, shifts that were overstaffed and chosen by the employee (in their preferred schedule), got a positive number in the left corner. This is shown in Figure 6.8 and aimed to help the staff create a functional schedule.

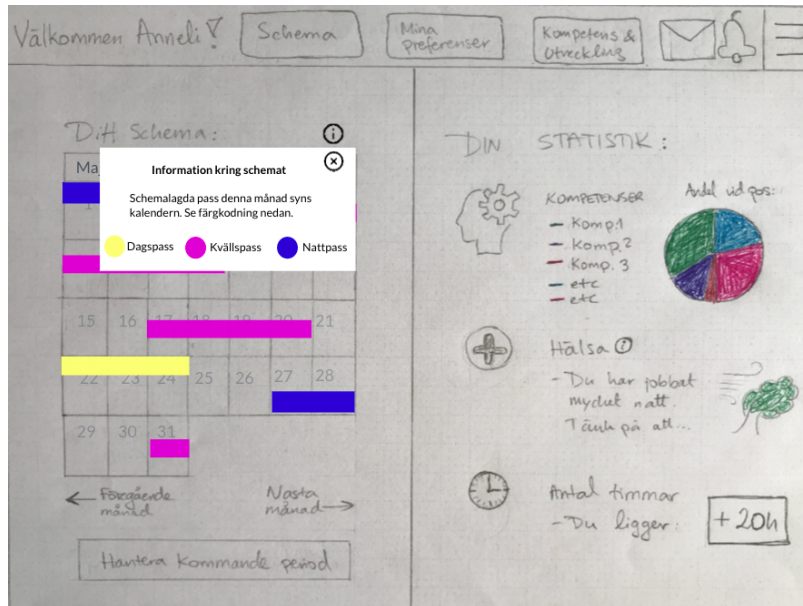


Figure 6.7: The home page of MyPage in the second iteration.

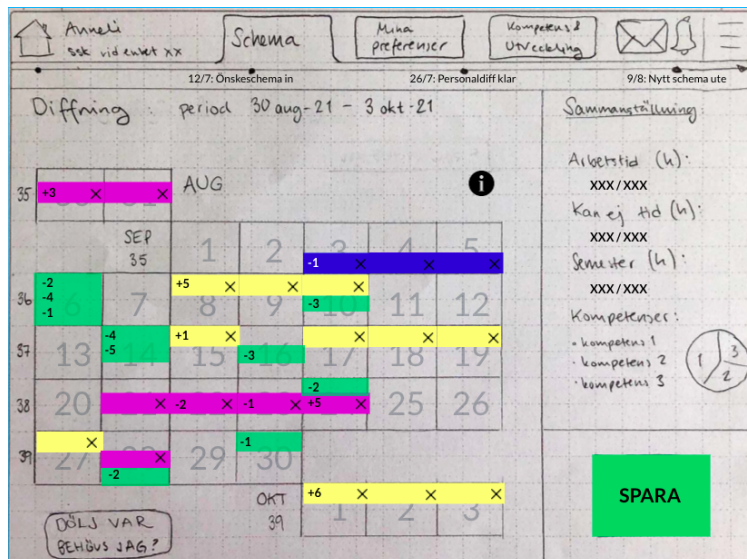


Figure 6.8: The Schedule page in the second phase of the scheduling process for the MyPage, in the second iteration.

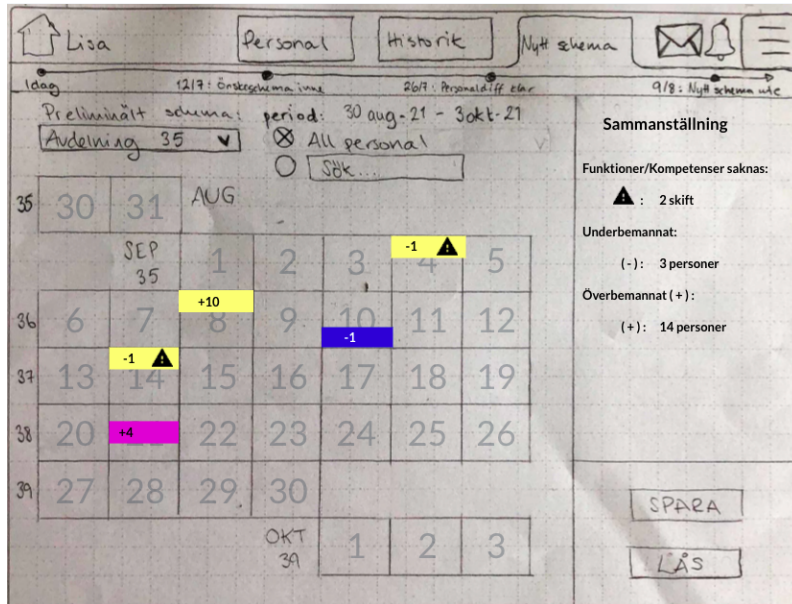
## 6.4.2 The Scheduler

The three sections *Staff*, *History* and *New schedule* were kept in the second iteration as the testers maneuvered successfully during the test. Changes made in each section are described below.

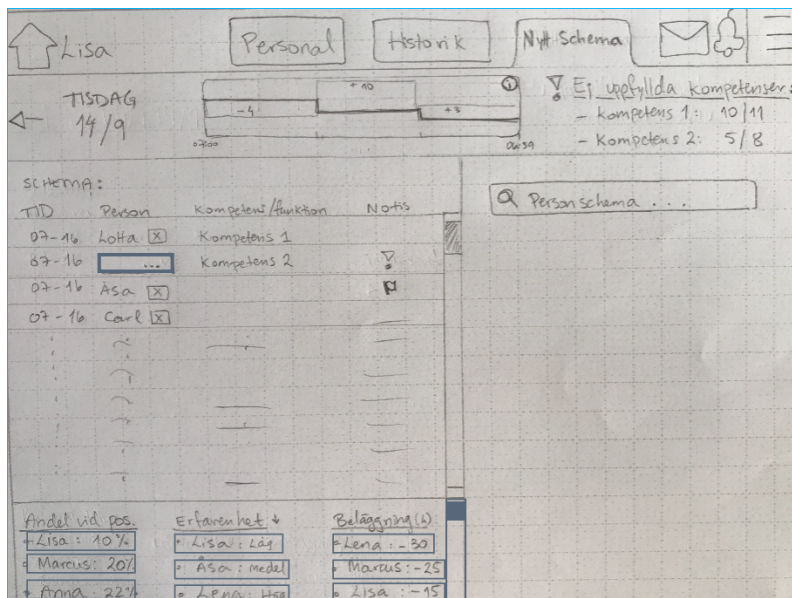
- **Home page** - Details were added to the home page, including a change of alert icons and better headlines. A weekly view of the calendar was kept, and once an alert icon was clicked information in relation to that vacancy was showed in the side panel, with possible employees to call in. A decision made was to add a button called *Solve vacancy* (Swe. Lös vakans) so that a chosen employee would replace the original staff member in the schedule and the alert on that day would disappear. If clicking on a day twice, the schedule of that day would appear.
- **Staff** - This page was kept similar to the previous iteration.
- **History** - On this page the sheet with information was replaced with a calendar, that could be scrolled up and down in order to reach different months. There was a side panel with a search bar and filters to choose a time span. Changes that were made in the schedule over time, were shown as exclamation marks on those days, in line with the principle signifiers [18]. When clicked, information about the change, such as who did what and why, appeared as a pop-up. A calendar of a department was set as default and the headline of the department was placed in the top left corner, in line with the F-shaped reading pattern [20]. This was done with the assumption that schedulers usually were interested in history of whole departments rather than for individual employees. However, if inputting an employee in the search bar their page would appear with individual statistics and history. The search bar was placed in the side panel as it was deemed secondary.
- **New schedule** - As the scheduling process was renewed the scheduler did not play a part until phase 3. In this phase her/his aim was to make a fully functional schedule out of the combined schedule. Thus, the first page was changed into a calendar with colour and notes on shifts that were not functional (under/overstaffed), as seen in Figure 6.9. Negative/positive numbers indicated under/overstaffed and warnings indicated missing competences. A summary of the period was in the right hand panel. Again, a specific department was set as default but could easily be changed to other departments in the drop-down list, indicated by the arrow as a signifier [18]. Furthermore, showing schedules for individual employees was possible if selecting *Search* (Swe. Sök) instead of *All staff* (Swe. All personal) and searching for a person. The calendar would then show her/his preferred schedule from phase 2.

When clicking on a non-functional shift, the day view of that shift would appear. This view was split into two sections, the left one slightly bigger than the right. The left showed the schedule for that day with shifts (specified times), personnel scheduled, competences needed, and notifications. The bottom part of the section had a headline called *Information about the staff*. The right hand section had a search bar with the title *Employee schedule* (Swe. Personschema), where individual schedules could be shown. An understaffed shift would show as an empty box in the schedule. When clicked, information about suitable employees was shown in the bottom box,

as seen in Figure 6.10. In this view, there was an additional top section with the date, a figure describing current under/overstaffing during that day, and a summary over missing competences.



**Figure 6.9:** The *New schedule* month view for the Scheduler in the second iteration. The under/overstaffed work shifts are shown in the calendar, and a summation of the shifts are shown in the right hand sidebar.



**Figure 6.10:** The *New schedule* day view for the Scheduler in the second iteration, showing the missing staff and suggested staff to fill in.

## 6.5 Testing and evaluating 2<sup>nd</sup> iteration

This lo-fi prototype was again tested by a group of three people [33]. One with previous interaction design insights, and two in the appropriate age span: from early 20s to mid 50s, in line with the age group of the user study interviewees. Once again, the Think Aloud method [14] was used with the Marvel App as medium for the user to interact with the prototype in. Differently from iteration 1, testers did not receive written instructions but had a test leader present through Zoom or in person, giving them one task at a time. When the test was completed, a short semi-structured interview with six evaluating questions was held that gave insight on how the user perceived the prototype, in place of the survey in iteration 1. Both the test questions and the follow-up questions can be found in Appendix F.

## 6.6 Findings from the 2<sup>nd</sup> iteration

The feedback received from the second testing resulted in multiple findings. The test subjects were positive to the concept, and the prototype, commenting that its functions lowers the administrative burden and makes room for the actual task at hand. The menu bar was easily interpreted and used by all participants. Some of the feedback received from the participants was that they were lacking context and did not understand some of the concepts and icons used, indicating that some clarifications were necessary. The information icons (ⓘ), with additional explanations shown in pop-ups, that had been added to many of the pages, were appreciated and well used. However, they were not always found straight away and their placements might not have been optimal. Furthermore, one of the testers had a suggestion of incorporating a tutorial of the software, for an easy and fast introduction to the system, as well as a possible revisit to refresh the memory. In Table 6.2 the feedback on specific pages is gathered.

**Table 6.2:** Findings from user test 2.

| <b>Section</b>                    | <b>Key findings</b>   | <b>Quote</b>  |
|-----------------------------------|---|---|
| MyPage - Home page                | Perceived as easy to grasp and understand. Suggestion to add a To-Do list, to make sure that staff knew when the scheduling deadlines were coming up. Another option thought of was to add a notification on the <i>Schedule</i> tab when deadlines were closing in. The <i>Healthy schedule</i> information was commented on as important and interesting.   | <p>- <i>I'm guessing this is my schedule.</i></p> <p>- <i>A To-Do list might be good.</i></p> <p>- <i>Healthy schedule is good. Should be considered when making a schedule.</i></p>  |
| MyPage - Competences/ Development | Easy to find and added competences with ease. However, did not completely understand what competences meant.  | <p>- <i>What does competences mean?</i></p> <p>- <i>Good that you can choose what competences to develop in.</i></p>  |
| MyPage - Schedule                 | Perceived as hard to grasp with a lot of information. The timeline was appreciated but not completely understood due to the small text. An explanation of the timeline and scheduling processes was requested. Hovering over days to see shifts was suggested as well as moving the checkbox for <i>Choose all suggested shifts</i> . Accessing <i>Healthy schedule</i> information was asked for, and the <i>Where am I needed?</i> button seemed unnecessary.   | <p>- <i>Too much going on.</i></p> <p>- <i>I liked the timeline.</i></p> <p>- <i>Where can I choose all shifts?</i></p> <p>- <i>How do I make this healthy?</i></p> <p>- <i>Do I have to click "Where am I needed"?</i></p>   |
| Scheduler - Home page             | Good visual overview. Some clarifications of icons and concepts were requested, e.g. describing the vacancies in more detail. An idea was to get information by hovering over vacancies.  | <p>- <i>What's 7-16?</i></p>  |
| Scheduler - New schedule          | Tasks regarding the upcoming schedule left testers somewhat confused. The name of the tab might be misleading. The page itself was perceived as clear, simple and easy to understand, with a good visual sorting of information. The timeline appreciated. There was some confusion when trying to add a person to the schedule regarding the sorting filters; the headlines chosen were not understood. One of the testers understood the figure describing the current situation that day (under/overstaffed) but two did not. Information on <i>healthy schedules</i> was requested for the scheduler. All testers were looking for a <i>Save</i> button in the day-view page. | <p>- <i>This the new schedule.. I need the upcoming one..?</i></p> <p>- <i>Can easily see that there is one person missing 14/9 and 4/9.</i></p> <p>- <i>I want to know where I am in the timeline.</i></p> <p>- <i>Don't get a visual overload.</i></p> <p>- <i>Healthy schedule?</i></p> <p>- <i>I don't understand this.</i></p> |
| Scheduler - History               | Clear and straightforward. Testers easily solved the tasks.   | <p>- <i>That wasn't so hard.</i></p>  |

# 7. High fidelity prototyping

---

This chapter describes the process of creating a hi-fi prototype of the concept, also a part of the prototyping and evaluating part of the design process, shown in Figure 7.1. The prototype is based on the feedback received in the first two lo-fi iterations. A more detailed description and more advanced functions are described, followed by the testing and evaluation of the prototype with a test group of five test subjects. Last, the findings from the testing is presented.

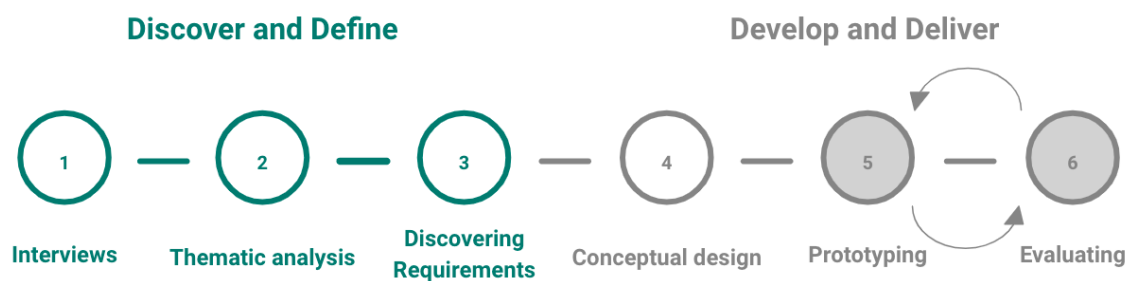


Figure 7.1: Process overview

## 7.1 Third iteration

A high fidelity prototype is more advanced than a lo-fi prototype. It resembles the final product more and enables the user to maneuver in it as if it was the real product [14]. For this thesis, the interface design tool Figma [34] was used. Icons and illustrations used were retrieved from Icons8 [35]. With findings from the two lo-fi iterations, the prototype was further developed in Figma.

