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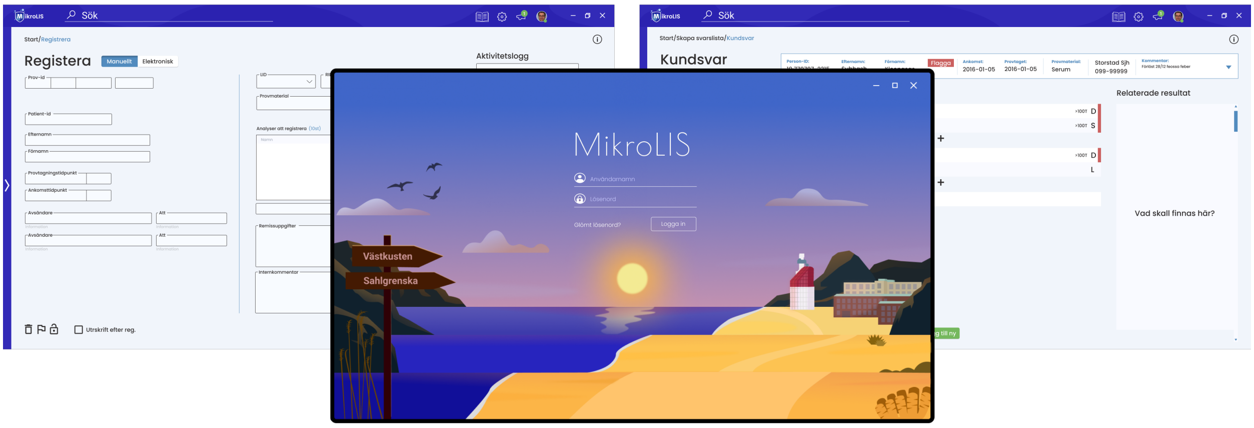

User-centred design proposal for clinical microbiology LIS

Usability study of Swedish laboratory information system

Master's thesis in Interaction Design & Technologies

Ludvig Andersson

Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2021

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Abstract

Multiple hospitals around Sweden are currently taking steps to improve the digital systems used within their clinical laboratories. The laboratory information system is an important program which in many cases be decades old. When there is no suitable application purchasable on the market, the hospitals have to develop it themselves. The systems are required to be very efficient and the functionality and design have to accommodate this demand.

The thesis examines how the user experience can be improved to amplify the effectiveness of a LIS. By performing user-centered design, the results are expected to be directly interlinked with the user's needs, and the design well-founded. A three-pronged user study series was conducted to reveal general guidelines to use when developing a user interface for a LIS. The series consisted of a semi-structured interview, a workshop, and an evaluation. Based on the study series, seven fundamental guidelines were derived and later applied to create an interactive design prototype. The guidelines are derived from a very specific set of users within a hospital in Sweden, where a large part of the user base has multiple years of experience using a LIS. Thus, the findings are tailored to this scenario, but the guidelines are presented as a useful starting point when analyzing the usability of another LIS. The guidelines are also expected to be helpful when creating a LIS where no digital environment exists.

Keywords: LIS, re-design, usability, user centered design, Sahlgrenska, interaction design.

Acknowledgements

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I would also like to express special thanks to my supervisor at Sahlgrenska, Evelina Lindroth, IT Project Manager at MTMIS, for her guidance and encouragement throughout the project. Also, thanks to the developer team at MTMIS for their explanations and feedback during the project.

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Finally, I would like to express my gratitude to the laboratory personnel that participated in my user study series, and provided valuable feedback over the course of the project.

Ludvig Andersson, Gothenburg, June 2021

Abbreviations

MTMIS = Medicinsk Teknik Medicinska Informationssystem
LIS = Laboratory information system
LIMS = Laboratory information management system
CSS = Cascading style sheets
UI = User interface
UX = User experience
SWOT = Strengths, Weaknesses, Opportunities, and Threats
EMR = Electronic medical record

Contents

List of Figures

1
Introduction

The following chapter introduces the purpose of the project, its aim, and the various stakeholder involved.

1.1 Purpose

Sweden aims to become the leading actor globally in its usage of digital healthcare, by the year 2025 [53]. To accomplish this goal, a digital transition is being carried out throughout the whole healthcare sector. A part of the vision is to strengthen resources for improved independence and participation for patients in their societal life. For this vision to be realized, a high-quality digital work environment for healthcare workers is mentioned as a key requirement. To be able to provide the desired e-health platforms patients and medical practitioners use, all pieces within the healthcare service needs to be up to par digitally, and work in compliance to provide good results. This applies to systems within each hospital, as well as between hospitals nationwide. Sahlgrenska University Hospital has a leading role in the transition as the largest hospital in Sweden.

A digitalization effort is being implemented based on a strategy laid out by Region Västra Götaland [29]. The digitalization of various laboratory departments at Sahlgrenska is ongoing, to collect and keep information up to date, and to store it in the same location. Laboratories handling bacteriology, virology, serology, and immunology will share one *laboratory information system* (LIS) that is currently under development and is in partial use. The system will handle medical information like results for the three laboratory departments and a module for healthcare hygiene (spread of infection) at the hospital. It will also keep track of more administrative information, for example, order management, statistics, and more. Parts of the system have been delayed due to the demanding circumstances facing hospitals during the COVID-19 pandemic, but development is now planned to resume.

The program that is being developed will only be a temporary solution for Sahlgrenska, whilst a bigger transition being carried out nationwide. The electronic health record system Millennium will become standard in the year 2023. Sahlgrenska will transition from their own systems and instead use Millennium together with the whole region Västra Götaland. This system will first be tested in selected parts of Sweden, before becoming standard everywhere. This is in line with Swedish policy to purchase already existing solutions if they exist and meet requirements, before developing something new. This means that design decisions within the project should be taken with the consideration that a new system will soon replace everything. Unless decisions are beneficial in the short term (the remaining two years) or benefit transition to Millennium, they should be reconsidered.

1.2 Research question

To determine the best way to improve the user experience of Sahlgrenska's laboratory information system MikroLIS, the research question for the project was:

What guidelines are most important when re-designing a clinical microbiology LIS to effectively operate for different expert laboratory personnel at Sahlgrenska University hospital.

1.3 Deliverable

The research question aims to find out the needs and behavior of users of a laboratory information system, and then produce a design proposal that should be possible to implement into the existing system. The proposal will be a high fidelity prototype that should show key functionality that has been discovered through the design research and user testing. The proposal should also have been evaluated with stakeholders to validate that it is designed in a way that suits the users' need. The design proposal will thus also consist of a report outlining the various finding. For the proposal to be functional for the specific set of users with extensive experience using the prior system, the guidelines will have to cover the connection between the old program and the new one.

1.3.1 Delimitations

The programs that are being combined, as well as the LIS under development, consist of a large number of functions. It would be impossible to analyze everything in the given time frame. Thus the project has been limited to the key processes of: *Registrera, Patientöversikt & Kundsvar (Translation: Register, Patient Overview & Customer Response).* The project will mainly focus on the design of the user interface of the program, and thus not place a large emphasis on how additional processes might function. It is however an important issue of how the design will be implemented and that the right functionality exists. Thus programming aspect, additional functionality and more will also be considered while doing the design. Any feedback related to these issues that might be presented during the user studies, and project in general, will be conveyed to the developers.

1.4 Stakeholders

The following section presents the stakeholders within the project. The stakeholders are people or institutions that influence the thesis, or are in some way affected by its outcome.

1.4.1 Thesis author

The thesis is conducted by a student within the Interaction Design & Technology master's programme at Chalmers University of Technology, with prior qualifications in the form of a bachelor in information technologies.

1.4.2 Chalmers University of Technology

The thesis is written as part of the Interaction Design & Technology master's programme at Chalmers University of Technology. Chalmers are responsible for thesis quality control and approval. The university also provide various channels of counseling, mainly the assistance of an assistance of the academic supervisor Gordana Dodig Crnkovic and examiner, Staffan Björk.

1.4.3 Sahlgrenska University Hospital

The thesis is carried out in collaboration with Sahlgrenska University Hospital. The departments involved are MTMIS (Medicinsk Teknik Medicinska Informationssystem) and clinical microbiology. Sahlgrenska provide expert support, counseling, and access to the technology used in the thesis. Supervising as part of counseling from Sahlgrenska was done by Evelina Lindroth.

1.4.4 Developer team

A small developer team are working on the program studied, MikroLIS, and provided weekly counseling during the project. The final design and guidelines created during the project will later be presented and past on to the developers.

1.4.5 Laboratory personnel

The users for the laboratory system being studied are laboratory personnel at various laboratories within the department of clinical microbiology. These users are both directly affected by the outcome of the thesis, but were also involved as participants during the thesis' user study series.

1.4.6 Stakeholder Overview

Figure 1.1 show the people that are most closely associated with the project.