The hi-fi prototyping allowed the developers to create a more realistic prototype by adding functions and actions that increased design principles visibility, affordance and mapping [18]. The learnability was also increased as the future testers had a better idea of how the interface would actually look and got better feedback from the prototype [18]. Functions like hovering, drop-down lists, scrolling and drop-shadows were added.

The colour theme of the prototype was decided to go in a green/blue/white palette, as those colours have been shown to relate to science and health in colour semantic studies [36].

A green colour (with hints of blue) was applied to the menu bar, pop-up screens, buttons, and enclosed areas, which increased visibility, affordance, and consistency in the prototype [18]. It also increased the number of signifiers and supported the Gestalt



principle figure-ground [19]. In addition to this, other colours were used to catch the users attention, introducing the Gestalt principle focal point [19]. This was applied in the calendars throughout the prototype distinguishing the different work shifts from each other; yellow for days, blue for evenings, and purple for nights. The colour red was used for different warnings; for example when there were vacancies for the scheduler to solve, or missing people in a schedule. To make it easy for the user to choose between different alternatives, buttons situated close to each other were coloured with different colours to signify a difference by creating a contrast between them. For example pop-up alerts with the choice of "Yes" or "No", had different coloured buttons. Bright green for the "Yes" button and bright red for the "No" button, as to signify *Success* or *Stop* [37].

To increase visibility and signify that buttons were clickable, they were coloured distinguishing them from the background and drop-shadows were added to them. The *Save* buttons were coloured with a grey colour as they only affected the user her/himself, while buttons implying an action affecting others, such as *Send schedule*, or *Solve vacancy*, were green, in line with the colour theme of the prototype.

The corners of the buttons were slightly rounded since sharp corners make the shape look brighter, and thereby harder to look at [38]. Rounded corners point inwards toward the center of the shape, which invites the user to click the button [38]. As the aim was to make the buttons as easily understood as possible, the labels were big and covered the whole button. This way they were easy to read and users could efficiently grasp the intended action of the button, relying on the usability goals and design principle signifiers [18].

Furthermore, the Sign In-page was modified, allowing the choice of signing in as *Anneli Karlsson* (staff) or *Lisa Andersson* (scheduler) to simplify and make the test flow more authentic. To comply with the feedback regarding deadlines the timeline was added below the menu bar in all pages. An addition was made in terms of adding a dot on the timeline, showing where one is in the scheduling process, as well as a small pop-up with more information (a short To-Do list) when hovering over the different deadlines in the timeline. This way users could easily see when deadlines were coming up and what was expected of them. Titles were added below the icons in the menu bar as additional signifiers, and feedback in terms of pop-up alerts reporting that an action had been performed, was added. Lastly, a shortcut to a tutorial of the software was added to the collapsed menu in the top right corner. This tutorial was not further implemented. Development and changes to the different pages in the hi-fi prototype will follow below.

### 7.1.1 MyPage

The feedback regarding the MyPage resulted in the changes that are explained below.

- **Home page** - With the addition of the timeline to all pages (home page included) the To-Do/deadline feedback was included in the prototype. The home page was coloured according to the colour theme and today's date was indicated with a red circle in the calendar, as can be seen in Figure 7.2.
- **My preferences** - While hovering on the *My preferences* tab in the menu bar, a pop-up screen appeared right below the menu bar, as an extension of it. It showed a preview of the chosen preferences, to make the product efficient to use. For more information the *Manage my preferences* button could be clicked, directing the user to the *My*

*preferences* page. The layout of this page was kept similar to the second iteration. However, the choice of preferred work shifts was changed to a selection where one could mark the wanted type of shift (day, evening, night) by pressing on it and the box turning grey to signify that it was chosen, as feedback.

- **Competence & development** - The layout was kept intact, apart from the feedback received when adding competences. The list of possible competences one could ask to be trained in had circled plus signs on the left hand side, by each competence. When that specific competence was clicked, the circle was filled with bright green colour and a minus sign was placed in it. Simultaneously, a red dot with a cross appeared to the right hand side of the competence along with the text *Remove*, signifying that the choice could be undone either by pressing the minus sign, or by pressing the red *Remove* dot.
- **Schedule** - To clarify the scheduling process and increase the learnability [18], a page with instructions and information was added when clicking the *Schedule* tab in the menu bar. The information was shown within a coloured square in line with the colour theme, using the common region Gestalt principle [19]. A checkbox was placed below the square, on the left hand side, with the text *Do not show this information again*. If marked, the information would not be shown the next time she/he was heading to *Schedule*. The calendars representing the schedule were edited in order to increase visibility by splitting each day into three sections. This way the different shifts were distinguished. A shortcut to the *Healthy schedule* page was added in the side panel, allowing users to access the information and then go back to the current page. The two scheduling phases were changed as seen below.
  1. In the first phase the *Choose all suggested shifts* button was moved from the bottom to the top of the page, right beneath *Choose shifts*, to make it more visible. This can be seen in Figure 7.3.
  2. In the second phase, the *Where am I needed?* button was removed and a view with understaffed shifts shown was presented straight away. This was done in order to make the workflow more efficient and avoid unnecessary clicking.



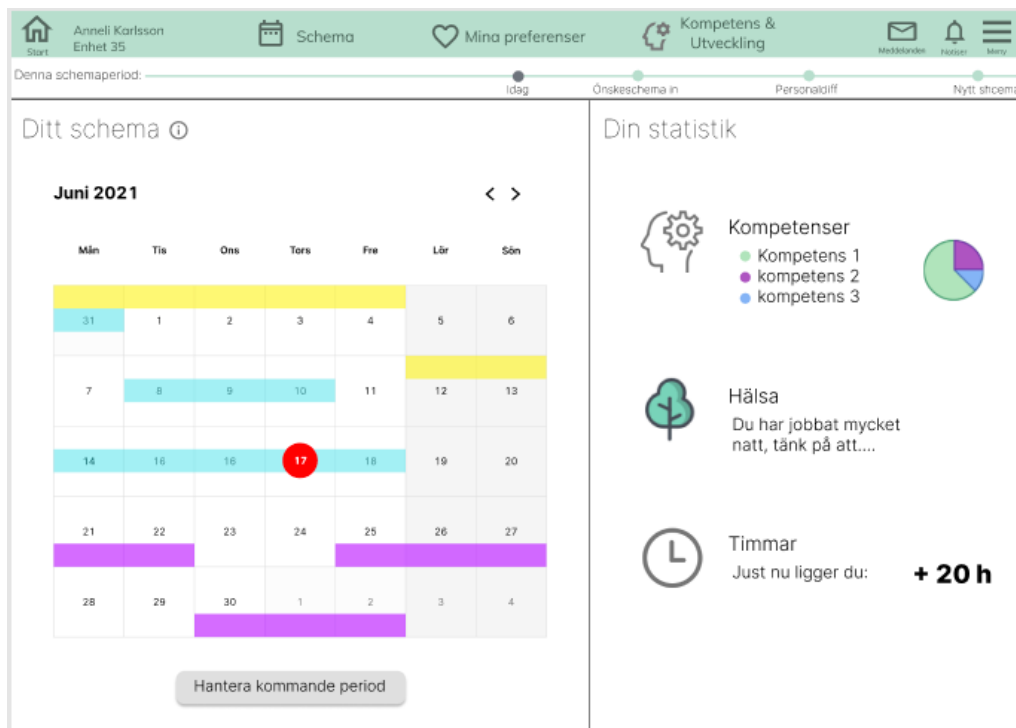


Figure 7.2: The home page for the MyPage in the third iteration. Today's date (the 17th of June) is marked with a red circle.

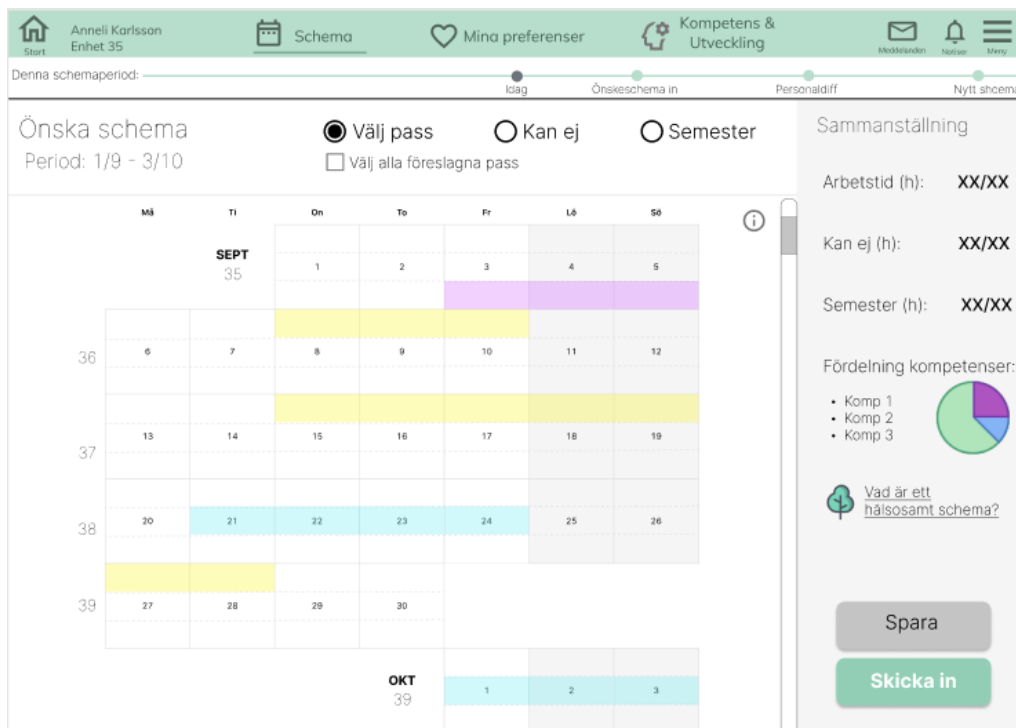


Figure 7.3: Phase 1 of the scheduling process in the MyPage, where the generated suggested schedule is shown in highlighted coloured boxes, and the staff gets to choose their preferred schedule.

## 7.1.2 The Scheduler

Based on feedback from the second iteration the menu bar tab *New schedule* was renamed *Upcoming schedule* to avoid confusion. Further changes are summarized below.

- **Home page** - The weekly calendar view was kept, along with the side bar, as seen in Figure 7.4. To mark today's date, the three sections in that day were coloured light blue as a signifier [18]. The exclamation marks indicating a vacancy were coloured red, and the section they were located in was also coloured light red for attention. They had brief explanations of how many vacancies there were. In the side bar, a summary of that week's vacancies was shown. When a vacancy was clicked, its section turned grey, to signify that it had been chosen. Information about it was shown in the side bar, along with suggested employees to call in. The information shown was more detailed, to avoid confusion. A button was added to the bottom part of the side bar with title *Report change* (Swe. Rapportera ändring). If there was a change in the schedule, not connected to vacancies in the system, it could be added manually. This would then be registered and shown in *History*.
- **Staff** - The layout was kept similar. When choosing an employee, pie charts with competence and shift statistics were now coloured accordingly. A shortcut was added above the brief history section on the employee page, directing the user to the *History* page showing the full scheduling history for that employee.
- **History** - The search bar and time span filters were moved to the top of the page, since it was reevaluated to be more important and thus relocated in line with the F-shaped reading pattern [20]. The calendar was changed so that one could scroll through the months, instead of clicking the *Next month* button. A side panel was introduced where information about the changes was shown, when clicking on icons in the calendar. This replaced the pop-ups from the previous iteration, since the number of clicks would be lower. According to Fitts' law [14], the execution of tasks would be faster, not having to close each pop-up. When searching for specific employee history, the layout was changed to remain the same as general history, showing the employees earlier shifts in a calendar view with a side panel containing statistics. This was done in order to increase consistency [19].
- **Upcoming schedule** - The first page was kept very similar to the previous iteration. Changes were made in the daily view, entered when clicking on a non-functional day on the first page. A *Save* button was added in this view since all testers had issues with finding the *Save* button on the first page. This was done to give the user a feeling of safety, when editing in the schedule. When clicking on a shift that is missing a person, suggestions of staff would appear at the bottom of the page, as seen in Figure 7.5. When a person is chosen, this box with suggestions would disappear. The suggestions are shown in three different columns that can be sorted according to the headlines. An information icon was added by the *Amount of time at position* (Swe. Andel vid position) headline, since testers had a hard time understanding it. When hovering over alerts in the schedule, small pop-ups appeared with information. Lastly, the figure describing under/overstaffing and the *Unsatisfied competences* information swapped places. This was done since the information was an important

summary of the page, while the figure was merely an aid to gain an overview. Thus, the more important content was placed further to the left, in line with the F-shaped reading pattern [20].

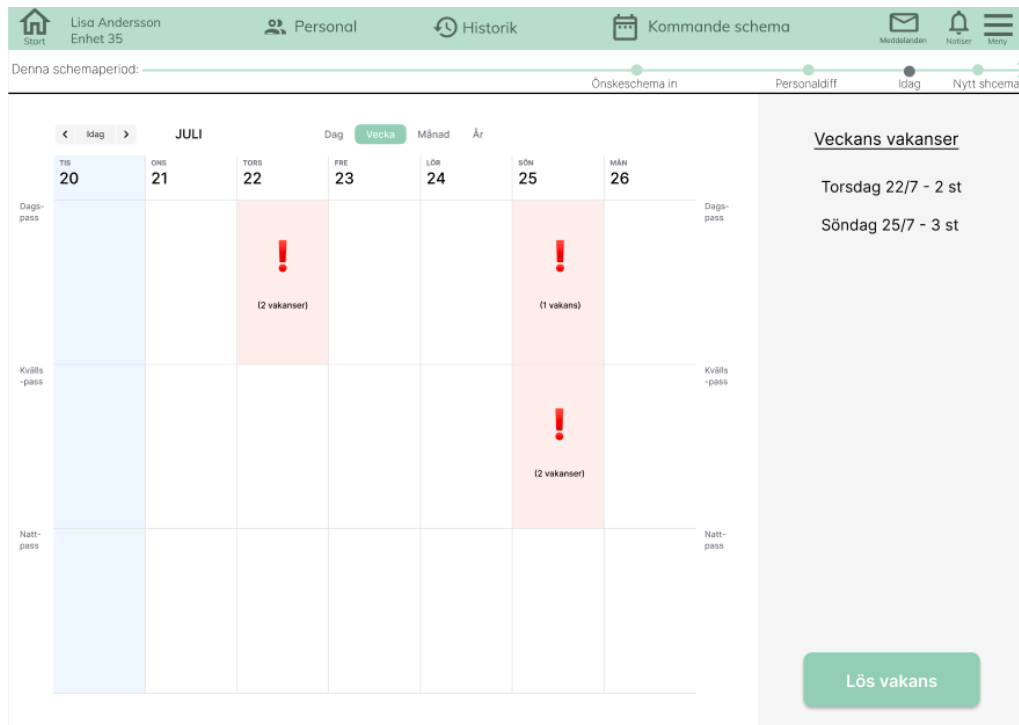


Figure 7.4: The home page for the Scheduler in the third iteration.

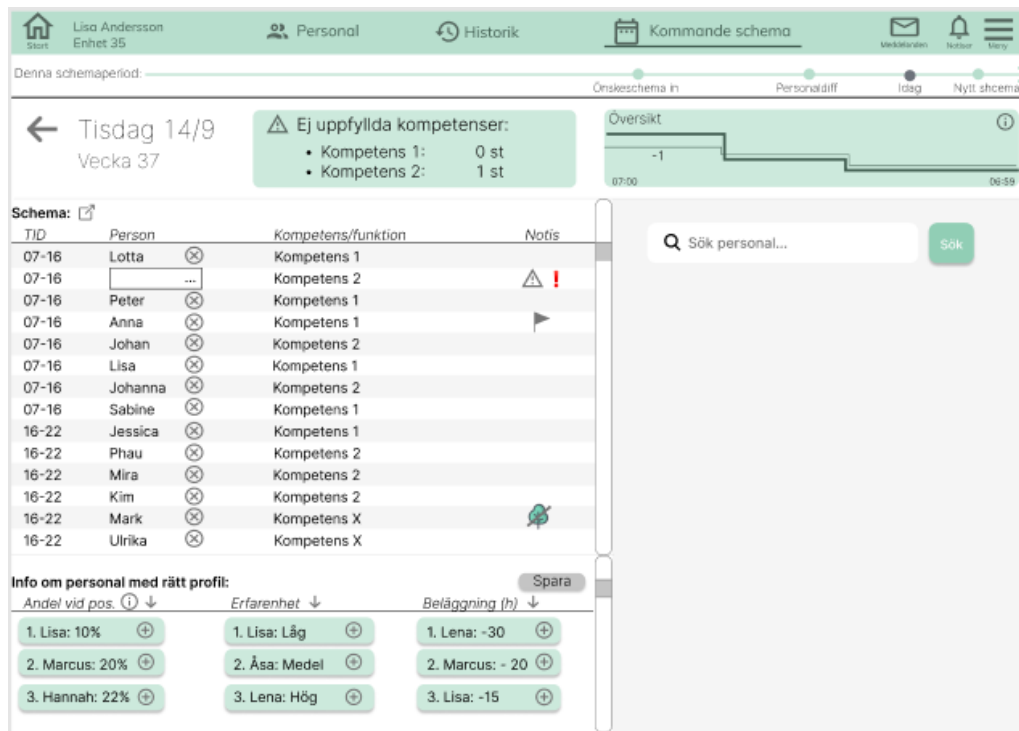


Figure 7.5: The daily view of the Upcoming schedule with suggestions of employees with the right profile to fill the empty shift.

## 7.2 Testing and evaluating 3<sup>rd</sup> iteration

Testing the hi-fi prototype was performed in a similar way to the second iteration. This time, Figma was used as a medium for the tester to interact with the prototype. There was a total of five test subjects [33]. Four out of those five had extensive insight into the Swedish healthcare sector, as they were all actively working in it. Two as nurses, one as an assistant nurse/medical student, and the last as head of unit for the nurses at one of the hospitals in the user study. The two nurses worked at a hospital that was not a part of the user study. The last test person had previous interaction design insights. This group of testers covered a wide range in terms of age and experience within the sector. The Think Aloud method was used, along with the short semi-structured interview following the test, used in the previous iteration. The tasks can be found in Appendix G, and interview questions in Appendix F.2.

## 7.3 Findings from the 3<sup>rd</sup> iteration

Valuable feedback was received regarding the interface design, and on how well the concept would actually work in a hospital setting. The concept was positively received, with comments on how out of date the current scheduling system is, and how this is really needed. However, there was room for improvement, change, and addition of features.

The prototype was experienced as easy to use and maneuver in. The menu bar with three main sections in each part, gave a good overview and testers understood where to click when maneuvering around and solving tasks. They appreciated the fact that there were few buttons incorporated in the design. The timeline was positively received and there were comments on how it contributed to the overview. Further comments regarded how it was easy to learn by just clicking around and not having to undergo training to understand it. Comments such as: *"Easy to use for everybody, not just 30-year-olds"* and *"Easy system to use, even as new to it"*, indicated that the interaction design was well received. Another comment was on how there was not too much informational overload. The colour theme was positively received with comments on how it was calming and tranquil, with nice colours and visually pleasing. The minimalist and clean design was appreciated, as well as the *Healthy schedule* part. The health focus was commented on positively by many of the testers.

However, there was some confusion. Some of the feedback was about making the software foolproof, with clearer information and descriptions. The information icons were simply not found or noticed in most cases, which in turn led to a lot of confusion. This was particularly evident when testers interacted with different schedules, since it was not obvious what the different colours in the schedule meant. In many cases, the testers eventually figured out that the three colours indicated the type of work shift, but this took a lot of effort. The idea of having different colours for different shifts was appreciated but the legend was too hard to find in the information icon pop-up. One tester commented: *"Normally, I print my schedule and colour it myself!"*. Furthermore, some of the colours used to indicate different competences were similar to the ones distinguishing different shifts (shades of blue and purple), which was very unfortunate and caused a lot of confusion. Suggestions from the testers were to change the colours of competences or simply use patterns to distinguish them from one another, instead of using colour.

One thing that was not taken into account in the prototype were the inconvenient

working hours and how those shifts were "worth more" in terms of points, money, or flexible working hours (Swe. Flextid). For example, Friday nights were counted as inconvenient working hours and should thus, technically, be a part of the weekend. This was not portrayed in the prototype. One of the testers commented how he usually "*Work very inconvenient hours because it gives me more free-time*", since those hours are worth more. Moreover, salary information and how the worked hours are translated into salary or flex hours was requested. Finally, more feedback was requested, for example by the change of colour of a button, if one had made a change that had to be saved. Page specific feedback will be listed below, in Table 7.1 for the Scheduler and Table 7.2 for MyPage.

**Table 7.1:** Findings from user test 3 - Scheduler.

| <i>Section</i>           | <i>Key findings</i>   | <i>Quote</i>  |
|--------------------------|---|---|
| Scheduler - Home page    | The start page was commented on as straight forward and the tasks were easily solved.   | - <i>Our system has the same start page.</i>  |
| Scheduler - New schedule | There was confusion with the calendar since the legend was hard to find and the edges of each day were not clear enough, making it difficult to distinguish the days. However, the first view was fairly easily understood despite this. The daily view was somewhat harder to grasp. The three lists appearing at the bottom of the screen with suggestions of staff (when adding a new person, see Figure 7.5) were hard to understand. There was confusion regarding "Lisa" being in multiple lists. Multiple testers wanted to add Lena instead of Lisa, which lead to confusion since only Lisa was implemented. The <i>Amount of time at position</i> column was not understood, although there was an information icon describing it further. The arrow back, was commented on as a new way of navigating. | - <i>Lisa is here too, what does it mean?</i><br>- <i>Lena has a lot of experience, I want to add her.</i><br>- <i>I like the unhealthy schedule warnings.</i><br>- <i>It's better if there's one row and you can sort by different parameters.</i> |
| Scheduler - History      | This section was well received without many difficulties.   | - <i>I can see that there was a change made!</i>  |

**Table 7.2:** Findings from user test 3 - MyPage.

| <i>Section</i>                    | <i>Key findings</i>  | <i>Quote</i>  |
|-----------------------------------|--|---|
| MyPage - Home page                | It was commented on as visually pleasing with good features and a good overview. The information button was not found in most cases so there was confusion regarding the colours in the schedule and the competences. The competences and healthy schedule shortcuts were appreciated. An overview of one's flexible working hours was requested to be included here.  | <p>- <i>So these are my competences in the schedule... but what is yellow?</i></p> <p>- <i>The information button was great!</i></p> <p>- <i>Health promoting is good!</i></p>  |
| MyPage - Competences/ Development | The competences were very well received and appreciated. There was a comment on changing the division of the pie chart, as it usually has the biggest slice on the right hand side.  | <p>- <i>I think it's really smart to include competences.</i></p> <p>- <i>The pie-chart should have the biggest part to the right, in a clockwise direction.</i></p>  |
| MyPage - My preferences           | One tester wanted to add two preferred shifts, while the design only allowed 1 of the 3. There were contradicting comments on the <i>I work well with</i> -option, since it was remarked as going against values of the workplace but also as a really good feature since a tester was currently asking the scheduler not to put her/him with someone, in person.  | <p>- <i>It would be great if you could choose multiple shifts.</i></p> <p>- <i>I appreciate that you can state who you like working with instead of who you don't work well with.</i></p> <p>- <i>Everybody should be able to work with everybody. This goes against our values.</i></p>  |
| MyPage - Schedule                 | The colours in the schedule were appreciated but there was confusion since the edges of each day were not clear enough, making it difficult to distinguish the days, along with the competence colour mix up. The numbers indicating dates should have been bigger. Distinctions between inconvenient shifts were sought. The summary and side panel was appreciated. The <i>Send</i> button was seen as excessive since it was already saved. In the 2 <sup>nd</sup> phase one tester wanted the green shifts indicating understaffed shifts to be red as a warning. Another note made was that the current system had negative numbers when the shift was overstaffed. This could cause confusion. | <p>- <i>Good to use colours instead of adding hours, it makes one happy.</i></p> <p>- <i>It's hard to make out the days, the edges are too thin.</i></p> <p>- <i>Important to include different worth hours.</i></p> <p>- <i>The numbers are too small.</i></p> <p>- <i>In our system it's minus for overstaffed. It's confusing.</i></p> <p>- <i>Understaffed is a problem! Should be red.</i></p> |



# 8. Final model

---

In this chapter the final model is presented. First the changes based on the findings from the third iteration is described, followed by a sample of slides from the final model.

## 8.1 Changes

The final model was modified from the hi-fi prototype with the feedback received. However, it was not tested on a test group, but merely modified based on the feedback. The changes are listed below and shown in the next section.

- *Overall changes*

- The days in the calendar were more clearly separated by adding thicker lines surrounding each day.
- A colour legend for the work shifts was added to clarify the meaning of the colours in each calendar.
- The colours representing different competences were changed into three new colours not overlapping with the work shift colours. To clarify even more, numbers were added to the different segments of the competence pie chart, that related to that certain competence.
- The pie charts were mirrored, as the biggest filled part of the chart should be on the right hand side and in the clockwise direction.
- The method for going back on the daily scheduling view for the scheduler, and the *Healthy schedule* in MyPage, was changed from an arrow to a button with the text "Go back" (Swe. Gå tillbaka). The button was placed in the lower right hand corner to increase the consistency of the way of navigating in the design.
- The grey colour of the weekend was added to the evening and night shift on Friday in order to represent the inconvenient hours.

- *MyPage*

- The *Send*-button for sending in the schedule in the 1<sup>st</sup> stage of the scheduling process was removed leaving a single *Save*-button, in line with Hick's law [21].

- *The Scheduler*

- The three sorted lists with suggestions of staff when filling an empty shift in the daily view of the *Upcoming schedule* was changed into a single list with suggestions, that could then be sorted based on different parameters.



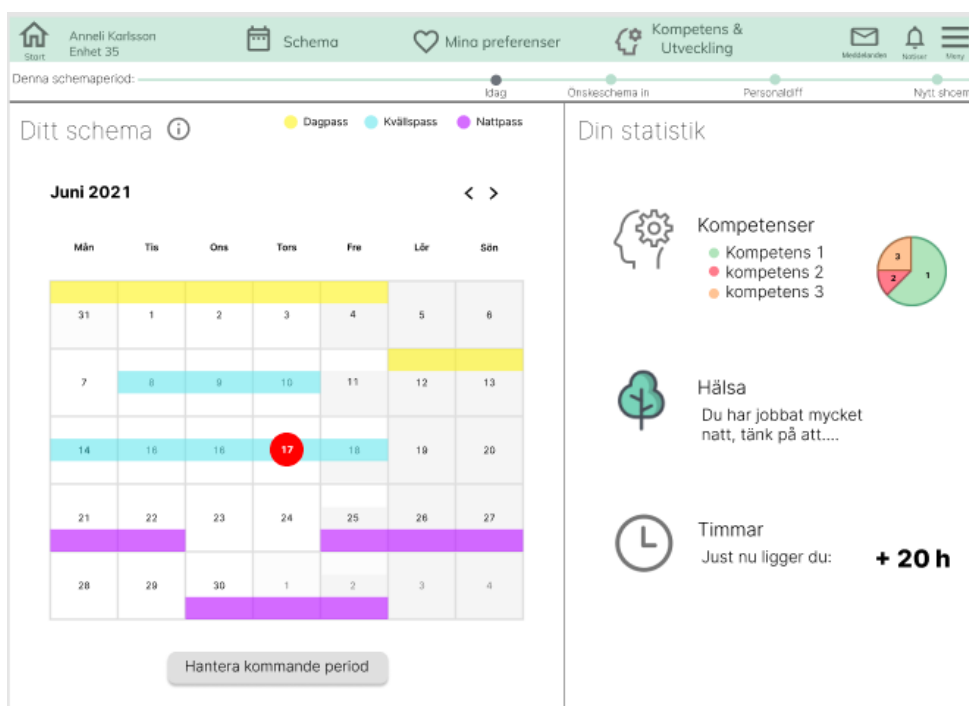
- A shortcut was added to the calendar on the home page, enabling the scheduler to find changes made to previous shifts without having to go through the *History* section. Now, by going backwards in the calendar on the home page, the scheduler can see the history automatically and can do all the actions available in the *History* section.

There was feedback received that was not applied in the prototype. The function to add preferred people to work with, got opposite feedback by two of the test subject. The function was well received as this meant that the employee did not have to ask the scheduler not to put her/him on the same shift as someone, in person, but could instead add who she/he liked working with on her/his page. This gave a more positive feeling. The other feedback was that the function went against the organization's values, which is that everyone should be able to work with each other. The function was discussed, but decided to be kept, as it lowers the workload of the scheduler and can be a choice for the organization to decide to include in the software or not. Further on, there was feedback regarding the colour of the *Where am I needed?*-boxes. Instead of a green colour, the comment was to make them red to signify a warning that the schedule is not functional. The colour was decided to be kept green as the developers wanted to encourage the staff members to contribute to a functioning schedule, instead of scaring them into it.