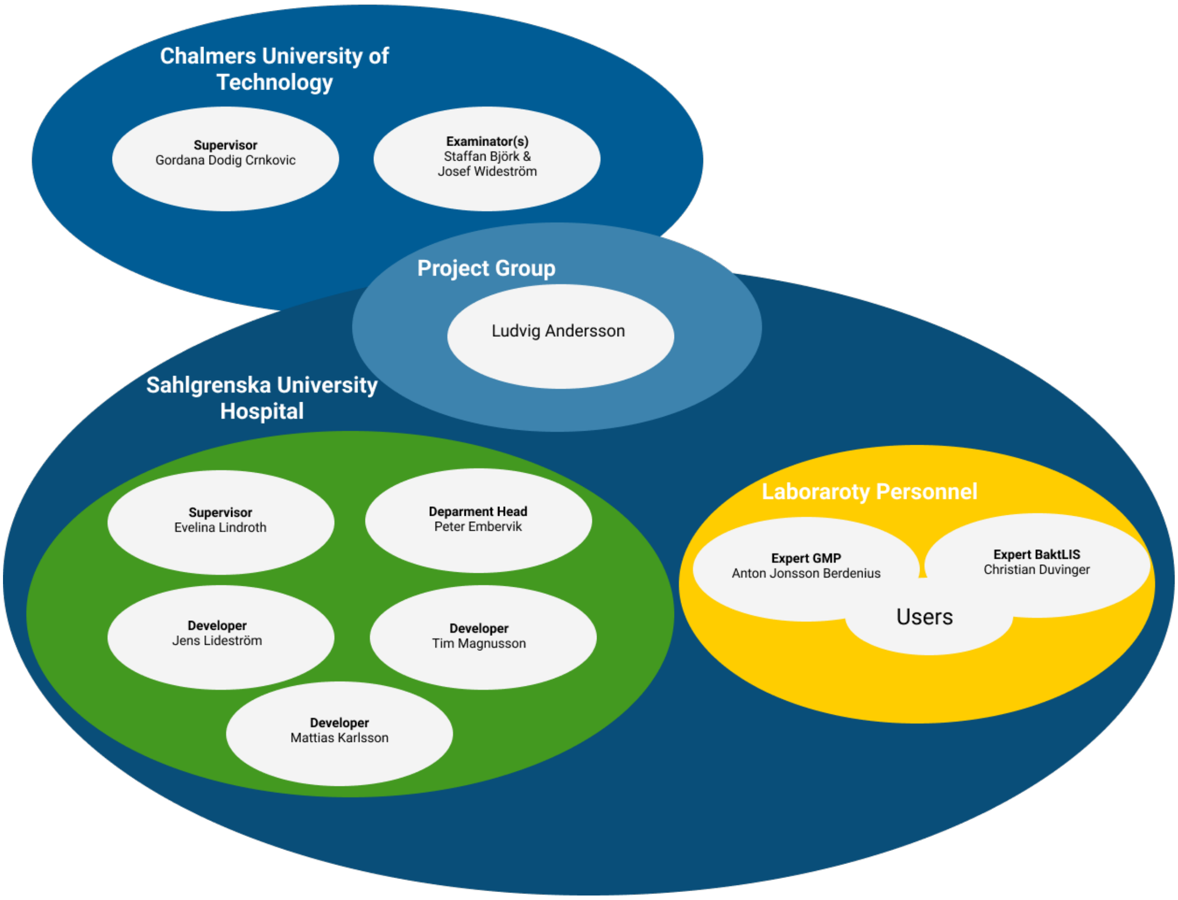


Figure 1.1: A chart over the stakeholders for the project.

2

Background

The following chapter gives context to the project, introducing the state of the art products that exist as well as related research.

2.1 State of the art

Laboratory information systems (LIS) have been commonly used for decades [14]. Yet there is still a great lack of accessible material to be found surrounding them. It is unclear why this is the case, but one could imagine that keeping patient related systems hidden improves security. It is also reasonable to consider that companies are keeping their systems secretive to avoid competitors replicating their solutions.

2.1.1 Laboratory information systems forecast

There is not one definitive system being used nation wide within Sweden as of yet. This is about to change with the introduction of the US-based Cerner Corporation system Millennium [16]. Millennium is explained to cover the role of a electronic health record (EHR), electronic patient record (EPR) or electronic medical record (EMR). But the company also creates laboratory systems, which is the use case for Sahlgrenska's laboratories. Cerner have also been involved in creating a nation-wide LIS within Ireland called MedLIS [35], making the company active world-wide.

North America is the leading actor globally within the LIS market. Europe is not far behind and Asia is growing rapidly. There are large groups of competitors in the market [34], with several key companies expansion of their LIS portfolio [44]. This is likely to rapidly improve the market. As of current, the top five companies are [44]:

1. Sysmex Corporation [64]
2. Roper Technologies (Sunquest Information Systems, Inc) [62]
3. XIFIN Inc [72]
4. Cerner Corporation [16]
5. Orchard Software Corporation [59]

2.1.2 Laboratory information systems in Sweden

Similar to the global situation, finding out exact information regarding a hospital's LIS in Sweden is quite difficult. Information is often not published online, and when it is, there is mostly a mention of the system name. A closer investigation into these systems was not within the scope of the project and would have required getting in contact with each region, or a hospital directly.

The information gathered at Sahlgrenska and the web revealed that the following systems are currently in use:

Lifecare is an information handling program developed by the company TietoEvry. It manages multiple parts of the business, like documentation, decisions and financial support [42]. The program is used within the department for clinical chemistry at Sahlgrenska.

SymPahty is another program used within Sahlgrenska, at the department of clinical pathology. The program was originally within the umbrella of laboratory products made by Tieto (now known as TietoEvry) called FlexLab [1]. The program has however since then been developed, in conjunction with four other companies, to fit the specialized work at Sahlgrenska, with the name PATOS [67].

Sahlgrenska also uses the systems BaktLIS within the departments of bacteriology, among others, and GMP for the department of virology. These systems will as mentioned by replaced by MikroLIS, and in time also Millennium. They have however been the staple at the hospital for decades.

LabVantage Medical Suite is a lab management system created by the company Software Point [50][41], and is currently in operation within the region Skåne [51]. The LIS is used for the department of clinical pathology at the university hospitals in Lund and Malmö, as well as the hospitals in Helsingborg and Kristianstad.

2.2 Related work

The public research done on laboratory information systems is also very limited. And the work done specifically related to the user interface, usability, or re-designing, is even less common. The topic of UX design is quite newly created, and many programs were designed before a good design was of concern or even a possibility. Companies have likely researched the topic, but this material is not publicly shared.

By doing an exhaustive investigation into the specific topic of a Swedish LIS re-design, one can determine that there has never been a replica of the study. There are no exact studies based searching multidisciplinary article databases like Google Scholar and Microsoft Academic, neither can any be found on Aminer, a Computer Science specific database. Thus, to find related work, one has to reduce the criteria of similarity. Studies of interest were found by excluding or altering one or multiple of the following search terms: Sweden, LIS, UX Design, User interface. This generated for example studies regarding LIS in other countries, or re-designs of other medical systems.

2.2.1 Related LIS studies

The authors Sepulveda and Young studied the topic of creating an ideal laboratory information system by going through literature and holding interviews with LIS users [56]. They looked at the possibility of creating a system where the user interacts with a substantially leaner interface, where the system automatically handled activities where human errors are a possibility. The author list 12 features that could improve the quality and cost-effectiveness of a LIS. These features cover the whole system, everything from the program's interaction and design, to functionality and software/hardware. Some of the mentioned features are partially implemented today, and the others are possible improvements for the future.

Two studies have been conducted on the usability of LIS:s using the system usability scale (SUS), one in the United States [46] and the other in both Ireland and Saudi Arabia [6]. The results from the study conducted in the United States indicates that the usability is poor. Only one program scored above the benchmark value of 68 [68], with the average being 59,7. The study regarding the Irish and Saudi Arabian systems did not derive a resulting value per hospital, but instead compared the hospitals to each other. The findings showed similar weaknesses for both countries, despite their differences.

Another study analyzing the usability of the LIS were conducted on the LIS for the academic hospital affiliated with the Kerman University of Medical Sciences in 2017 [5]. The study was done with a standardized heuristic evaluation, and 162 usability problems were identified. The highest amount of problems concerned flexibility and efficiency. The authors concluded that the system could possibly be improved by considering standards and principles like the heuristics used in the study.

A study reviewing the effects of the introduction of a LIS within the laboratory workflow in Serbia found that using a digital system vastly improved effectively at the workplace, prevented errors, saved time, and more [43]. The authors concluded that to continue getting good results from the digital systems, the program had to keep being improved at the rate of dynamic laboratory. The biochemist needs to define desirable LIS characteristics and continuously suggest changes which the laboratory needs, to the developer. This points to the importance of including the user in development.

2.2.2 Related EMR studies

A literature review study of the usability of Electronic Medical Records (EMRs) were conducted by Zahabi, Kaber, and Neubert [73]. The authors studied articles in a set of databases containing the keyword EMR usability. Based on these studies, a set of usability problems were identified among the literature, and design guidelines to address these problems were formulated. The study also presents a concept for an enhanced EMR design. Both the guidelines and the concept aims to reduce the usability problems in patient diagnosis and documentation.

A Swedish thesis was created with the goal of making a UX redesign of a digital healthcare tool [63]. The authors used a human-centered design process to re-design the system and develop a new improved prototype of the program. The prototype was evaluated with 12 test participants and was shown to provide a better usability than the original.

2.3 Interaction design guidelines

The study aims to produce a set of interaction design guidelines specific to a LIS. Raising universally accepted guidelines and heuristics, within the field of interaction design, is an important step to create a foundation for the research. These can later be built upon to create ones specific to a LIS. There are a myriad of different guidelines and heuristics that have been proposed over time, but the ones proposed by Schneiderman and Nielsen have gained traction within the field and are commonly referenced in literature.