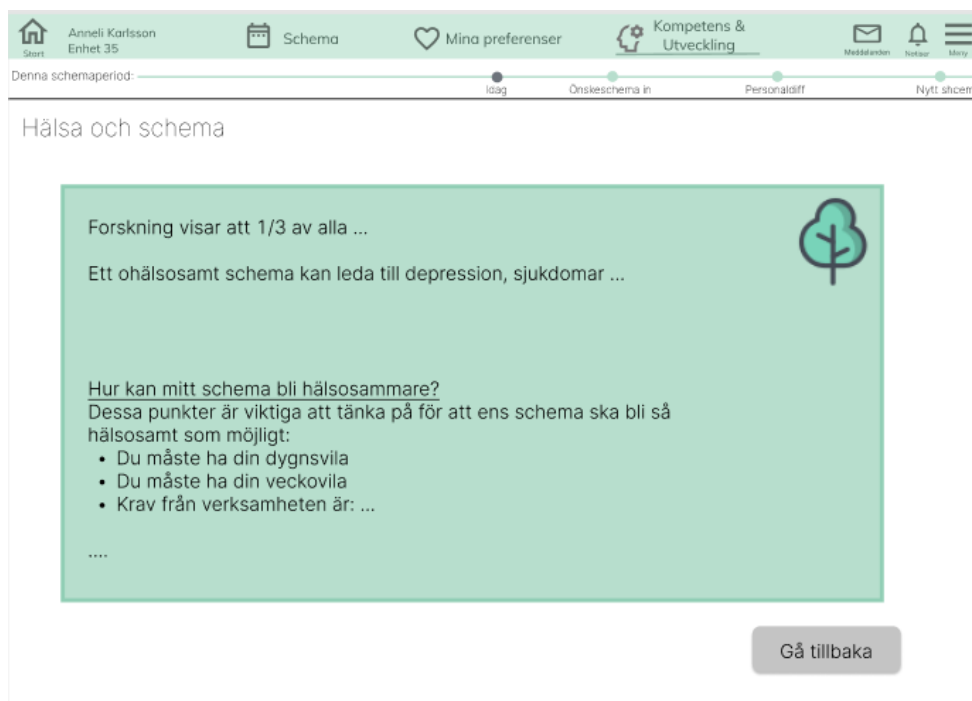
## 8.2 Slides from the final model

In this section slides from the final model will be shown in the figures below. First, slides from the MyPage will be presented, followed by the slides from the Scheduler's part.

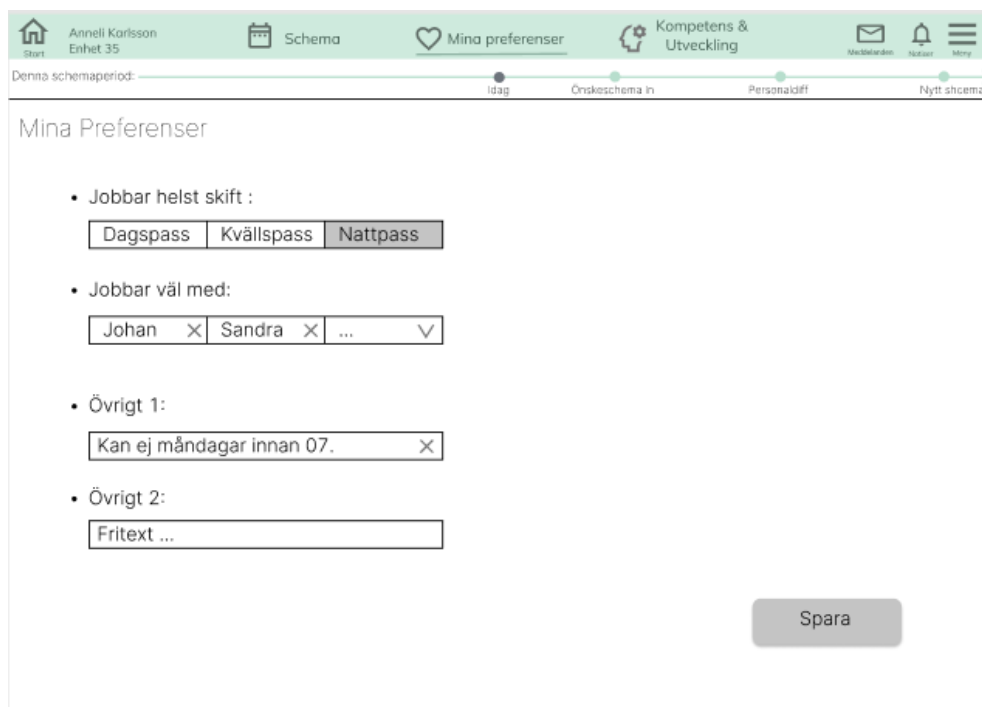
### 8.2.1 MyPage



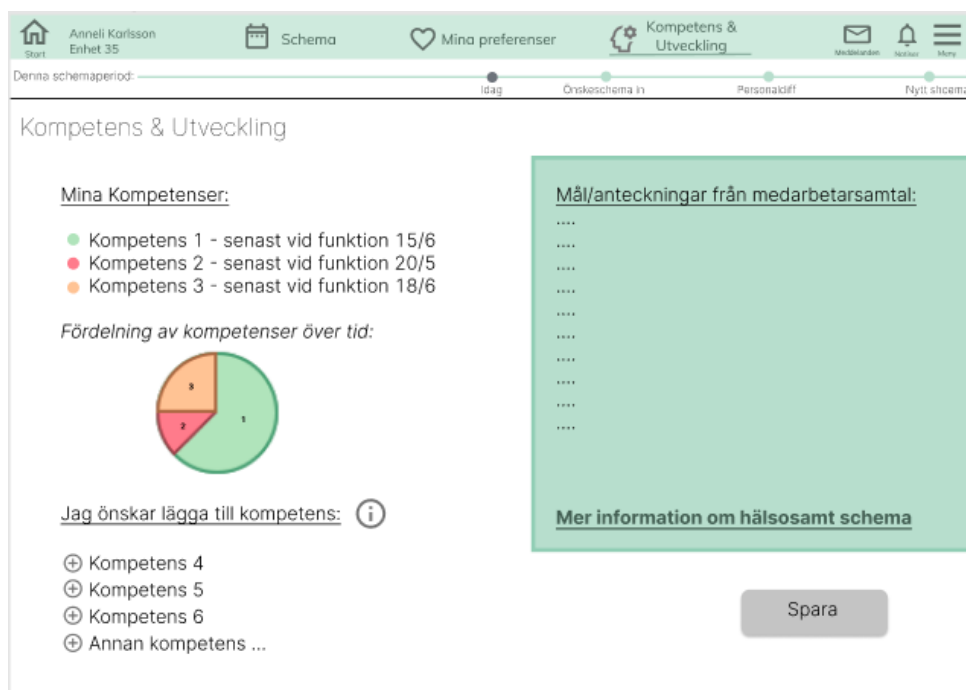
**Figure 8.1:** The home page for the staff with the legends, the changes on the competences and the more clearly separated days.



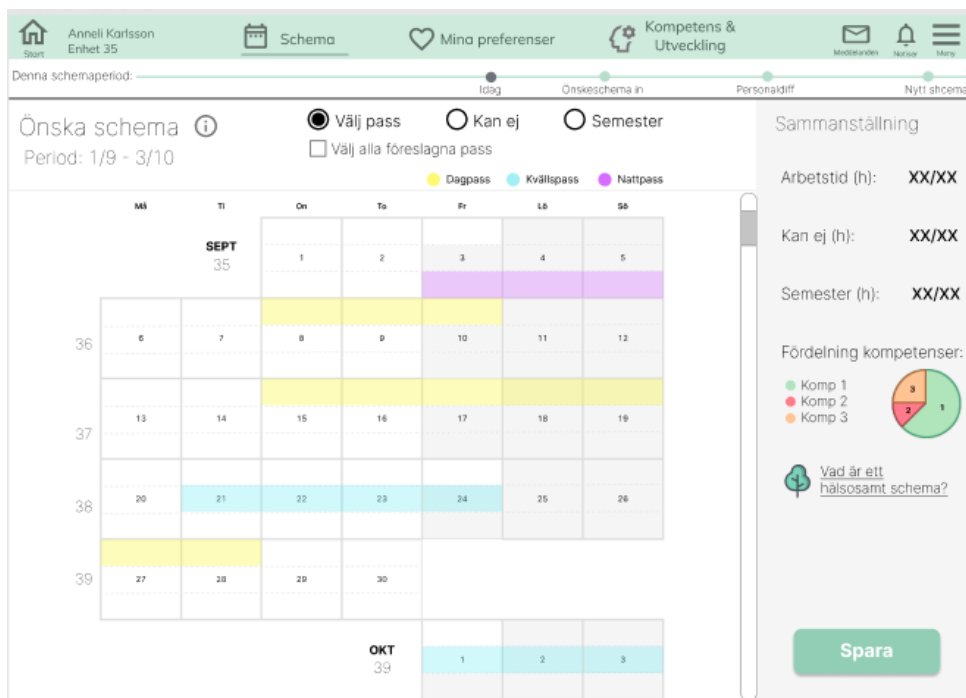
**Figure 8.2:** Information about a healthy schedule can be found both from the home page, and from the *Schedule*-section.



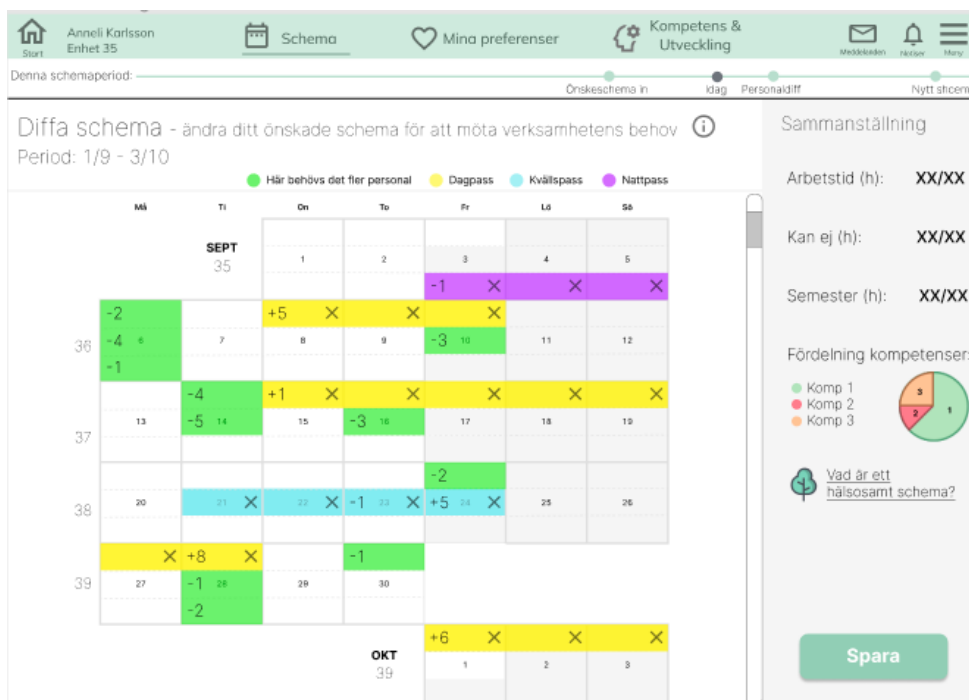
**Figure 8.3:** The preferences of the staff members are manageable in *My Preferences*.



**Figure 8.4:** The competences of the staff members are viewed in *Competences & Development*, where they also can ask for new competences to be schooled in.



**Figure 8.5:** The *Schedule*-section in the first phase of the scheduling process where the staff can wish for a preferred schedule, with the legends for work shifts and the new design on the competences.



**Figure 8.6:** The second phase of the *Scheduling*-section. The staff is shown green coloured work shifts for where they are needed.

## 8.2.2 The Scheduler

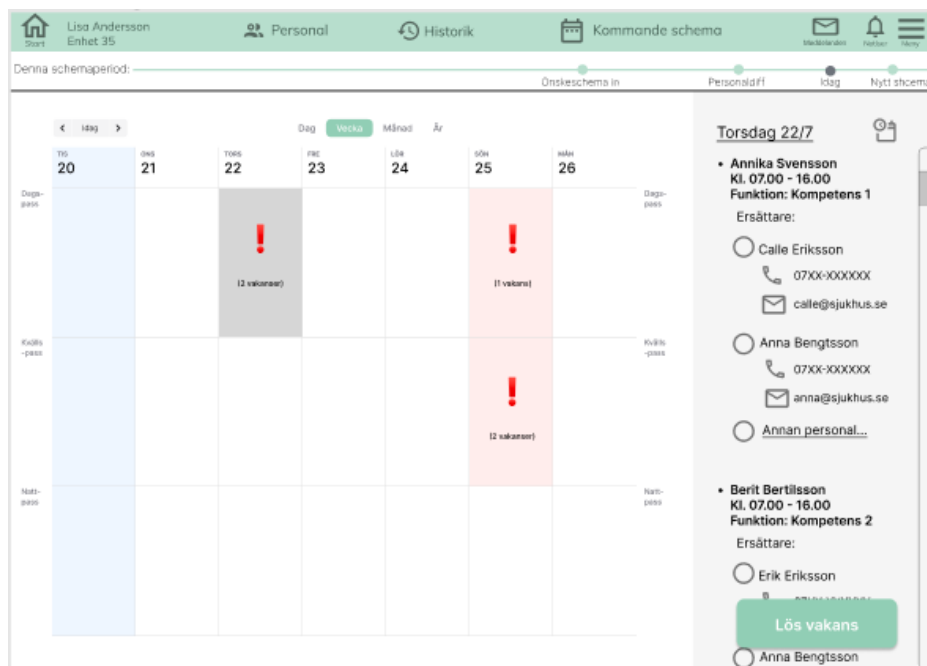


Figure 8.7: The home page for the scheduler. Thursday has been chosen in order to solve the vacancies. Staff members that fit the profile have been suggested for easy access.