2.3.1 Schneidermans's eight golden rules

In he book Designing the User Interface: Strategies for Effective Human-Computer Interaction, Schneiderman introduces the reader to eight golden rules of interaction design [54]. These rules have since then been reflect by some of the largest technology companies in the world [71] to produce what we consider to be the pinnacle of today's modern design. The rules are intended as a tool to learn design, but have been used as a tool to analyze design to find possible flaws [13]. The eight golden rules are:

- Strive for consistency
- Seek universal usability
- Offer informative feedback
- Design dialogs to yield closure
- Prevent errors
- Permit easy reversal of actions
- Give users the control
- Reduce short-term memory load

2.3.2 Nielsen's ten usability heuristics

Nielsen's ten usability heuristics have been created with the intention to be able to evaluate a design and find flaws within it. The heuristics were originally created together with Molich, but have later been refined by Neilsen to the set we use today [48]. What Nielsen created were so called heuristics, not guidelines [48]. The intention was to provide general rules of thumb, as opposed to strict rules. The strength of heuristics is their universal character. They can be applied to most interactive interfaces for a well made designed. The heuristics are:

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognize, diagnose, and recover from errors
- Help and documentation

3
Theory

The following chapter presents the theoretical foundation for the project and involves relevant topics for the whole process.

3.1 Design theory

As designers, the decisions made regarding a product should be based on theory, and not artistic preferences [61]. The lines between the field of interaction design and that of artistry can however get blurry on occasion, especially when expanding a research sector. Coming up with new ideas consists of both prior work, but there is also an element of personal creativity. But the main point of the design is to build upon established concepts. Design theory is as such, about answering the question "Why am I designing it this way?" with references and facts [61]. To be able to do this accurately, different relevant subtopics of design need to be studied and understood, before any design decisions are made.

3.1.1 Design research

Based on the research by Frayling, there are three types of design research [28]. The first is research for design, where you research user interviews, stakeholder interviews, or diary studies, to create a design. The second is research into design, where the designers themselves, or the work they conduct, are studied. This type of research aims to understand how designers work or how their investigations and experiments are conducted. The third type is research through design, where design is used as a tool to find out something or to solve a problem.

Frayling's work has since its creation been developed further to match modern design work. The boundaries that he set up have started getting erased. Today's projects typically involve work in iterations, and this work is no exception, where you begin by gathering knowledge for a design, but the results are rarely a finalized product. Instead, a prototype is used to evaluate a concept, and based on the results, another iteration of user research and ideation begins. There becomes a cyclical structure, where the research is for design, becomes through design, and then goes back to being for design once again.

For the following project, defining which type of design research is being used, is subsequently quite tricky. The project was not structured in a way where a product was developed, evaluated, and changed in multiple larger iterations. Neither was it quite as linear as Frayling's definition of research for design. Instead, an adapted type of research for design was used, with influences of the iterative-based structure of modern design projects.

3.1.2 Four basic activities of interaction design

Pierce et al. present four basic activities used to create good design [52]. These activities are staples in many design disciplines but are the essentials of interaction design.

Establishing requirements is the process of gathering knowledge about the users, capturing their needs and wishes are before starting any development. By collecting data about the user, educated design decisions can be made and backed up with research. What is considered a requirement is up to the designer and the project, but the activity is meant to uncover both requirements-related functionalities, as well also feelings, emotions, frustrations, and more.

Designing alternative is the core activity of design, where ideas are suggested to meet the requirements established within the first activity. Pierce et al. mention that there are two sub-activities, conceptual design, and concrete design [52]. The conceptual design focuses on how a product can be used and how you interact with it. While concrete design revolves around the details of the product, like color, sound, images, and more.

Prototyping involves creating something that can be shown to stakeholders and later evaluated. Pierce et al. specify that a prototype should be interactive, but not necessarily software-based [52]. Other authors like Cooper et al. and Hartson & Pyla do not specify the need for interactivity, with Hartson & Pyla especially mentioning non-interactive low fidelity prototypes [18][31].

Evaluating is the process of determining the viability of a prototype [52]. Evaluation is typically done directly with the users, with them giving feedback on the design. It can however also be done within a development team, using methods like heuristic evaluation. By involving the user in the process of designing, the evaluation is likely to have a satisfactory outcome with the prototype being acceptable.

The completion of one activity will enable a designer to start with the next. This is repeated in iterations, both within each step, but also going through the whole activity multiple times. For each iteration, more knowledge about the user and the design is collected. This will gradually create a better and more appreciated design. The project was structured around one iteration with all of the four activities being present. Within each activity, there were multiple smaller iterations done, where different types of methods were used. For example, multiple types of observation were done during the establishing requirement phase. Each session of observation built upon the prior one, to improve and adapt it.

3.1.3 User centered design

Interaction design is essentially about creating a product that works for a user. Thus, applying a user-centered approach, where the users are involved in the project, is crucial to achieving this goal. Real users, with real goals, are the driving force of development, not only the technology [52]. Well-designed products make use of the knowledge the user possesses. No matter if the user is an expert with very specific needs and opinions or a beginner that has difficulties grasping how the design is intended to work. The designer can always gain perspective by listening to a user and letting them guide the process.

Gould and Lewis created three principles that later became the basis of user-centered design [30]. *Early focus on user and tasks*, meaning that a designer needs to observe the user performing their normal tasks, study the nature of the tasks, and then involve them in the design [52]. This process is about understanding the users and their behavior, as well as their characteristics. Secondly, *empirical measurements*, where the characteristics as recorded before and during the project, to make it possible to compare results. Lastly, *Iterative design*, where problems that might arise during development are fixed and the process starts over once again to see if the design is improved and if it can become even better.

This project is said to take on a user-centered design approach to finding guidelines for a LIS. Thus, the project involved the users right away with observation and interviews. They were also involved directly in the design of the program during the design workshop. And finally, they also gave feedback on the developed design prototype. The users are also expected to have a role during the program's development going forward, as it progresses through multiple iterations.

3.1.4 Design thinking

Design thinking, similar to user-centered design, puts the user at the core of the design. Whilst user-centered design involves the user in different steps of the process, design thinking is about focusing the creation on the users [32]. By applying the design thinking methodology, anyone can, no matter the discipline, create better products that are suited to the users. When tackling ill-defined and complex problems, the methodology can be used to focus the investigation on the human needs [19].

Norman emphasizes finding the right problem. He mentions that engineers and business people learn to solve problems, but they never stop and question if the problem is what should have been solved [49]. In the real world, the questions don't come neatly defined, a good designer has to explore the problems and find the real issue to solve. Thus, design thinking is about applying a process to "finding the right problem and meeting human needs and capabilities" [49].

When re-designing a LIS for expert users, countless issues need addressing. The users know the programs inside and out and have repeated requests of things to solve. But they think of the problem from their point of view, the effects of the problem. As a designer, by applying design thinking, the actual issues need to be addressed, the cause of the issue.

To find the cause of the problem, there are different types of methods one can use. Norman explains it as a process of a root cause analysis, where you repeatedly question the answers given to a problem until the actual root cause has been identified [49, p.165]. Dam & Siang give a five-stage process for applying design thinking [19], originally proposed by the Hasso-Plattner Institute of Design at Stanford (d.school). These steps are as following:

1. Empathise
2. Define
3. Ideate
4. Prototype
5. Test

These two methods of finding the cause of a problem and solving it will be used whenever a complex issue arises.

3.2 Patterns, guidelines, or heuristics

The goal of the project is to create a set of guidelines that one can apply when re-designing a LIS. Thus, finding out the definition of guidelines is appropriate. Guidelines are a common use strategy to present research and gives a reader a tool to apply to future work. But the word guideline is often used interchangeably with another term like pattern or heuristics. But When does it become patterns or heuristics?

The dictionary definition of a guideline is: "information intended to advise people on how something should be done or what something should be" [21]. When breaking this into pieces, one can see that a guideline does not have to involve any information given to any person. This is very broad and gives room for interpretation. A pattern is similar, with the definition declaring the particular way something is done [23]. A heuristic on the other hand stipulates that a student uses the knowledge to discover things, rather than them being told something [22].

Like any word, the context it is used within makes a difference. Nielsen, the author of some of the most commonly used heuristics within interaction design [48], writes that his heuristics are to be considered "Rules of Thumb", and implies usability guidelines to be stricter. This does not exactly correlate with the earlier mentioned definitions.

The word guideline will be utilized within this project, with the meaning "a non-specific rule or principle that provides direction to action or behavior" [69]. The word pattern has is many situations the expectation of a underlying model. And a heuristic has the implication that one should use the findings as tools for learning or discovery [47], not wrong for the thesis, but not as accurate as the definition for guidelines.

3.3 Prototyping in interaction design

Prototyping is the use of accumulated design research results, with the intent to evaluate the feasibility of a not fully developed product. The prototype can use different mediums and serve different purposes.

3.3.1 Fidelity of the prototype

Pierce et al. describe a prototype as the manifestation of a design, to allow stakeholders to interact and explore the suitability of a design [52, p. 386]. This design manifestation can be of a range of different levels of detail, often expressed as the fidelity of the prototypes.

A low fidelity prototype, or commonly referred to as a lo-fi prototype, are prototypes far from the finalized design in look and functionality [52, p. 389]. Benyon simplifies the lo-fi prototype as simply made of paper [12], while Pierce et al. include other simplistic materials like cardboard or wood. The lo-fi prototype is used to quickly present ideas, which can later be discarded [12]. Methods usually associated with creating a lo-fi prototype are storyboarding and sketching. And wizard of oz is typically used to simulate functionality.

A high-fidelity prototype, or hi-fi prototype, is much closer to the actual product. The medium used is typically more permanent and can often be the same as the one used for the final product. Both Pierce et al. and Benyon explain that hi-fi prototypes are often used to sell an idea or concept [52][12]. By being close to the actual product, with slight compromises, the design can be evaluated for technical aspects. Since a hi-fi prototype is both time and resource-intensive to create, it is made in the later stages of designing. Ideas and concepts have firmed up and been decided, reducing the occurrence of problems that impact the feel of the design.

For a project done over approximately 20 weeks, developing multiple hi-fi prototypes would not be possible. Instead, a few lo-fi prototypes will be created to guide development on one larger hi-fi prototype, that will be presented as the result of the thesis.

3.3.2 Interface design principles

In the interest of building upon existing research regarding interface design, and not studying already established concepts, design principles were studied. This would also be of use as pointers when creating guidelines for the specific purpose of a LIS. Areas within the field of graphical and interface design were within the scope of the research.

3.3.2.1 Typography

The principle goal of text within a user interface is to help the user read the information on the screen. The rules for typography is the same for digital interfaces, as it is for newspapers or books. And these rules have not significantly changed for hundreds of years, as pointed out by the author Kahn [36]. As long as the human visual system and the roman lettering format is unchanged, so will the rules for typography. The medium presents different challenges and possibilities, and it is up to the designer to adapt.

Cooper et al. write that people mainly recognized words by their shape, making it possible to quickly pick up very condensed information [18]. On the other hand, if the text is poorly shaped, it can create confusion and complicate the reading of an interface.

Both authors emphasize the need for contrast within the text, as well as the importance of picking a correct letter size and shape [36][18]. The contrast between the type and its background is what makes the text visible [36]. High contrast without using complementary colors, around a contrast value of 80%, is the golden standard.

The use of typography can be seen in the final design, with the use of differently sized titles, headers, and paragraphs. The use of high contrast can be seen in for example in the use of white text on dark blue backgrounds, and black text on the creamy white backgrounds.

3.3.2.2 Size

The relationship between objects is all about context. An object is compared to the overall size of a screen, but also about its relation to the information around it. Larger objects draw more attention in relation to smaller objects [18]. The users also assign relative quantities to an object based on size and sequence them according to the one with the highest value. A larger bolder text is thus read first, whilst the smaller thinner text is read after. The larger object appears to be closer on the screen and has thus higher importance [65]. The final prototype within the project has a grid structure, where the different elements have been given different sizing based on their context and importance.

3.3.2.3 Color theory

The study of color theory gives a collection of rules and guidelines that a designer can use to communicate with a user [27]. Picking the right colors for a design is not, as it might seem, guesswork [58]. The choice of colors a designer makes should be based on the user's goals, the context, environment, and the brand [18]. But importantly, how the colors are perceived by the user is based on human perception, not exact qualities. What can help guide this process of finding and creating a color palette is however understanding the properties of colors.

- Value - How light or dark a color is [18].

- Hue - The appearance of the color [27].
- Saturation - The intensity of a color, a saturated color appears pure, while a non saturated color is pale [66].
- Tint - The mixture of white to a pure color, making it appear pastel-like [10].

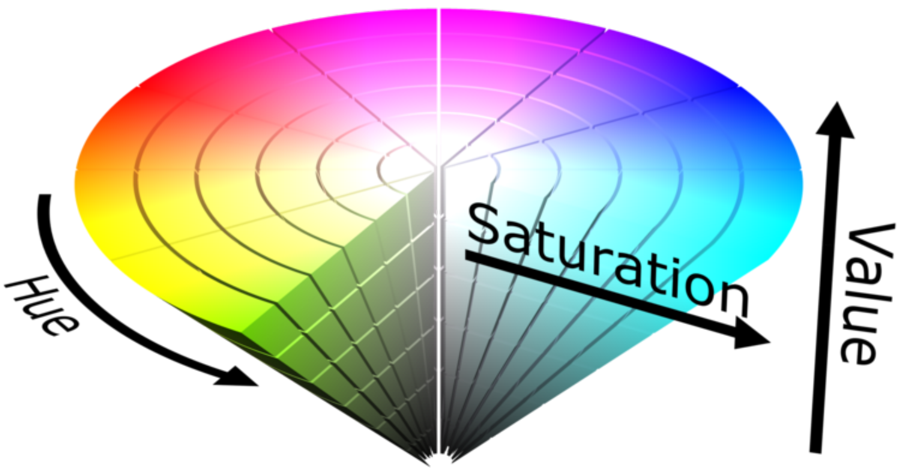


Figure 3.1: Visual illustration of color properties: value, hue, and saturation [20]

Finding the right set of colors, and applying it to an interface is a process exploration [57]. With knowledge of which colors exist and how they interact, the creative process can begin. The earlier mentioned rules and guidelines can here help make a structure to the process, but not create a step by step guide for success. Using rules of thumb like the 60-30-10 rule [24][4], originally introduced for interior design, one can create a design that has balance. But it does not guarantee success. It is up to the designer to either improve the visibility of the interface with the colors or to apply them all over and create a mess.

When a specific set of colors, that match and form a palette, has been found, they can be applied to different elements on the page to create focal points on the screen. Similar to the handling of size, colors can create a sequence for the user to follow when looking for information, starting with the most prominent color.

The work studied about color theory was the base for the prototype's color palette. It was also essential for the creation of the guideline Modernizing the design.

3.3.2.4 The Bouba/kiki effect and its generalization

The Bouba/kiki effect is traditionally a linguistic or psychological concept where the human brain attaches abstract meanings to words. The word *Bouba* is likely to be paired with a rounded shape and the word *Kiki* a pointy one. The phenomenon was originally invented by Köhler in 1929, using slightly different words [40].

The theory has later been applied to various design areas such as character design, logo design and UX design [39]. The way a designer works rounded shapes is no longer a trend, but an industry-standard [7]. It has been found that rounder shapes are easier on the eyes, and the bouba/kiki effect tells us that it also affects the user's perception of an interface [39]. Applying this approach can affect the overall feel of a design. Sharp edges can make a design feel reliable, whilst too much sharpness can be perceived as aggressive. Rounder shapes can create the feeling of friendliness [39].

The user of a program subconsciously shapes their overall impression within seconds [39]. By reducing the design into different shapes, the physiology of the design can be revealed. Shapes such as squares and rectangles create the feeling of security and reliability, whilst circles, ovals, and ellipses can be perceived to be magical and mysterious [9].

For a medical related system like the one studied in this thesis, the intention is to find a middle ground between the feelings the shapes provide. There needs to be a neutral feeling, where the program is reliable and secure with square shapes. But also somewhat fun and inviting. An aim is to remove the boring connotation many medical applications can have, by for example using some rounder shapes and also colors.

4
Methods

This chapter discusses the various methods and techniques used within the project, as well as some possible methods that were considered as alternatives.

4.1 Research Methods

A major part of the project was understanding how Sahlgrenska's laboratories use their digital tools for daily work. These laboratories are serology, bacteriology, molecular bacterial diagnostics, and molecular virological diagnostics. This endeavor is mainly focused on understanding how the old programs were used, and how to transition to a new program. This is a complex task of merging and updating functionality from the old programs into a new main program. To be able to accomplish this, one needed to define requirements for what the program should be able to do, as well as understanding the workflow of each laboratory. Luckily, this was an ongoing process for the developers during the creation of MikroLIS and had also been unfolding during improvements and upkeep of the old programs. The information had however not been documented during this process, and the task would realistically have been too complex. This means that to be able to assist in the development, the information had to be gained from the users directly once more, using different methods of user research. Some information could also be explained by the developers directly, by asking them why they had taken different design decisions.

The interface of the program and its usability is the main focus for this project and is one part of the prior mentioned effort to understand Sahlgrenska's LIS. This area had been down-prioritized as of yet in the development of MikroLIS, in order to have a working program during the pandemic. Especially some less crucial parts like visual design had been postponed. This enforced the need of once again studying the user, to define how they needed and wanted the design to look. And also how it should function.

Making the project purely design-focused was initially the intention, but one quickly realized that to be able to understand any of the requirements for the program, the project also had to consist of learning the basics of biomedical analysis. The user research was thus twofold, picking up wants and needs, and at the same time learn how everything functions. The research thus stretched beyond the digital space, and to the workplace and the people within it. Something that would also end up being beneficial for when looking at the digital aspects, for example how the system behaves in a busy environment when the phones constantly ring.

The project was user-centered, with the users being involved in the project throughout a user study series consisting of three parts. The users were also involved in the initial requirement gathering, where observation and heuristic evaluation was used. That lead to a questionnaire that was sent to the lab managers for distribution to the personnel. The results from these guided the user study series which started with group interviews, and later also a workshop where the participants got to draw their ideal LIS.

After all the research and user-involved methods, the interview was transcribed, and all the results collected were analyzed using various affinity diagrams. The project then went into a new phase where a design prototype was to be developed and a set of guidelines created. This process consisted of the methods of ideation, sketching, and prototyping. To ensure the prototype's validity, it was later evaluated using a system demo and a SWOT analysis.

4.1.1 User centered design process

The driving force behind product development should go beyond technology and directly involve the real users and their needs and goals. This means to make the most of human skill and judgment by directly involving them in the design [52, p. 327]. This philosophy of design will make sure the system will support rather than constraint the user [52, p. 327]. It is an especially good idea for any project that re-designs a program since there will be a large set of expert users with invaluable insights.