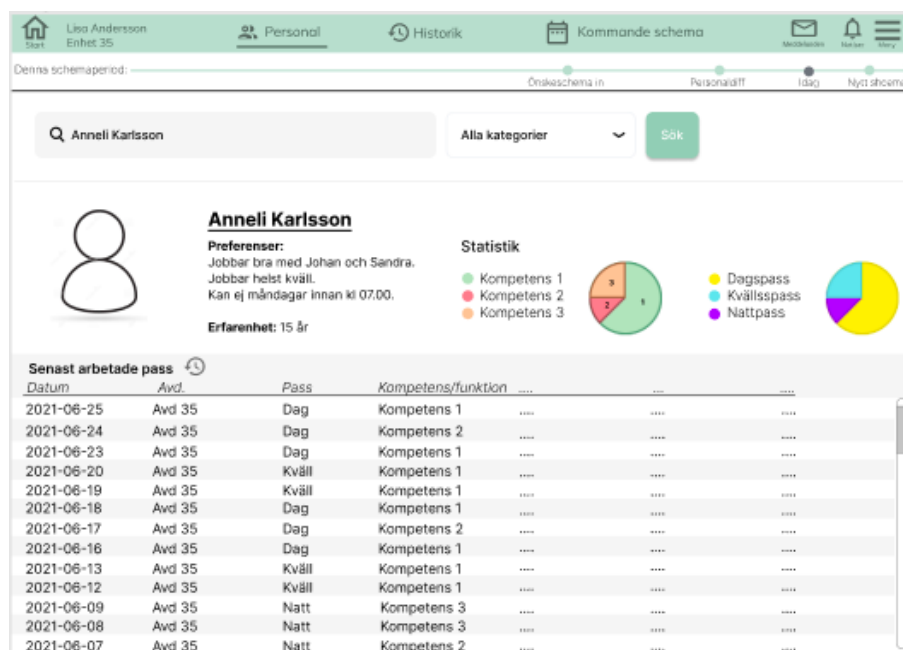
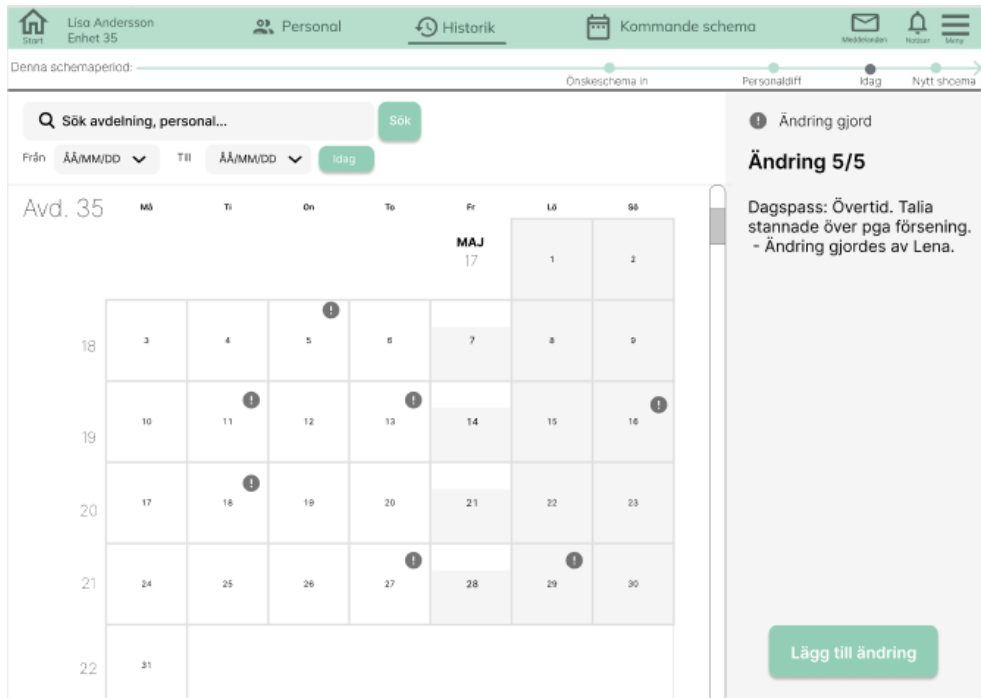
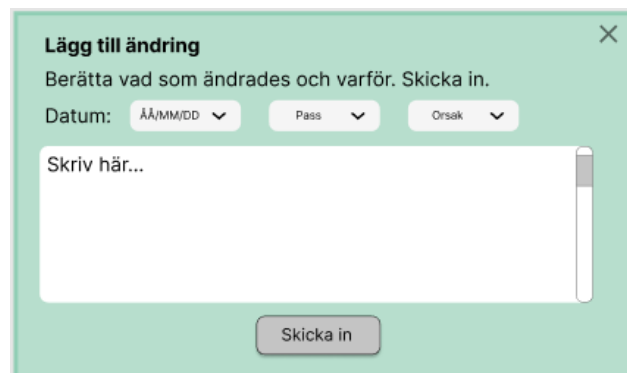


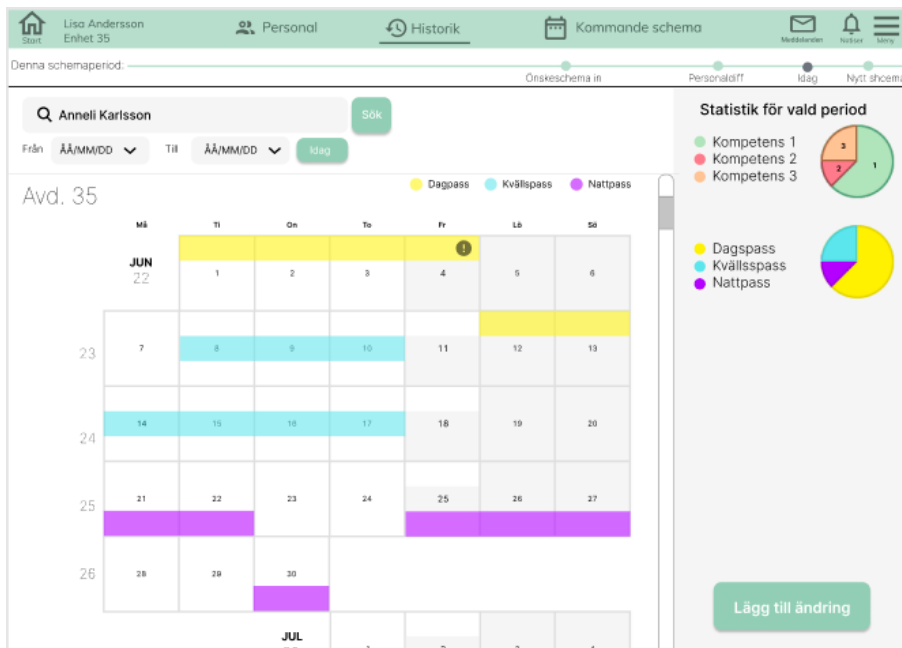
Figure 8.8: The Staff-section with a list over all staff, with a summary of their competences and preferences. By selecting one in the list, the scheduler is directed to their page with further information.



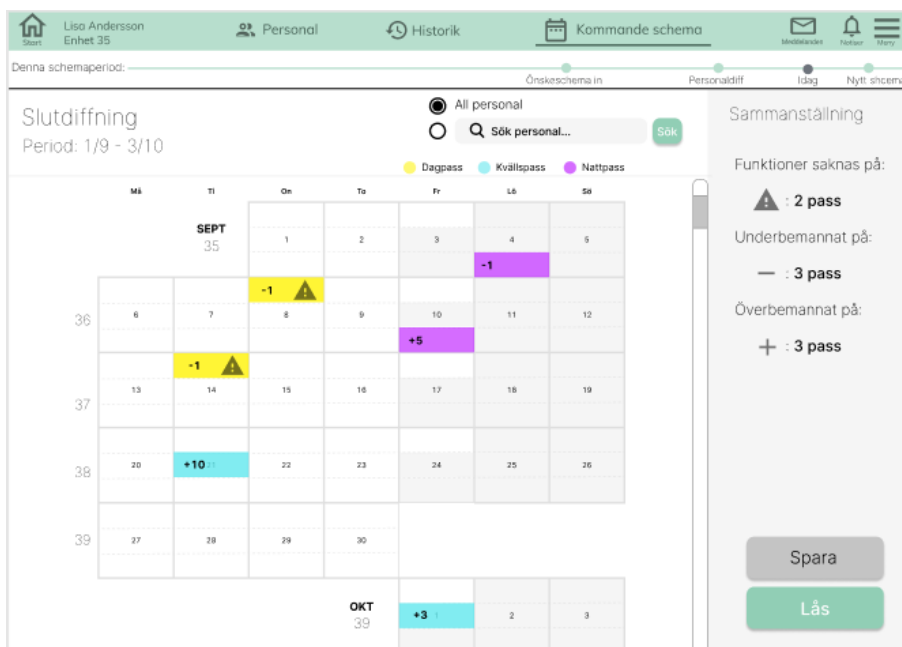
**Figure 8.9:** The *History*-section with a calendar over the month, where it is possible to search for a specific unit or staff member, during a specified time period. By clicking on a notification that symbolises that a change has been made, the change will pop up in the right hand side bar.



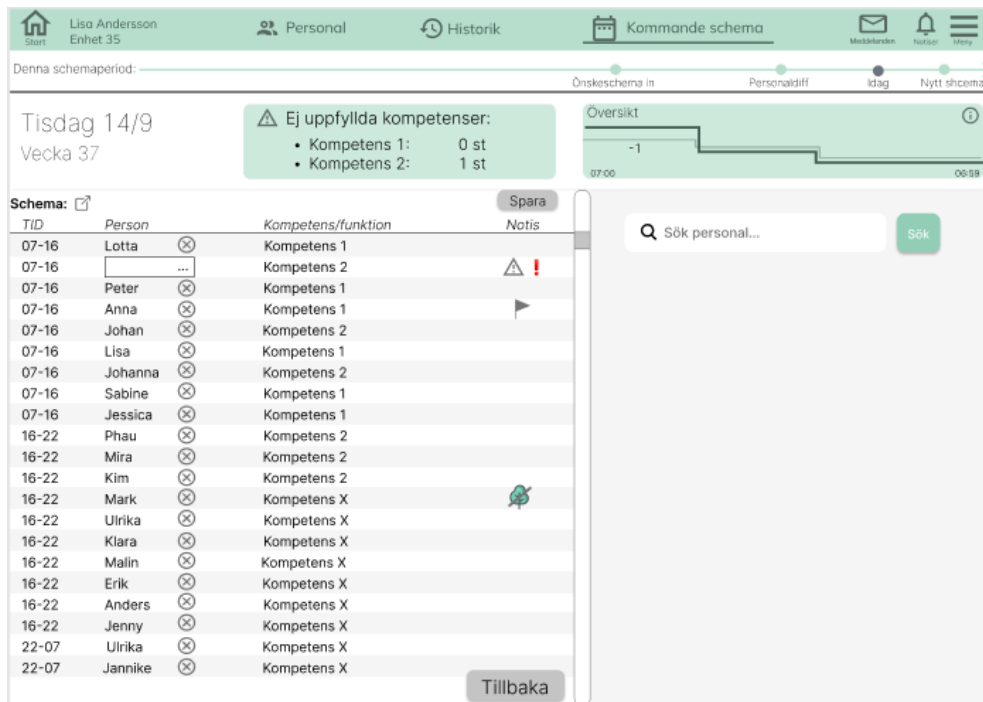
**Figure 8.10:** The *Add a change* pop up that simplifies making a change for the scheduler by giving selectable options.



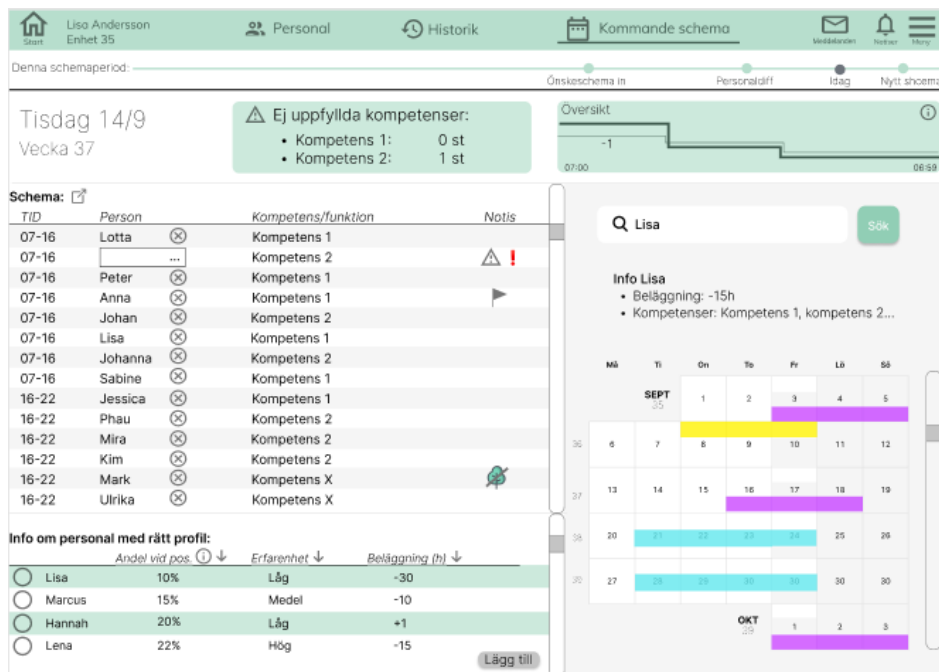
**Figure 8.11:** By searching for a staff member in the *History*-section, the staff members schedule for that period is shown in the calendar, together with the statistics over the competences and work shifts in the side bar.



**Figure 8.12:** The *Upcoming schedule* page where the scheduler can get an overview of the upcoming schedule and regulate it to fit the organizational demands.



**Figure 8.13:** The daily schedule for the scheduler. Missing competences are shown in the green box to the left, and in the box to the right, it is shown if there are people missing from minimum staffing.



**Figure 8.14:** The daily scheduling page for the scheduler with one row per staff member who has the possibility to fill the empty position. It is possible to search for a specific staff member and show their schedule to the right.





## 9. Discussion

---

In this chapter the findings and the final product is discussed along with a discussion of chosen methodology and execution. A summary of the process can be found in Figure 9.1. The following sections cover discussion of the process and framework, delimitations and scope, the user study, conceptual design, and prototyping. Lastly, the next steps is discussed.

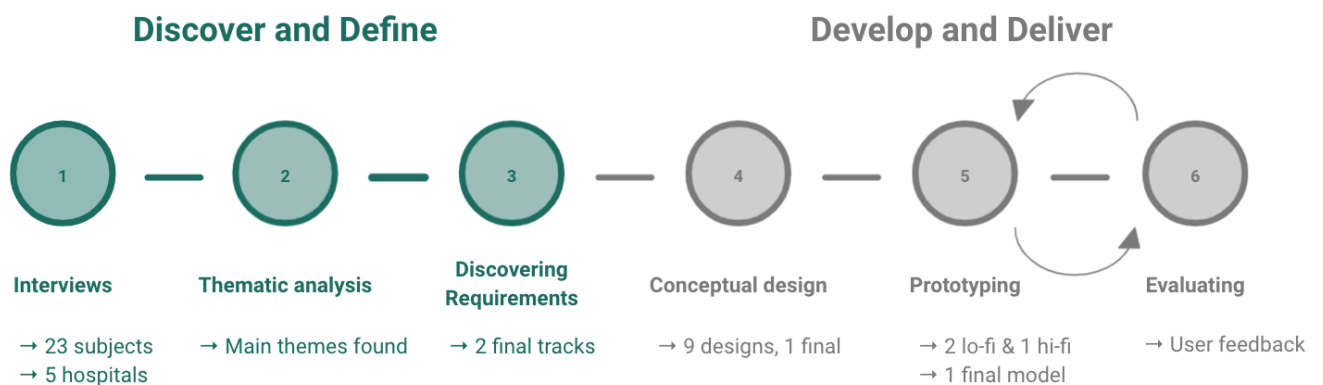


Figure 9.1: Figure illustrating the process overview in this thesis.

### 9.1 Final model

The created and developed final prototype had features meeting many of the found needs relating to scheduling such as competence retention, a healthy schedule focus, an easily accessible history database, and automatic summary of missing competences. This, together with a clearer and more intuitive design, simplifies the scheduling process for both scheduler and staff. Furthermore, this platform allows for a more automatic workflow and digital communication resulting in less manual work for the schedulers as well as less paper notes and separate documents at the workplace. According to feedback gained from the hi-fi testing the system is easier to use and learn compared to current systems and routines in use, however there is room for development and incorporation of additional features. No additional features were added when creating the final model.

### 9.2 Process and framework

This thesis is constituted of several parts, with an emphasis on the user study. A great effort was put into the user study, making it substantial, because it was deemed to be of high

significance and importance in this design process. Since healthcare is such a complex system [10], it is crucial to understand it comprehensively. Not focusing on single, separate issues, as it is all interconnected [10]. Conducting an extensive user study increases the validity and reliability of the insights, which in turn creates a solid foundation for the next steps in the design process. However, an extensive user study is time consuming, which left less time for the later steps of the design process, resulting in a less developed prototype.

The thesis primarily followed the Preece et al. [14] design framework, with the diverging and converging thinking of the Double Diamond framework [22]. The choice to mix the two frameworks was based on the fact that all design processes are non-linear and iterative learning processes. They can look different for different projects, and thus the frameworks describing them are overlapping. Preece et al's, four iterative steps; discovering requirements, designing alternatives, prototyping, and evaluating, were followed but can also be described by the Double Diamond framework. The steps included a divergent user study, that did not converge until the very last step where the final two tracks were decided on and defined. The divergent thinking was once again applied as multiple conceptual models were created, before converging to the choice of the best suited option to move forward with. Three iterations of prototyping and evaluating, i.e. applied diverging and converging, resulted in a final prototype.

## 9.3 Delimitations and scope

The scope of the study was very broad, since it related to a complex system. Because of this, the research question was wide-ranging relating to efficiency and planning within the Swedish healthcare sector. The user study was explorative and kept diverging, in order to obtain a comprehensive understanding of the problems that are faced within the sector today, before converging and narrowing the scope. The delimitations made to ensure that the work stayed on track without deviating into other areas were crucial. However, it was a fine line to balance, when in the diverging phase. It was decided that the efficiency and planning was related to production, staff and resources in terms of instruments, machines and beds, rather than specific patient protocols, treatments and medicines. Workplace conditions were analysed from the staff's point of view, which is not necessarily overlapping with patient experiences. This was not covered in the study and may have influenced the result. The interview subjects were from different instances of the hospital organizations, however, most of them actively worked or had previously worked as nurses, which presumably influenced the result and thus was added to delimitations. However, there were efficiency and planning insights gained from doctors that overlapped well with the nurses'. The altered working conditions and altered way of working due to Covid-19 was disregarded and data was gathered with a typical workday in mind. Although this was specified, the Covid-19 impact was still evident (resulting in a theme in the thematic analysis, later to be excluded) and may have had significance to result, stressing the importance of efficiency within healthcare.

## 9.4 User Study

As mentioned, the user study was the main focus in this thesis, and it was thus extensive. It included 23 subjects working within the Swedish healthcare sector in five different hospitals, with a total of 18 different interviews. Due to the Covid-19 pandemic, all interviews were conducted through digital software Zoom and Microsoft Teams. This transition to remote work was favourable since employees at hospitals all over Sweden could be interviewed, with no travels or trips. However, there is a difference between in person interviews and online interviews. Communication through a screen is harder since body language cannot be read, there is a bigger risk of misinterpretations, as well as possible technical difficulties [39]. There were interviews in which the sound quality was poor since the test subjects often used stationary computers at the hospital without knowledge on the whereabouts of the microphone. This was not a significant problem but caused minor interruptions in some of the interviews, sometimes leading to lost track of thought. Furthermore, the restrictions limited the ways of gathering information. It would have been desirable to have on site observations in addition to the interviews, resulting in the use of the method *Triangulation* [14]. This use of multiple sources for data gathering would increase the credibility and validity of data. Although this was not possible, the data gathered was validated by interviewing subjects from five separate hospitals in Sweden, ranging from a very small hospital, to large university hospitals. Similar and overlapping insights were gained from all hospitals, increasing the reliability of the data. However, the hospitals and their interviewees were chosen by convenience sampling, which might have affected the results as the interviewees could potentially have been individuals with particular interest in the research question. Thus, more general research is necessary to investigate the question further.

Since the research question is related to efficiency and planning within the healthcare sector, scheduling was identified as an area of importance when preparing the interview guide. Although the data gathering was explorative and diverging, the scheduling questions might have been too specific, resulting in many findings in this area. This might have influenced the thematic analysis since there was a lot of content obtained connected to scheduling. During the data gathering it was also noticed that the consent agreement was phrased relatively strictly, in relation the sensitivity of the data gathered. The data itself was not sensitive, however, the authors wanted to give the interviewees a safe environment so that they could speak freely, phrasing the consent agreement so that sensitive data could be shared. However, this made the handling of data much more difficult, and was in retrospect an excessive measure.

During the thematic analysis, the guidelines by Braun and Clarke [26] were followed. Word-by-word transcription of the interviews was performed, excluding long pauses, sounds like "um", "eh", and "hm". Minor rephrasing was done in order to preserve the meaning of the sentence. However, by excluding and rephrasing, the risk of altering the meaning of the sentences is present. This was accounted for by having both interviewers present at each interview, thus, both being able to recall what the context and essence of the statements were later on. Throughout the coding process, it was important to work in a consistent way, giving each interview the same amount of attention. However, coding interviews properly was a learning process which might have resulted in more detailed coding of the first interviews, compared to the ones coded last. This has presumably not

affected the results significantly since similar insights were found in later interviews but might be a source of error. Finally, technical difficulties might again have affected some interviews more than others.

Discovering requirements was done through iterations of clustering and rephrasing of the found problems. When the final problems were defined, the underlying needs could be established. Again, the high amount of content relating to scheduling might have had impact on the different problems found, and affected what was deemed as important. However, this extensive material gave great insights to the current status of scheduling within healthcare. There were five final clusters of needs as seen in Table 4.3, and those were further merged into the two final tracks.

## 9.5 Conceptual design

The personas were created with both main tracks in mind. A great deal of effort was put into this, so that they could be applied to either track, thus increasing their validity. The nine conceptual models were created by the two authors, in parallel. This resulted in a diverging process, elaborating on different features, functions and details. However, some of the concepts were more developed than others, which could have affected the results in the evaluation of concepts. The Pugh matrix analysis described by Cervone [31] was used, and the needs found when establishing the requirements were used as factors when comparing the conceptual models. Since there was no weighting among the models but merely of the factors (ranked by importance to the research question), concepts that were more general, developed and comprehensive scored higher total points. The concepts that were not as general, but solved a few specific needs in a better way, thus, scored lower total points. This was not taken into account and might have skewed the comparison of models somewhat. The second method for evaluation relied on the personas made. Although they were comprehensive, slight changes to their person could have affected the outcome and was thus a potential source of error. By combining the two methods of evaluation and receiving overlapping results, the validity and reliability was increased. This indicated what concepts were most functional and leading in solving the needs.

## 9.6 Prototyping

Three iterations of prototyping and evaluating were performed, with two lo-fi iterations and one hi-fi iteration. The two first iterations were created on paper and connected in the Marvel App, while the last prototype was created in Figma. Both methods allowed the authors to work simultaneously and were easy to use. They also provided good platforms for the testers to interact with the prototypes. Following this a final model was created based on the feedback from the hi-fi iteration. The second lo-fi iteration was more of a hybrid iteration between lo-fi and hi-fi. A lot of the feedback received in the first iteration was connected to functions. Since the Marvel App was used it was deemed possible to implement some of those functions in the next iteration, by copying screens and adding text or pop-up screens in Marvel. However, this was rather time consuming and a faster, less detailed second lo-fi iteration was in retrospect more beneficial. Nevertheless, valuable

feedback was received during this iteration.

In the two first iterations, a group of three people were used to test the prototype, while five were used in the last iteration. This choice was made in order to gain more insights on a prototype that was more developed. In addition, four out of those five had a healthcare background and no previous user test experience, thus, a more developed prototype was easier to grasp and test. The first iteration had one tester with insights to the healthcare sector, while the second iteration did not have any. The prototype development took place during the summer, which meant that the hospitals were lower staffed due to vacations. This made scheduling of tests with staff more difficult. Having staff with experience in hospital scheduling and insights to the healthcare sector in all iterations would have been more beneficial. However, the last iteration included two nurses from a hospital not part of the study. Their feedback validated the concept and prototype.

The test methods and evaluation were similar throughout the iterations, with an exception of the first iteration when a survey and written instructions were used. This was decided against in the two following iterations since it was experienced to cause confusion. This could potentially have led to fewer insights gained from the first iteration, however, the testers had vast design knowledge and shared their thoughts freely without having to be reminded of speaking. Thus, enough feedback was gathered in order to go forward with the next iteration. Another test method that could have given the evaluation extra credibility was the method System Usability Scale (SUS), where the test subjects answers questions about the product in a scale between 1-5, which is later calculated into a usability score of the product. This was not included in the study since it was not deemed as necessary, as well as due to the time constraints. Furthermore, a closer collaboration with the healthcare employees, for example by including them as partners throughout the design process, could have given valuable insights and more extensive feedback.

## 9.7 Next steps

The final model was designed with the feedback from the earlier prototypes in mind, but was not tested with test subjects, which would be the next step. Further development of the model is needed to better meet all the requirements. For example by visualizing for the staff what competences one is scheduled to use at a certain shift, as well as enabling adding specific competences during the preferred schedule creation. Furthermore, functions such as adding if, and in that case when, employees are available to work outside of their scheduled work shifts should be added. Thus, giving the staff a way to communicate that they want more hours, which can aid the scheduler while solving vacancies. Another function that would be profitable to add to the concept is to interconnect the software with the salary system. This would increase functionality and meet the user needs in a better way. Further on, implementing and creating of the software is needed, as well as more extensive testing with hospital staff.



## 10. Conclusion

---

The Swedish healthcare sector of today is not reaching its goals in terms of the statutory *Health care guarantee* (Swe. Vårdgaranti). There is a need for a more efficient way of working, with room for improvement in both production, planning and scheduling processes within the healthcare sector.

The extensive user study found several areas in these processes with a need for improvement. These include scheduling of staff, organizational workflow, as well as organizational structure and coordination, work procedures and work environment, as well as communication. A large amount data was collected and analysed in regards to each area. The wide range of needs found made it evident that additional efforts were needed in order to meet all these needs. In this thesis it was chosen to go forward with planning and scheduling of staff.

A prototype of a digital tool was created. The models and prototypes of the project were well received by the testers, expressing that there is a need for a better scheduling solution. Several new functions and more intuitive maneuvering was introduced in this model that distinguishes it from the ones presently used, such as the aid for employee competence retention (to ensure that employees regularly use all of their competences, avoiding the need for re-training), information about, and the pronounced focus on healthy schedules, as well as schedule suggestions based on the unit needs and staff preferences. However, further development of the prototype is needed, as well as more extensive testing.

The prototype successfully aimed to fulfill some of the needs found in the area of planning and scheduling of staff. However, the established needs are vast and cover many areas. It is a difficult task to successfully incorporate all in one product. The healthcare sector is a complex system and therefore the solutions are rarely simple. In order to fulfill the needs to a further extent, a closer collaboration with the healthcare workers as partners throughout the design process could be a valuable asset, as well as a more extensive prototyping and evaluation process.





# References

---

- [1] Sveriges Kommuner och Regioner. Väntetider i vården - Vårdgarantiläget i Sverige; <https://www.vantetider.se/vantetiderivarden/vantetidsstatistik/vardgarantilaget.46227.html> (2021-06-23).
- [2] Statens Offentliga Utredningar. Effektiv Vård - Slutbetänkande av En nationell samordnare för effektivare resursutnyttjande inom hälso-och sjukvården, SOU 2016:2. Stockholm: Elanders Sverige AB; 2016. Available from: [https://www.regeringen.se/contentassets/42b0aef4431c4ebf9410b8ee771830eb/effektiv-var-d---slutbetankande-av-en-nationell-samordnare-for-effektivare-resursutnyttjande-inom-halso--och-sjukvarden\\_sou-2016-2.pdf](https://www.regeringen.se/contentassets/42b0aef4431c4ebf9410b8ee771830eb/effektiv-var-d---slutbetankande-av-en-nationell-samordnare-for-effektivare-resursutnyttjande-inom-halso--och-sjukvarden_sou-2016-2.pdf).
- [3] Myndigheten för vårdanalys. Ur led är tiden - Fyra utvecklingsområden för en mer effektiv användning av läkares tid och kompetens, 2013:9. Stockholm: TMG Sthlm; 2013. Available from: <https://www.vardanalys.se/wp-content/uploads/2013/12/Rapport-2013-9-Ur-led-%C3%A4r-tiden.pdf>.
- [4] Hedström G; 2020. Interview.
- [5] Persson J, Rydenfält C. Why Are Digital Health Care Systems Still Poorly Designed, and Why Is Health Care Practice Not Asking for More? Three Paths Toward a Sustainable Digital Work Environment. Journal of Medical Internet Research. 2021;6. Available from: <https://doi.org/10.1191/1478088706qp063oa>.
- [6] Socialstyrelsen. "70 procent av det läkare skriver i journalen är upprepningar". Läkartidningen. 2014;111:C4T4(40/2014). Available from: <https://alfresco-offentlig.vgregion.se/alfresco/service/vgr/storage/node/content/workspace/SpacesStore/5b9b0ab8-c390-481a-8aa9-af8a3416c101/Glise%2c%20L%C3%A4kartidningen%202014-09%2c%20mfattande%20samsjuklighet%20vid%20utmattningssyndrom.pdf?a=false&guest=true>.
- [7] Kakunje A. Stress Among Health Care Professionals - The Need for Resiliency. Online Journal of Health and Allied Sciences. 2011;10(1).
- [8] Arbetsmiljöverket. Arbetstidslagen (ATL); <https://www.av.se/arbetsmiljoarbete-och-inspektioner/lagar-och-regler-om-arbetsmiljo/arbetstidslagen/#2> (2021-06-23).