According to Williams, a user-centered design (UCD) process consists of three phases: research, design, and evaluation [70]. The goal here is to involve users effectively at critical stages within a project. Firstly by identifying the users and their needs, then involve them in the designing, and finally by getting their feedback through evaluation. These steps closely resemble the four basic activities of interaction design presented by Pierce, Rogers, and Sharp: establishing requirements, designing alternatives, prototyping, evaluating [52, p. 331]. The notable change here is the addition of an iterative process of designing alternatives, which is simply a broadened view on the second step, design, presented by Williams.

Methods to use to actually achieve a UCD differ from project to project. Research can be for example questionnaires, interviews, or observation. Design can be a workshop or card-sorting. And evaluation can once again be an interview, a focus group, or usability testing. Methods utilized within this project are presented below.

4.1.2 Heuristic evaluation

Heuristic evaluation is a method developed by Rolf Molich and Jakob Nielsen, with the intent to create a method that could assist to identify problems associated with the design of user interfaces. The method is structured around a set of heuristics that helps to evaluate to find issues with a design. The heuristics are a set of agreed-upon best practices within user interface design, or usability “rules of thumbs” [45]. A common set of heuristics are the 10 main ones created by Jakob Neilsen [48]. The method is traditionally done with experts, reducing the need for users. It can also be used as a design tool, where you can, by using the heuristics as a baseline, identify any missing usability elements from a design. This helps the designer to examine a design and to recognize anything that might have been overlooked or missed.

4.1.3 Observation

There is a myriad of methods that could be considered to be under the umbrella term of observation, from direct observation in the field to indirect observation where you track users’ activities [52, p. 263]. What type of observation that is performed is thus determined by the degree of participation. The degree of participation chosen depends on the goals of the exercise as well as the practical and ethical issues that constrain and shape it [52, p. 255]. For all types of observation, the goal is to observe the participant performing their regular task. One method of observation where the researcher tries to stay as neutral as possible is the *fly on the wall* [8] approach. This method simulates being a fly on the wall, that is simply observing and taking notes, without interacting with the participant. Another common approach is to let the participant perform their regular task and explaining their actions using the *talking out loud* method. This approach acknowledges that a researcher is present and making use of it by going complementing the participant’s actions with commentary.

4.1.4 Questionnaire

A common approach for gathering a large set of data is to send out a questionnaire. The method is a survey instrument designed to collect self-reported information from participants [45]. The method collects written information about the participants’ characteristics, thoughts, feelings, perceptions, behaviors, or attitudes [45]. The information is typically collected using digital tools, where participants are sent a survey to fill out at their own discretion, without any constraint of location, making it a very practical method quantitative data accusation, but it can also be used to gain qualitative data as well.

4.1.5 Interviews

Interviews are regularly divided into types based on how structured they are and how much they follow a set of predefined questions. These "conversations with a purpose" [37] can be either held in groups or with one participant at a time [52, p. 233]. What type of structure appropriate is determined by the purpose of the method and at what stage in the lifecycle of the project [52]. The researcher has often decided on a guiding set of topics to be discussed [45], and if the interview is structured, a set of predetermined questions are also defined. The goal of an interview, in contrast to for example a questionnaire, is to gain a deeper understanding of a particular participant. The method involves picking up visual and audible details to paint a more complete picture of a person's opinions. The method also makes it possible to ask follow-up questions to gain a deeper understanding. After the interview is finished, there are multiple ways of analyzing the results, with differing precision. What method is chosen depends on the questions asked. Open-ended questions might be well suited for a summarizing method and structured questions could be ideal for deeper evaluation and comparing. The process of analyzing an interview typically starts by doing a transcription of the recording. This can be done at different levels of detail. Standard verbatim where you lightly edit the transcript to make it easier to read. True verbatim where you capture everything, from filler words to non-verbal communication. Or lastly, intelligent verbatim where the transcript is highly edited to correct grammatical errors or improve sentence structure [33].

4.1.6 Affinity diagram

One method of analyzing data is the affinity diagram. The method is a process of identifying meaningful clusters within data collected during research [45]. The first step of quantitative analysis is to look for patterns [52, p. 291]. These patterns might have already emerged during research, but can also be found or re-confirmed during sorting of the data. 50-100 points of observations can typically be the basis for the analysis [45]. By looking for similarities within data points, themes emerge which in turn create groups. These groups can be seen as research-backed insights that can later be utilized during further research, or during designing.

4.1.7 Workshop

Design workshops can be a great tool to engage the user within the design. By allowing the participants to co-design the product, they feel more invested in the result and are likely to contribute a wealth of insight unattainable from simply asking questions. The method requires the participant to think about the task in a more creative way. Whilst this can be challenging, it can also produce unique ideas.

The workshop can be designed in different ways but starts off by organizing a session with multiple participants at a location that is convenient to all, likely the workplace [45]. They are then presented with materials and one or multiple tasks and are asked to collaborate to design something. The facilitator presents the agenda and the task, this is later followed by group discussions and a plan of expectation. An important aspect of the workshop is to allow the participant an opportunity to present their creation and to gain feedback. It is also common to later present how their insights were used to produce something concrete. When asking a participant to be involved in the design, it is important to show that their effort was helpful and possibly directly impactful.

4.1.8 Prototyping

Having established requirements, the next step is to test whether or not the design decisions have been the right ones. This is where prototyping comes in. A prototype is a way of demonstrating a design and allows stakeholders to explore its suitability [52, p. 386]. A prototype can be of varying complexity and completeness, and different prototypes serve different goals. More hastily created prototypes, or low fidelity prototypes can be rapidly created and tested. High fidelity prototypes on the other hand allow for more in-depth investigation, testing design decisions that are very similar to the intended finished design. These of course takes more time to create and are likely more expensive.

A prototype can in fact be anything from a simple sketch to more or less a final product, and everything in between. The medium is also adaptive and can be something physical like paper, Styrofoam, or wood. But it can also be digital, like for example simple software program.

4.1.9 Sketching

Sketching is a very flexible method that can be utilized early on in the design when ideas simply need to be materialized. But they can also be used later in the design, being very detailed and serving as a prototype. Sketching is simply the process of putting pen to paper and translating an idea into a drawing. Sketching is also a terrific method to do when holding a workshop with a non-designer since it is relatively easy to pick up.

4.1.10 Evaluation

Evaluating research is an important step in the design where real potential users test prototypes, products, or interfaces [45]. The goal of evaluation is to gauge the human perception of a design, determining if what has been created is desirable, useful, and usable. Ideally, this process is done iteratively, with the user testing a design after their feedback has been processed and implemented. There is a balance between having a practically finished design that is expensive to change, but without ambiguity, and one that is less finalized which can easily be changed. The decision should be taken depending on how many iterations are possible. Evaluation should however never be reserved only for the final design since changes will be too expensive and time-consuming [45].

Evaluation becomes critical when dealing with very complex systems where the user's needs can not easily be anticipated. The competence of medical practitioners, or in this case biomedical analysts, will be invaluable when gaining feedback on the design. Their needs are more advanced than that of traditional users of other programs.

4.1.11 SWOT analysis

A SWOT analysis is a way to analyze, for example, a company, based on four distinct characteristics. These four categories are Strengths, weaknesses, opportunities, and threats. The goal of the method is to assess a topic and to discover and overcome weaknesses and threats, whilst also leveraging strengths and opportunities [55]. The method is often done in larger groups where each participant is allowed to present their feedback and then combine it with the findings of the group. Traditionally the results are presented using a cross-shaped grid, to easily observe the different findings between each other.

5
Planning

The following chapter introduces the plan and scope of the project, laid out prior to its start. The few minor alterations throughout will also be presented.

The project was planned to be performed over 22 weeks during the first half of 2021, with an official starting date set as the 18th of January 2021, and finishing date of June 15th. The project was defined as being within the *Interaction design and technologies* master program held at Chalmers University of Technology, Gothenburg, Sweden. The project would mainly be done remotely with weekly supervision from both Sahlgrenska and Chalmers being carried out digitally. But certain activities like the user study and observation would be done on-site.

5.1 Activity plan

In table 5.1, the activity plan for the project is shown, displaying how many hours each activity was planned to take. As can be seen within the table, the project consisted of four different types of activities: academic work, research, expert & user studies, and design work. The activity types mainly follow a linear structure, but importantly, design- and academic work are iterative activities and were thus planned for a longer period. These activities also overlap with other activities like user studies.

The academic work section is comprised of activities for the university, from writing a planning report to the final thesis text. This section also includes smaller tasks like preparing and being an opponent during presentations, as well as holding a presentation. The research section includes work during the early stages of the project, and is aimed at planning everything with the company, Sahlgrenska, and then preparing the material needed for a successful project. This is later followed by structured user studies, both including experts and users. A notable change here is the removal of pilot studies. The time planned for the pilot study was instead used for evaluation, which took longer than expected. The last section is the design work, which includes ideation and prototyping. These activities focus on the final design, an interactive prototype.

Activity	Time requirement (hours)	Implementation period (week)
Academic work		
Planning Report	60	1 → 4
Thesis Report	170	5 → 8, 12→ 22
Opposition	25	21→ 22
Presentation	40	20 → 22
Research		
System Observation	40	1 → 2, 4
Administration	20	1 → 3
Literature study	70	3 → 7
Expert & User studies		
Preperation	75	4 → 11, 14, 18→19
~~Pilot study~~	20	9
Studies	50	10 → 11, 14→15
Evaluation	30	19 → 20
Design work		
Ideation	65	5 → 11, 15
Prototyping	135	12 → 18
Sum:	800	

Figure 5.1: An overview of the activities within the project

5.1.1 User study series

A large part of the thesis was dedicated to a user study series. The series contained three parts, a semi-structured interview, a workshop, and a presentation with evaluation.

5.1.2 Ideation and prototyping

Due to the lengthy user study series, the ideation and prototyping parts of the project were relatively short. Shorter ideation methods were utilized, but no structured iterations were possible in the limited amount of time. Within the final weeks of the project, an interactive prototype was developed as a tool to present the findings visually. Work on the prototype was however developed as part of the preparation for the second user study session, the workshop. Since a part of the workshop was inspirational material and visual aids during the discussion, the material created could be tweaked and reused for the final prototype.

5.1.3 Report and presentation

The master thesis report has been developed throughout most of the project, with the material being gathered and stylized to be presented within the report. The related text has been mainly written in the latter weeks after the methods were executed. The final week prior to the presentation revolved around fixing small details within the report, creating a presentation, and preparing for the opposition.

5.2 Timeline

The following section presents the timeline created for the project and when various activities were planned to be done.

5.2.1 Gantt Schedule

To easily view how the different activities are planned out during the project, a Gantt schema was created. This schema illustrates how different activities are spread out over several weeks and how they overlap. For any week, the schema shows what activities are planned, but does not specify how much time should be given between them. A separate design for the schema was created to estimate approximately how much time each activity should take for a specific week. Two or three activities are approximated for each week, resulting in the 40h being divided between them. A black rectangle is therefore around 13h of work but could be anything from 5 to 30 hours. The schedule was followed quite closely thanks to the milestones pacing the project. But time approximated hours for each box were not followed. Another inaccuracy is the planned completion of the report. To ensure that deadlines for the various milestone gates could be fulfilled, writing on the thesis was mostly relocated further into the project, and written at a higher pace.

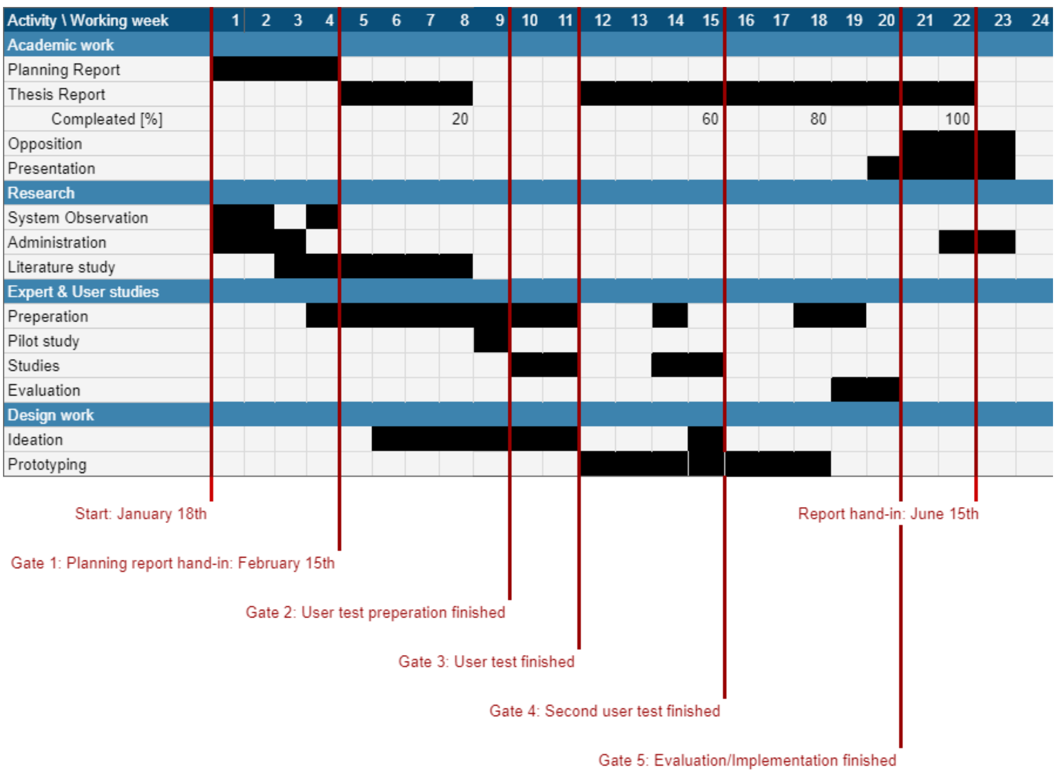


Figure 5.2: Gantt planning schema for the project

5.2.2 Milestone Gates

To pace the project, milestones were created and spread out at different notable events throughout. These milestones are notated as ”Gates”, which emphasizes their function as stopping points in the project. During the gates, the material would be presented to the people involved in that material. These people mainly consisted of supervisors, but could also be developers, examiners, and the department head. If the work presented was approved, the work could continue. The exact completion dates are once again not exactly accurate. Through weekly meetings were planned for the project, having decided upon milestones as well would make it easier to communicate when working from home. Having time dedicated to evaluating how the project progressed, would make it easier to make sure everything functioned as expected and that nothing was overlooked.

Milestones	Day	Completion Date	Working Week	Decision maker
Planning report	Monday	15/02/21	5	
Gate 1	Monday	15/02/21	5	CTH: Examiner & Supervisor
	Friday	12/02/21	4	SU: Supervisor
User test preperation	Thursday	18/03/21	9	
Gate 2	X	X	X	CTH: Supervisor
	Wednesday	17/03/21	9	SU: Supervisor
First user test	Friday	02/04/21	11	
Gate 3	X	X	X	CTH: Supervisor
	Wednesday	07/04/21	12	SU: Supervisor & Department Head
Second user test	Wednesday	21/04/21	15	
Gate 4	X	X	X	CTH: Supervisor
	Wednesday	21/04/21	15	SU: Supervisor
Evaluation & Implementation	Tuesday	01/06/21	20	
Gate 5	X	X	X	CTH: Supervisor
	Wednesday	02/06/21	20	SU: Supervisor & Department Head
Full time presentation	X	X	X	CTH: Examiner & Supervisor
	X	X	X	SU: Supervisor
Report	Tuesday	15/06/21	22	CTH: Examiner & Supervisor
	Wednesday	09/15/21		SU: Supervisor

Figure 5.3: Milestones gates used within the Gantt schema and during the project

5.3 Risk Analysis

A risk analysis has been made, assessing the main factors that could negatively affect the success of the project. The analysis has been made to help anticipate potential risks and their likelihood of occurring in the project. These risks have then been given a rating based on the consequences, which has then been derived into a risk value. Proactive and reactive actions have been set up to be prepared for a negative event happening. A probability value of 1 indicates a low risk and 5 the highest risk (1=probably not going to happen, 5=likely to happen). The same structure has been used for consequence values; 1 means a low consequence and 5 means a high one (1=small inconvenience, 5=potentially delaying the project). The values have been derived by weighted them against each other.

Several project-related risks scored a risk value of ten or more, see whole analysis as Figure 5.4. These have either high consequences, are likely to happen, or both. In any of these cases, the risk needs a comprehensive solution plan if they occur.

As with almost any project that involves the user, finding willing and available participants is a big concern. This issue is likely to delay studies and if done with a low amount of testers, lead to insufficient findings to make any well-established claims. The current laboratory systems have quite a large set of expert users that are ideal testers since they will become users for the new system as well. This makes the biggest hurdle in establishing contact with the right people and deciding when studies can be safely held during a pandemic. The users are vital personnel, and only a few people can leave at a time, or the laboratories can not work normally. This will require substantial planning and should be done as soon as possible. The first step will be to get in contact with department managers, and then allowing them to pick a suitable date. This flexible approach will hopefully result in as many available testers as possible. I also have contact with experts of the system that can help out more regularly.

Three project-related risks are related to working on a large project alone. I will likely face scenarios when my knowledge will not be enough to make good decisions. Involving as many relevant stakeholders as possible and looking through prior research will ensure that personal bias is removed. Asking the right people for assistance, for example, supervisors will also make getting the right knowledge easier. Involving people, having controlled deadlines, and a clear schedule will ensure that work is carried out and unproductiveness is avoided.

Project related risk	Consequence(s)	Probability (1-5)	Consequence (1-5)	Risk value (P*C)	Preventative actions	Reactive actions
Academic supervior is unavilable	Delays	1	2	4	Plan regular weekly meeting times,	Contact examinor/cordniator instead, talk to other students
Produced results are insufficiant	No examination	2	4	8	Clear planning, involve supervisors	Re-plan, salvage what is good and improve
Academic deadlines are missed	Delayed examination	1	5	5	Plan deadlines, schedule	If possible - complement assigment late
Academic information is missed, inadequte, or wrong	Failed tasks	2	3	6	Updates and meetings with academic supervior	Contact examinator or cordinator for additional information
Advisor at company is unavailable	Delays	1	2	4	Plan ahead, scheduled meetings	Try another channel, ask someone else
Results does not meet requirements from the company	Disappointment	1	3	3	Closed-communication, regular meetings/updates, planning report	Re-plan, continue anyway (if no time to fiix)
Disagreements between company and worker	Disappointment	1	4	4	Closed-communication, find research to back up decisions	Talk to third part (academic supervior), comply
Communicative misunderstandings between stakeholders	Requirements are not fulfilled,	1	4	4	Planning, Keeping notes, Continues meetings and updates	Plan in extra meeting, try in-person communication if possible & safe
Lack of available repondents for various studies	Insufficient findings, unable to hold test	3	5	15	Early planning, clear description, choice of method	Change study method, change to a broader user group
Insufficient findings from studies	Unable to make good decisons	2	5	10	Pilot study, clear and meticulous planning	Run another study session, change method, tweek method
Insufficiant relevent litterature	Baseless decisons	3	3	9	Locate large litterature database, focus on similar projects	Ask around for more litterature, look for books in library, ask experts
Travel related issues	Unable to get to hospital	1	2	2	Have backup transportation	Use digital solutions
Pandemic lockdown	Unable to travel	1	2	2	Keep everything cloud stored	Ask personnel at location for help
No in-person communication possible	Misunderstandings, Delays	3	1	3	Plan safe in-person meetings, utalize best online video tools	Change planning, go digital
Insufficient design tools	Delays, repetitive work	1	4	4	Research tools, use familiar tools	Find suitable new tool
Technical issues	Delays, lost work	1	3	3	Back-ups, cloud based, start with best technology	Solve issues, talk to informed people, swap technology
Worker does not posess neccessary competenece	Lacking quality, missing things, time consuming	3	3	9	Find good literature early, planning, talk to experts	Litteratury study, ask experts, practice
Poor decisions due to personal bias	Lacking quality	3	2	6	Involve supervisors, user studies	Critical thinking exercises, proof reading
Unproductiveness	Stress, missed deadlines	3	2	6	Multiple close deadlines, clear plan	Work weekends/evenings
No medical understanding	Misunderstandings	3	1	3	Involve users, research	Talk to experts, reserach
Forced work abcense (medical etc.)	Delays	2	2	4	Work from home, wash hands...	Work pushed, reschedule