- [9] Mitchell M, Newman M. Complex systems theory and evolution. Encyclopedia of evolution. 2002.
- [10] Plsek EP, Greenhalgh T. The challenge of complexity in health care. *British Medical Journal*. 2001 September;323:625–628. Available from: <https://doi.org/10.1136/bmj.323.7313.625>.
- [11] Hollnagel E. FRAM: The Functional Resonance Analysis Method. Boca Raton, FL, USA: CRC Press - Taylor & Francis Group; 2016.
- [12] Hollnagel E. FRAM - The functional resonance analysis;. <https://functionalresonance.com/> (2021-02-02).
- [13] Cook IR, Render M, Woods DD. Gaps in the continuity of care and progress on patient safety. *British Medical Journal*. 2000 March;320:791–794. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1117777/pdf/791.pdf>.
- [14] Sharp H, Preece J, Rogers Y. *Interaction Design: Beyond Human-Computer Interaction*, 5th Edition. Indianapolis, USA: John Wiley & Sons Inc, Canada, Limited.; 2019.
- [15] Abras C, Maloney-Krichmar D, Preece J, et al. User-centered design. *Bainbridge, W Encyclopedia of Human-Computer Interaction* Thousand Oaks: Sage Publications. 2004;37(4):445–456.
- [16] Gould JD, Lewis C. Designing for usability — key principles and what designers think. *Communications of the ACM*. 1985;28. Available from: <https://doi.org/10.1145/800045.801579>.
- [17] ISO - the International Organization for Standardization. ISO 9241-210:2019(en) Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems;. <https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-2:v1:en> (2019).
- [18] Norman D. *The Design of Everyday Things*. New York, USA: Basic Books, A Member of the Perseus Book Group; 2013.
- [19] Wagemans J, Elder JH, Kubovy M, Palmer SE, Peterson MA, Singh M, et al. A century of Gestalt psychology in visual perception: I. Perceptual grouping and figure-ground organization. *Psychological bulletin*. 2012;138:6. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482144/>.
- [20] Nielsen, Jakob. F-shaped reading pattern for reading web content (original study);. <https://www.nngroup.com/articles/f-shaped-pattern-reading-web-content-discovered/> (2021-08-11).
- [21] Roberts RD, Beh HC, Stankov L. Hick's law, competing-task performance, and intelligence. *Intelligence*. 1998;12(2):111–130.

- [22] Design Council. What is the framework for innovation? Design Council's evolved Double Diamond;  
<https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond> (2021-07-07).
- [23] University of Copenhagen. Model: Double Diamond;  
<https://innovationenglish.sites.ku.dk/model/double-diamond-2/>  
 (2021-07-07).
- [24] Arvola M. Interaktionsdesign och UX - om att skapa god användarupplevelse. Lund: Studentlitteratur AB.; 2014.
- [25] Zhu S, Fan W, Yang S, Pei J, Pardalos P. Operating room planning and surgical case scheduling: a review of literature. *Journal of Combinatorial Optimization*. 2019 04;37. Available from: <https://doi.org/10.1007/s10878-018-0322-6>.
- [26] Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 2006;3:77–101. Available from:  
<https://doi.org/10.1191/1478088706qp063oa>.
- [27] QSR International. NVivo; <https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home> (2021-04-30).
- [28] Magnusson C, Rasmus-Gröhn K, Tollmar K, Deaner E. User Study Guidelines. HaptiMap EU project. Hapti Map Consortium; 2009.
- [29] Just In Mind. 20 must-see user persona templates;  
<https://www.justinmind.com/blog/user-persona-templates/>  
 (2020-07-30).
- [30] Johnson J, Hendersen A. Conceptual Models: Begin by Designing What to Design. *Interactions*. 2002 January;9:25–32. Available from:  
[https://www.researchgate.net/publication/220382707\\_Conceptual\\_models\\_begin\\_by\\_designing\\_what\\_to\\_design](https://www.researchgate.net/publication/220382707_Conceptual_models_begin_by_designing_what_to_design).
- [31] Cervone HF. Applied digital library project management: Using Pugh matrix analysis in complex decision-making situations. *OCLC Systems & Services: International digital library perspectives*. 2009;25:4:228–232. Available from:  
<https://doi.org/10.1108/10650750911001815>.
- [32] App M. Rapid prototyping, testing and handoff for modern design teams;  
<https://marvelapp.com/>.
- [33] Nielsen J, Landauer TK. A Mathematical Model of the Finding of Usability Problems. In: *Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems*. CHI '93. New York, NY, USA: Association for Computing Machinery; 1993. p. 206–213. Available from:  
<https://doi.org/10.1145/169059.169166>.
- [34] design tool FU. The modern interface design tool;  
<https://www.figma.com/ui-design-tool/>.

- [35] Icons8. Icons, illustrations, photos, music, and design tools;. <https://icons8.com/> (2021).
- [36] Jahanian A, Keshvari S, Vishwanathan SVN, Allebach JP. Colors – Messengers of Concepts: Visual Design Mining for Learning Color Semantics. *ACM Trans Comput-Hum Interact.* 2017 Jan;24(1). Available from: <https://doi.org/10.1145/3009924>.
- [37] Babich, Nick. Using Red and Green in UI Design;. <https://uxplanet.org/using-red-and-green-in-ui-design-66b39e13de91> (2019).
- [38] Koladzyn, Carolina. How to design UI buttons that convert;. <https://medium.com/@carolinalina/how-to-design-ui-buttons-that-convert-d5ebb1080969> (2019).
- [39] O’Conaill B, Whittaker S, Wilbur S. Conversations Over Video Conferences: An Evaluation of the Spoken Aspects of Video-Mediated Communication. *Human-Computer Interaction.* 1993;8(4):389–428. Available from: [https://doi.org/10.1207/s15327051hci0804\\_4](https://doi.org/10.1207/s15327051hci0804_4).

# Appendices



## A. Consent agreement

---





**LUND**  
UNIVERSITY

Institutionen för  
designvetenskaper

## **Information till intervjudeltagare i examensarbetet: ”Verksamhetsplanering i vården med fokus på bemanning och resurser.”**

Vi vill fråga dig om du vill delta i ett forskningsprojekt som görs inom ramen för ett examensarbete. I det här dokumentet får du information om projektet och om vad det innebär att delta.

### **Vad är det för projekt och varför vill ni att jag ska delta?**

I en utredning gjord på begäran av Regeringen från år 2016 återfanns tydliga indikationer på att nuvarande arbetssätt inom hälso- och sjukvården i de svenska landstingen innebär ett ineffektivt resursutnyttjande. Det saknades alltför ofta en övergripande och genomgripande bild av vad som ska göras, hur det ska göras och vem som ska göra det (så kallad verksamhetsplanering). På många håll görs detta lokalt, men problemet som uppstår med sådana begränsade ansatser är suboptimering som gör att det uppstår problem med kapacitet på nästa instans då flödet endast förbättrats lokalt.

Syftet med studien är att ta reda på hur verksamhetsplanering inom vården kan förenklas och effektiviseras med hjälp av digitala stöd samt att ta fram en prototyp för en potentiell lösning. För att undersöka detta kommer vi att intervjua personer från olika sjukhus i landet för att sedan utvärdera var i planeringsprocessen de är i mest behov av stöd. Projektet görs inom ramen för ett examensarbete i interaktionsdesign vid Lunds universitet med handledning av forskare vid Lunds universitet och Uppsala universitet.

### **Hur går studien till?**

För att undersöka hur verksamhetsplaneringen ser ut idag kommer individuella intervjuer att genomföras. Intervjuerna behandlar frågor som rör rådande arbetssätt och rutiner kring schemaläggning av resurser i verksamheten, såsom personal, utrustning och lokaler. Intervjuerna tar ca 45 minuter i anspråk och genomförs digitalt över Zoom eller Teams.

### **Risker**

Deltagande medför inga särskilda risker.

### **Vad händer med mina uppgifter?**

Intervjuerna spelas in för att senare transkriberas. Vid intervjutillfället noteras personuppgifter som namn, arbetsplats, yrkesroll, arbetsuppgifter samt utbildningsbakgrund men inget personnummer.

---

#### *Telefon:*

Mia Cicovic: 070-757 47 19

Sanna Nordberg: 070-697 17 17

#### *Epost:*

[mi0454ci-s@student.lu.se](mailto:mi0454ci-s@student.lu.se)

[bmp15sno@student.lu.se](mailto:bmp15sno@student.lu.se)



**LUND**  
UNIVERSITY

Institutionen för  
designvetenskaper

Inspelat material kommer att lagras på USB minnen och arbetas med lokalt på studenternas datorer.

Alla personuppgifter kommer att hanteras i enlighet med EU:s dataskyddsförordning GDPR (General Data Protection Regulation).

Dina svar kommer att behandlas så att inga obehöriga kan ta del av dem. Arbetsgivaren kommer inte att informeras om dina individuella uttalanden och ditt agerande i samband med intervjun.

Ansvarig för dina personuppgifter är Sanna Nordberg och Mia Cicovic. Enligt EU:s dataskyddsförordning har du rätt att kostnadsfritt få ta del av de uppgifter om dig som hanteras i studien, och vid behov få eventuella fel rättade. Du kan också begära att uppgifter om dig raderas samt att behandlingen av dina personuppgifter begränsas. Om du vill ta del av uppgifterna ska du kontakta Sanna Nordberg med epost [bmp15sno@student.lu.se](mailto:bmp15sno@student.lu.se) eller på telefonnummer 070-697 17 17, alternativt Mia Cicovic med epost [mi0454ci-s@student.lu.se](mailto:mi0454ci-s@student.lu.se) eller på telefonnummer 070-757 47 19. Dataskyddsombud nås på [dataskyddsombud.lu.se](http://dataskyddsombud.lu.se) eller på telefonnummer 046-222 00 00. Om du är missnöjd med hur dina personuppgifter behandlas har du rätt att ge in klagomål till Datainspektionen, som är tillsynsmyndighet.

### **Hur får jag information om resultatet av studien?**

Resultaten från studien kommer att publiceras som ett examensarbete i Lunds Universitets Publikationsdatabas (LUP) samt eventuellt i vetenskapliga publikationer knutna till examensarbetet. Resultatet återkopplas till de verksamheter som ingår i studien.

### **Ersättning**

Ingen ersättning utgår.

### **Deltagandet är frivilligt**

Ditt deltagande är frivilligt och du kan när som helst välja att avbryta deltagandet. Din anställning kommer inte att påverkas av ett eventuellt deltagande eller icke-deltagande i studien. Om du väljer att inte delta eller vill avbryta ditt deltagande behöver du inte uppge varför. Om du vill avbryta ditt deltagande ska du kontakta den ansvariga för studien (se nedan).

### **Ansvariga för studien**

Examensarbetet bedrivs vid Lunds universitet och ansvariga för studien är Mia Cicovic och Sanna Nordberg (se kontaktuppgifter nedan). Huvudhandledare är Christofer Rydenfält vid

---

#### *Telefon:*

Mia Cicovic: 070-757 47 19

Sanna Nordberg: 070-697 17 17

#### *Epost:*

[mi0454ci-s@student.lu.se](mailto:mi0454ci-s@student.lu.se)

[bmp15sno@student.lu.se](mailto:bmp15sno@student.lu.se)



# LUND UNIVERSITY

Institutionen för  
designvetenskaper

Lunds universitet. Biträdande handledare är Gustaf Hedström och Mikael Laaksoharju vid Uppsala universitet.

## **Kontaktuppgifter**

Mia Cicovic, Student  
Civilingenjörsprogrammet Medicin och Teknik  
Lunds Universitet  
Tfn 070-757 47 19  
[mi0454ci-s@student.lu.se](mailto:mi0454ci-s@student.lu.se)

Sanna Nordberg, Student  
Civilingenjörsprogrammet Medicin och Teknik  
Lunds Universitet  
Tfn 070-697 17 17  
[bmp15sno@student.lu.se](mailto:bmp15sno@student.lu.se)

Christofer Rydenfält, huvudhandledare  
Institutionen för designvetenskaper  
Lunds universitet  
Tfn 046-222 98 91  
[christofer.rydenfalt@design.lth.se](mailto:christofer.rydenfalt@design.lth.se)

---

### *Telefon:*

Mia Cicovic: 070-757 47 19  
Sanna Nordberg: 070-697 17 17

### *Epost:*

[mi0454ci-s@student.lu.se](mailto:mi0454ci-s@student.lu.se)  
[bmp15sno@student.lu.se](mailto:bmp15sno@student.lu.se)



**LUND**  
UNIVERSITY

Institutionen för  
designvetenskaper

**Samtycke till att delta i studien**

Jag har fått muntlig och skriftlig information om studien och har möjlighet att ställa frågor.  
Jag får behålla den skriftliga informationen.

- Jag samtycker till att delta i studien ”Verksamhetsplanering i vården med fokus på bemanning och resurser.”
- Jag samtycker till att uppgifter om mig behandlas på det sätt som beskrivs i informationen ovan
- Jag är medveten om att jag när som helst, utan anledning, är fri att avbryta mitt deltagande i studien.

|                 |                   |
|-----------------|-------------------|
| Underskrift     | Namnförtydligande |
|                 |                   |
| Plats och datum |                   |
|                 |                   |

---

*Telefon:*

Mia Cicovic: 070-757 47 19

Sanna Nordberg: 070-697 17 17

*Epost:*

[mi0454ci-s@student.lu.se](mailto:mi0454ci-s@student.lu.se)

[bmp15sno@student.lu.se](mailto:bmp15sno@student.lu.se)



## B. Interview questions

---

### Person

- Var arbetar du någonstans? Vilken är din formella titel?
  - Vad har du för utbildningsbakgrund?
  - Vad har du arbetat med tidigare?
  - Kan du beskriva din senaste arbetsdag? Ex. I fredags/igår.
    - Är detta en typisk arbetsdag för dig? Om inte, hur brukar den se ut?
- 

### Flöde/Verksamhet

- Beskriv enhetsstrukturen
  - Beskriv kopplingen mellan era avdelningar
- Hur stora är avdelningarna? Vårdplats, personal
- Beskriv patientens väg.
  - Var börjar den sin resa?
  - Var avslutas den? Var tar patienterna vägen?
  - Vilken framförhållning behövs innan en patient kommer in på avdelningen?
  - Vilken praktisk information kring resurser/bemannning/plats behövs under patientens resa?
  - Hur sköts kommunikationen?
- Hur länge ligger patienten i snitt kvar på avdelningen?
- Vilka olika patientflöden finns det?
- Beskriv processen att flytta en patient från en avdelning till en annan.
  - Vad behöver du veta rent praktiskt innan du kan flytta en patient till annan avdelning?
- Berätta om senaste tillfället då transport mellan vårdavdelningar inte gick som förväntat.
  - Hur löste ni problemet?
  - Hur ofta sker det?

Figure B.1: Interview guide part 1

- Varför uppstod det
- Konsekvenser
- Vilka påverkades och hur? Professioner/avd
- Vilken typ av kommunikation finns det mellan avdelningarna och inom avdelningen?
- Berätta om senaste tillfället när det blev problem med kommunikationen
  - Hur löste ni problemet?
  - Hur ofta sker det?
  - Varför uppstod det
  - Konsekvenser
  - Vilka påverkades och hur? Professioner/avd
- Hur ser belastningen ut över tid? Jämför:
  - En vecka
  - En månad
  - Ett år
  - Är det olika på avdelningarna? Hur hanterar ni det?
  - Hur planerar ni för det?