Figure 5.4: Risk analysis for the project. (1 = low probability/consequence, 5 = high probability/consequence)

6 Process

The following chapter goes through the process of the project, how the methods presented in the prior section were used.

6.1 Literature study

A short literature study was conducted in the early stages of the project, both to establish a foundation for the work, but also as a part of the planning report. The goal of this study was to establish prior work within the field and to research what methods had been used with success within similar projects. The study consisted of inquiring relevant literature on the subject, then reading through and summarizing its content. Mainly the methodology and results were analyzed. The topics covered concerned LIS, LIMS, academic writing, modern UX design, and user-centered design.

6.2 Observation

As mentioned in the method section, a big part of the project was understanding the digital systems within the laboratory environment at Sahlgrenska. To be able to handle all clinical lab examinations at Sweden's largest hospital, many departments have to effectively operate and collaborate. For any modern hospital, this means that technology becomes a core part of the workflow. This complexity had to be observed first hand, and the programs used had to be inspected at different levels. In the beginning, it was about getting acquainted with the personnel and what they worked with. Then it became a question of understanding the core functionality of the older programs BaktLIS and GMP. The last part before performing user studies was to identify possible areas for improvement, and this meant more in-depth observation using structured methods. All activities together served as improving my understanding of the operation, and to be able to hold user studies collecting background knowledge.

A challenge during this phase of understanding the systems was the fact that I could not have personal access to the systems in use, due to patient discretion. I was allowed to observe when a professional used the system with test-patient data, and I was also able to obtain pictures of the system. Though I had signed an agreement to be allowed to view, but not record or publish, any patient information. I had not undergone the required training to handle the programs on my own. An exception was however MikroLIS since it was still under development and could be separated from the database of up-to-date patient information.

The beginning phase of observation contained a tour of the facilities and basic demos of the programs. The observation was also combined with explanations from different users and administrators. Any difficulties perceived during the observation, or possible issues with the program, were annotated during the observation. The notes later served as the basis for the user study questions. The next step of observation was done by using methods similar to the *fly on the wall* technique [8]. The user operating the program was quietly observed. A slight deviation from the method was however the use of follow-up questions.

6.3 Heuristic evaluation

To identify any issues with both MikroLIS and GMP, a heuristic evaluation was conducted together with a system administrator for GMP. For each area of interest within MikroLIS, a corresponding functionality within GMP was identified. Within the areas of concern, for example, registration, the process was defined. This was then broken down into smaller sub-tasks with a few simple steps to analyze. For each task, the 10 heuristics presented by Nielsen were used for the evaluation [48]. By going through the steps within the task, problematic design elements were uncovered and noted. When repeated problems got highlighted for multiple tasks, some heuristics were skipped. This was done to save time and be able to go through all areas of interest. Similar to the prior observation, these findings were used as the basis for the user study series, specifically what questions to ask.

6.4 User study series

A comprehensive user study series was held during the middle parts of the project, with participants from a majority of the laboratories that plan to use MikroLIS. The series included a semi-structured interview, a design workshop, and an evaluation. All studies were held within the laboratory building at Sahlgrenska.

6.4.1 Gathering participants for the study

Advantageous for the project, the user group for the program is known. Finding participants for the study was therefore as simple as contacting the right people to spread awareness that the study was taking place. To do this, contact information to all the managers for the various laboratory departments were supplied by the supervisor at Sahlgrenska. These department managers had already been informed that the study has taken place. An opportunity to present the study was given during their planned manager meeting. After this session, information regarding the study was forwarded by the managers to their staff, and in some cases directly to people that might be relevant participants. Names and contact information was handed back by the managers.

6.4.2 Interviews

The first session in the user study series was a group interview with three participants. The interview was planned to be semi-structured, with the participants mainly discussing the programs and their opinions of them each other. To ensure that the session would gain a good flow, the responsible coordinator was planned to ask follow-up questions when an interesting topic was presented, practically being a part of the discussion. A flexible booking schedule was used to ensure that the busy laboratory personnel would have a suitable time to partake in the study. Each group picked a date and either a morning slot or a time after lunch. A room was later booked for the decided time.

Some questions were prepared based on the observation and heuristic evaluation, in case the participants felt stuck during the discussion. However, during the first session, it became clear that the planned structure was too loose and would not yield any insights. The participants were not sure of what to discuss, and changes had to be made. The questions prepared became the leading topics for the interviews. Any discussions that arouse around the questions were however allowed and encouraged.

The session was planned to take place within the workplace, within a spacious conference room, or a lecture hall. It was important that the participants felt that they could keep appropriate distance considering the ongoing pandemic. It was also important that the recording of the session would be audible, making seating a concern as well. Masks were worn during the whole session according to hospital guidelines. Each session consisted of three participants, a coordinator and a secretary.

Since the study would collect information both in writing and using audio, it was important to get written consent from all participants. It was also important to provide the necessary information to them, to ensure that they felt comfortable with how their data would be used and stored. A translated version of the consent form used and details surrounding it can be found in Appendix B.

The topics covered during the interview were prior knowledge of MikroLIS and why it is being developed, how the programs are used today, what are the most pressing issues with the programs, and how you learn the programs. For each topic, there was a moderate amount of verity among the questions. The interview was fluent, meaning that depending on how the discussion progressed, the questions got asked in a different order. How much time each topic reserved also changed for each group.

6.4.3 Workshop

Around the halfway mark in the project, the second session in the user study series was planned, a workshop. The session was originally planned to be strictly a discussion of prepared design options. But considering that the first session ended up being quite restrictive, the aim changed and the session turned into a workshop. Instead of simply asking participants, the goal was to gain more insights by involving them in the design process. The workshop was thus decided to instead become a *design thinking workshop* [15]. The idea was to let the participant first define how they wanted their dream system to work and then draw it. The time scheduled for the session was extended, but due to the participants being occupied with very important work, only 1 hour and 30 min could be planned. This meant that the content of the workshop had to be condensed into merely the most important tasks. The important thing had to be skipped, like for example having icebreakers, looking at multiple areas within the design, doing iterations, and further develop their ideas.

Figure 6.1 shows the physical material used during the workshop. Basic equipment like a pen, paper, and eraser had been prepared at each seat, to allow the participants to easily begin the exercise. It also guided them to a suitable placement to be picked up by the audio recording and to keep some semblance of social distancing. The participants were also given two papers with inspiration. These papers can be seen as figure 6.2 and 6.3. This material had been custom made to fit the creation of a LIS system and to easily be understood by non-designer. Using a common language that anyone could understand. One of the pages consisted of commonly used icons that they could copy or view to come up with design ideas.

Other useful tools had also been supplied and placed in reach for all participants. Everything from colored pens and markers, to scissors and glue. These materials were not expected to be massively utilized, but to give the opportunity to possibly create something great.