---

#### Schemaläggning

- Hur planerar ni för att verksamheten ska fungera under en dag?
  - Varför görs det som det gör?
- Vem/vad ingår när du lägger schema?
- Beskriv hur processen går till vid schemaläggning?
  - Vill du utveckla?
  - Hur skiljer sig schemaläggningen för de olika kategorierna?
  - Vilka faktorer tas hänsyn till vid schemaläggning?
- När läggs schemat?
- Vad använder du för verktyg vid schemaläggning?
  - Hur fungerar verktyget?
    - Integrerbar med andra system?
  - Vilka funktioner har verktyget?
  - Varför detta/dessa?
- Hur flexibelt är schemat?
  - Finns det möjlighet att påverka schemat?
  - Hur hanteras oväntade situationer?
  - Beskriv vad som hände senast en i personalen blev sjuk.
    - Hur ofta händer det ungefär?
    - Hur löste ni problemet?
    - Konsekvenser
    - Vilka påverkades och hur? Professioner/avd
  - Beskriv vad som händer när en akut patient kommer in.
    - Hur får ni reda på att en akut patient kommer in? (Anpassa efter avdelning)
    - Hur ofta sker det?
    - Hur påverkas schemat?

Figure B.2: Interview guide part 2

- Hur ofta uppstår det problem?
- Beskriv problemet
- Hur löste ni problemet?
- Konsekvenser
- Vilka påverkades och hur? professioner/avd
- Finns det någon annan oväntad situation ni ofta är tvungna att hantera som påverkar verksamhetsplaneringen?
  - Berätta om senaste gången det hände.
  - Hur ofta sker det?
  - Hur löste ni problemet?
  - Varför uppstod det - förstå problemet
  - Konsekvenser
  - Vilka påverkades och hur? professioner/avd
- Hur kommuniceras förändringar i schemat?
- Beskriv processen när en förändring ska ske i schemat
- Hur ser belastningen ut över tid?
  - Jämför vecka/månad/år
  - Hur planeras/påverkas schemat utefter det?
- Hur görs samordning med andra schemaläggare?
  - Vilka stöd finns för det?
- Hur planerar ni för att verksamheten ska fungera under en dag?
  - Varför görs det som det gör?
  - Hur har ni arbetat fram det - mål
- Arbetar ni aktivt med produktionsplanering?
  - På vilket sätt
  - Berätta mer och utveckla
  - Hur påverkar det era avdelningar?
  - Hur har det fungerat?
  - Vad saknas? (funktionalitet)
  - Vad är de största hindrena?
- Arbetar ni med något annat förbättringsarbete?
  - På vilket sätt
  - Berätta mer och utveckla

---

#### **Operationsflöde**

- Beskriv operationsflödet.
- Vilka grundförutsättningar krävs för operation?
  - Hur ser minimibemanningen ut under operation?
  - Vad behöver man ta hänsyn till?
- Hur lång är tiden mellan operation - operation?
- Hur planerar man operationsverksamheten?
  - Beskriv processen
  - Viktiga aspekter/faktorer
    - Vad tar man hänsyn till

Figure B.3: Interview guide part 3



- Vem planerar?
- Verktyg som används idag
  - Hur fungerar verktyget?
    - Integrerbar med andra system?
  - Vilka funktioner har verktyget?
  - Varför detta/dessa verktyg?
- Vad finns det för rutiner?

---

#### Framtid

- Hur upplever du att schemalaggnings/planeringen fungerar?
- Vad är mest tidskrävande?
  - Har du ett konkret exempel på ett problem som uppstått pga det?
  - När var senast det uppstod
  - Varför uppstod det
  - Konsekvenser
  - Vilka påverkades och hur? professioner/avd
- Vad är svårast?
  - Konkret exempel
  - När var senast det uppstod
  - Varför uppkom problemet?
  - Konsekvenser av problemet
  - Vilka påverkades och hur? professioner/avd
- Var uppstår det oftast problem?
  - Har du ett konkret exempel på när det hände?
  - När var senast det uppstod
  - Varför uppstod det
  - Konsekvenser
  - Vilka påverkades och hur? professioner/avd
- Är det något du skulle vilja förändra eller förbättra?
- Vilka funktioner saknas i verktygen/processen du använder idag?
- Om du fick önska dig ett drömverktyg för planering, hur hade det fungerat?
- Vilken funktionalitet hade varit önskvärd i ett sådant verktyg?
  - Varför är en sådan funktionalitet önskvärd?
- Vilka tror du är de största hindren för att implementera ett sådant verktyg idag?

Figure B.4: Interview guide part 4

## C. Themes and Codes

---

|   |   |
|---|---|
| <b>Bemanning</b>  | <b>Verksamhet</b>   |
| Medarbetare <ul style="list-style-type: none"> <li>- Schemaläggare</li> <li>- Skillnader mellan usk/ssk/läk</li> </ul> Problematiskt           Sambemanning           Schemaläggning <ul style="list-style-type: none"> <li>- Arbetspass</li> <li>- Faktorer               <ul style="list-style-type: none"> <li>o Kompetenser</li> <li>o Krav från verksamhet</li> <li>o Minimi</li> </ul> </li> <li>- Framförhållning</li> <li>- Justeringar och byten</li> <li>- Önskeschema</li> <li>- Överbemanning</li> <li>- Perioder</li> <li>- Underbemanning (vakanta tjänster)</li> <li>- Vakanser (sjukluckor, VAB, kort inpå, transport)</li> </ul> | Ekonomi           Patientflöde <ul style="list-style-type: none"> <li>- In</li> <li>- Koordinering</li> <li>- Ut</li> <li>- Vårdtid</li> </ul> Samverkan           Struktur           Vårdplatser |
| <b>Arbetsätt</b>  | <b>Förändring och förbättring</b>   |
| Planering av saker           Problem <ul style="list-style-type: none"> <li>- Går inte att planera</li> <li>- Strykning</li> <li>- Tar tid</li> </ul> Rutiner           Stort VS litet           Verktyg <ul style="list-style-type: none"> <li>- Manuella hanteringar</li> <li>- System               <ul style="list-style-type: none"> <li>o Flöde                   <ul style="list-style-type: none"> <li>▪ Patientliggaren</li> </ul> </li> <li>o Journal</li> <li>o Planering</li> <li>o Problem</li> <li>o Schema</li> </ul> </li> <li>- Utrustning</li> </ul>  | Drömverktyg           Förbättringsarbete           Funktioner           Hinder           Önskad förändring  |
|   | <b>Arbetsmiljö</b>  |
|   | Belastning <ul style="list-style-type: none"> <li>- Låg beläggning</li> <li>- Överbeläggning</li> </ul> Inställning hos vårdpersonal           Personalfrågor                                     |
|   | <b>Kommunikation</b>  |

Figure C.1: The themes and codes used from the thematic analysis, in Swedish.

|   |   |
|---|---|
| <b>Staffing</b>   | <b>Organization</b>   |
| Co-workers <ul style="list-style-type: none"> <li>- Scheduler</li> <li>- Differences between employees (nurses, ass. nurses, doctors)</li> </ul> Problems <ul style="list-style-type: none"> <li>- Sharing of staff</li> </ul> Scheduling <ul style="list-style-type: none"> <li>- Shifts</li> <li>- Factors               <ul style="list-style-type: none"> <li>o Competences</li> <li>o Organizational demands</li> <li>o Minimal staffing</li> </ul> </li> <li>- Planning in advance</li> <li>- Adjustment and change</li> <li>- Preferred schedule</li> <li>- Overstaffing</li> <li>- Time periods</li> <li>- Understaffing</li> <li>- Vacancies (call in sick, care for sick child, short notice, transport)</li> </ul> | Economics <ul style="list-style-type: none"> <li>- Patient flow               <ul style="list-style-type: none"> <li>- Way in</li> <li>- Coordination</li> <li>- Way out</li> <li>- Length of stay</li> </ul> </li> <li>- Cooperation with other units</li> </ul> Structure <ul style="list-style-type: none"> <li>- Hospital beds</li> </ul> |
| <b>Work procedures</b>  | <b>Change and improvement</b>   |
| Planning <ul style="list-style-type: none"> <li>- Problems               <ul style="list-style-type: none"> <li>- Cannot be planned</li> <li>- Surgery deletion</li> <li>- Time consuming</li> </ul> </li> <li>- Routines</li> <li>- Size of organizations</li> <li>- Tools               <ul style="list-style-type: none"> <li>- Manual mode</li> <li>- System                   <ul style="list-style-type: none"> <li>o Flow                       <ul style="list-style-type: none"> <li>▪ Patientliggaren</li> </ul> </li> <li>o Journal</li> <li>o Planning</li> <li>o Problems</li> <li>o Scheduling</li> </ul> </li> </ul> </li> <li>- Equipment</li> </ul>  | Dream tools <ul style="list-style-type: none"> <li>- Current improvement/undergoing change</li> <li>- Functions</li> <li>- Obstacles</li> <li>- Desired improvement/change</li> </ul>   |
|   | <b>Work environment</b>   |
|   | Work load <ul style="list-style-type: none"> <li>- Low occupancy</li> <li>- High occupancy</li> </ul> Attitudes among employees <ul style="list-style-type: none"> <li>- Human resources</li> </ul>   |
|   | <b>Communication</b>  |

Figure C.2: The themes and codes used from the thematic analysis, in English.

## D. Discovering requirements

---



Figure D.1: Full affinity diagram over the found problems and issues.

# E. User test 1

---

## E.1 Instructions - User test 1

Talk-aloud! Prata under tiden, säg allt du tänker på. Kolla igenom prototypen tills du känner att du kan den.

Scenario att utföra som:

### 1. Personal

- Lägg till en kompetens som du önskar.
- Hitta info om hälsosamt schema.
- Hantera dina preferenser.
- Lägg till ett nytt schema för kommande period.

### 2. Schemaläggare

- Hitta databasen över all personal.
- Lägg ett nytt föreslaget schema och se vilka du kan lägga istället för Jonna. Lämna in schemat.
- Hitta vilka som bytte plats 14/4.

## E.2 Survey Questions

## Test av prototyp

Tack för att du testade vår prototyp! Svara gärna på dessa frågor så att vi kan förbättra prototypen.

**\*Obligatorisk**

Namn: \*

Ditt svar

Vad var ditt helhetsintryck av prototypen? \*

Ditt svar

Vad var bra med prototypen? \*

Ditt svar

Vad skulle du vilja förändra/förbättra? \*

Ditt svar

Figure E.1: Questionnaire from first lo-fi iteration.

---

Var det något som gjorde dig förvirrad? \*

Ditt svar

---

---

Var det någon uppgift du inte kunde slutföra?

- Personal - lägg till kompetens
- Personal - hitta hälsosamt schema
- Personal - hantera preferenser
- Personal - lägg till ett nytt schema
- Schemaläggare - hitta databasen över all personal
- Schemaläggare - lägg till nytt föreslagit schema
- Schemaläggare - hitta vilka som bytte plats

---

Har du några övriga kommentarer?

Ditt svar

---

Skicka

Figure E.2: Questionnaire from first lo-fi iteration.





## F. User test 2

---

### F.1 Instructions - User test 2

#### Testinstruktioner

Hej och välkommen till testet av vår prototyp!

För att vi ska förstå vad du tycker och tänker om prototypen är det viktigt att du pratar högt kring vad du tänker när du testar. Alla tankar och funderingar du har medans du testar är bara att säga rakt ut.

Du kommer att få en prototyp framför dig, som du kan klicka runt i lite för att lära känna produkten. När du känner dig redo kommer jag att ge dig några uppdrag som du ska utföra. Är du redo? Glöm inte att prata högt kring dina tankar.

#### Del 1 - MyPage

1. Logga in som personal.
2. Lägg till två kompetenser som du är intresserad av att lära dig. Spara.
3. Önska ett nytt schema för nästa period. Du vill ha alla föreslagna pass förutom helgen 1-3 oktober då du vill byta kvällspass till morgonpass. Spara och skicka in.
4. Nu är du inne i nästa period, där det handlar om att personalen diffar (ser till att schemat blir funktionellt genom att byta pass). Du har ditt sparade schema framför dig. Flytta dig från morgonpass till kvällspass den 28 september. Spara och skicka in.
5. Logga ut.

Varning! - försöka lägga dagskift den 6 sep, när man valt alla pass.

#### Del 2 - Scheduler

1. Logga in som schemaläggare.
2. Lös vakansen den 20 juni genom att byta in Calle.
3. Finn tre ändringar som gjordes i maj månad. Vem, vad och varför?
4. Ta reda på historik om Anneli. Vilken kompetens har hon blivit positionerad som mest den senaste månaden?
5. Du är inne i sluttampen av schemadiffningen. Se till att den 14 september är ordnad och inte saknar en person. Spara och skicka in.
6. Logga ut.

## F.2 Interview questions

Short semi-structured interview:

1. Vad tyckte du var bra med prototypen?
2. Var det något du inte förstod?
3. Finns det något du skulle vilja förbättra?
4. Vad tyckte du om konceptet?
5. Är det något som saknas?
6. Har du något övrigt att tillägga?

# G. User test 3

---

## Testinstruktioner

Hej och välkommen till testet av vår prototyp!

En prototyp är inte ett färdigt program utan bara en modell av hur det skulle kunna se ut! Vår riktning är mot planering och schemaläggning.

Du kommer att få klicka dig fram för att få bättre förståelse och lära känna produkten. När du känner dig redo kommer jag att ge dig några uppdrag som du ska utföra.

För att vi ska förstå vad du tycker och tänker om prototypen är det viktigt att du pratar högt kring vad du tänker när du testar. Alla tankar och funderingar du har medans du testar är bara att säga rakt ut.

SPELA IN

Är du redo? Du kan börja med att logga in som personal, Anneli Karlsson. Glöm inte att prata högt kring dina tankar.

### Del 1 - MyPage

1. Lägg till två kompetenser som du är intresserad av att lära dig. Spara.
2. Du har insett att du gärna jobbar mycket kvällar nästa vecka, ändra i dina preferenser. Spara.
3. Önska ett nytt schema för nästa period. Du vill ha alla föreslagna pass förutom helgen 1-3 oktober då du vill byta kvällspass till dagspass. Spara och skicka in.
4. Nu är du inne i diffningen. Du har ditt sparade schema framför dig. Flytta dig från dagspass till kvällspass den 28 september. Spara.
5. Logga ut.

Nu har det gått 2 v till!

### Del 2 - Scheduler

1. Logga in som schemaläggare, Lisa Andersson.
2. Lös vakanserna den 22 juli genom att byta in Calle och Erik.
3. Hitta vad för ändringar som gjordes den 5 maj. Vem, vad och varför?
4. Hur jobbade Anneli den 4e juni? Skedde någon förändring under det passet?
5. Hitta information och statistik om Anneli. Vilka pass jobbar hon mest?
6. Du är inne i schemadiffningen. Se till att den 14 september är ordnad och inte saknar en person. Spara och läs.
7. Logga ut.