Figure 6.1: Workshop setup with different types of material prepared

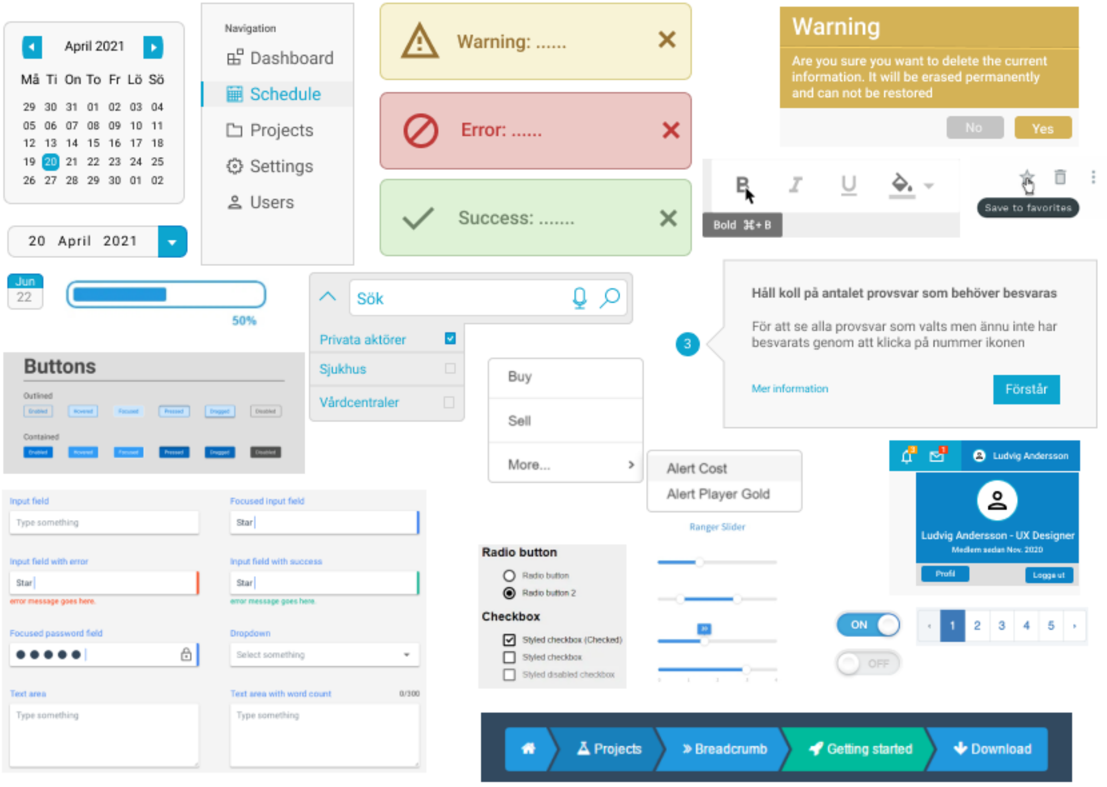


Figure 6.2: Printed inspirational material: Design elements

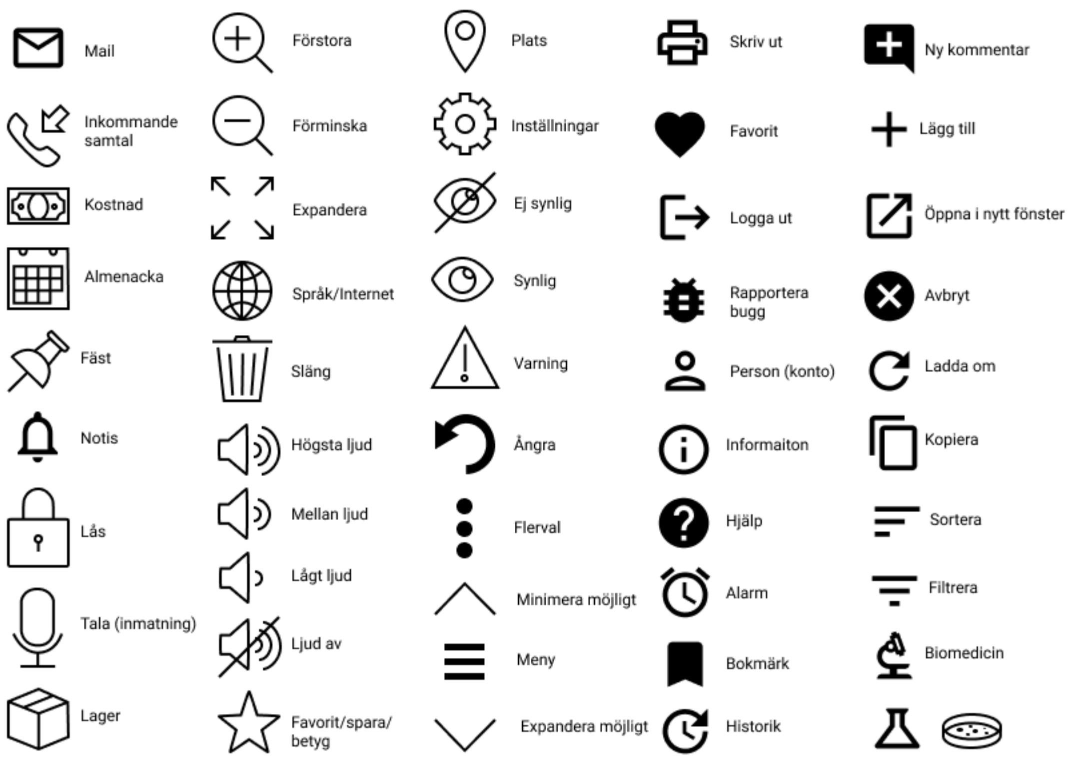


Figure 6.3: Printed inspirational material: Icons

A digital slideshow had also been prepared to introduce the task, clarify any questions they might have, and show digital inspiration. The slideshow pictures can be viewed in Appendix C. The inspiration consisted of pictures showing programs that share commonalities with a LIS. These pictures were strategically chosen to be familiar and to show some particular feature, whilst also being well designed.

Holding a workshop with non-designers can be challenging due to the participants' unfamiliarity with designing. Whilst they often could illustrate their ideas without any issues, there is an inherent barrier to get started. The participants are unsure of where to begin, which often results in them dodging the task in favor of more comfortable alternatives like writing or talking. All the material prepared was aimed to help reduce this feeling of insecurity and to instead make the participants feel up for the challenge. This, combined with assistance and encouragement, was done to help the participants achieve the best results possible based on their abilities. If at any point a participant felt that they needed to simplify the task and instead write words, that was accepted.

Two tools were chosen to define the at hand. The first one was a presentation task, where participants were asked to explain what they need when completing the task of "customer answering". The different things they felt they wanted were written on a whiteboard for everyone to see. This later served as the basis for the drawing part of the workshop. Another tool that was prepared was insight notes. Notes containing different useful insights that had been collected during the interviews were presented in a "how could we do this. . . " structure. This was intended to make the participants recall the feedback they (or other groups) had given during the interviews but structured as an action to design a solution.

The final section of the workshop consisted of the planned discussion over possible design alternatives. Different design options regarding issues like navigation, lists, and tutorials were presented. The participants were asked which optioned they preferred and why. The digital presentation consisting of the discussion topics can be found in Appendix C.

6.4.4 Evaluation

An evaluation of the final prototype was planned as a final step in the user study series. This session was planned to be held late in the project, and feedback was only going to be presented as part of the thesis. This meant that there was no planned iteration of the design based on the feedback given during the evaluation. This decision has some quite problematic repercussions since the only user feedback to affect the design came during the workshop discussions, in the middle of the project. Presenting the final design was thus going to be a big unknown. But to have time to complete the other steps in the user study series, this was a decision that had to be made. To gain some sense of direction whilst designing, continuous feedback was given by the developers. This helped guide the design through various stages of completeness, but could never fully replace direct feedback from the users.

The evaluation itself was a presentation of the developed design, combined with a discussion and SWOT analysis. The participants were also allowed to try the interactivity of the design. But due to the limited possibilities within the prototyping tool, this was not the main focus of the evaluation. The presentation was a live demo of the system combined with explanations for how different things would function. The participants were allowed to ask questions at any point, and a discussion after the demo was encouraged.

One bigger session was planned with all participants present, unlike the workshop and interviews that had been in smaller groups. During the evaluation, the participants were supplied with sticky notes and a paper for the SWOT analysis. The idea was to allow the participants to write their opinions of the design based on the categories. The paper also had written examples on it to make it clear what the categories could consist of. These could later be transferred to the whiteboard for everyone to see their combined thoughts.

Figure 6.4: Material used for the SWOT analysis

6.4.5 Analyzing the user study material

To be able to analyze the large quantity of qualitative data from the user studies, a version of affinity diagramming was used. Whilst a traditional affinity diagram is created by basing the groups on their natural relationship [11], the data analyzed here were gathered using discussion topics. This meant that the data was always going to be focused on specific topics, which naturally became the main candidates for themes in the diagram. The focus of the method was instead to combine and sort the findings from the different groups. The discussion did not always go in the same direction for each group, and thus the findings had to be processed to find relationships. A version of the affinity diagram methods was used after both the interviews and the workshop, these can be seen as figure 6.5 & 6.6.

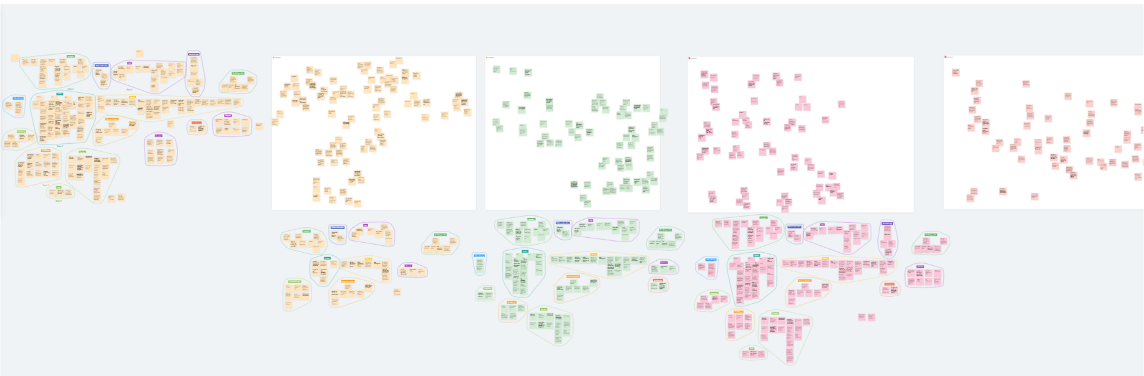


Figure 6.5: Overview of how the affinity diagram was used for analyzing the four different interviews, and how they all combined to one main diagram

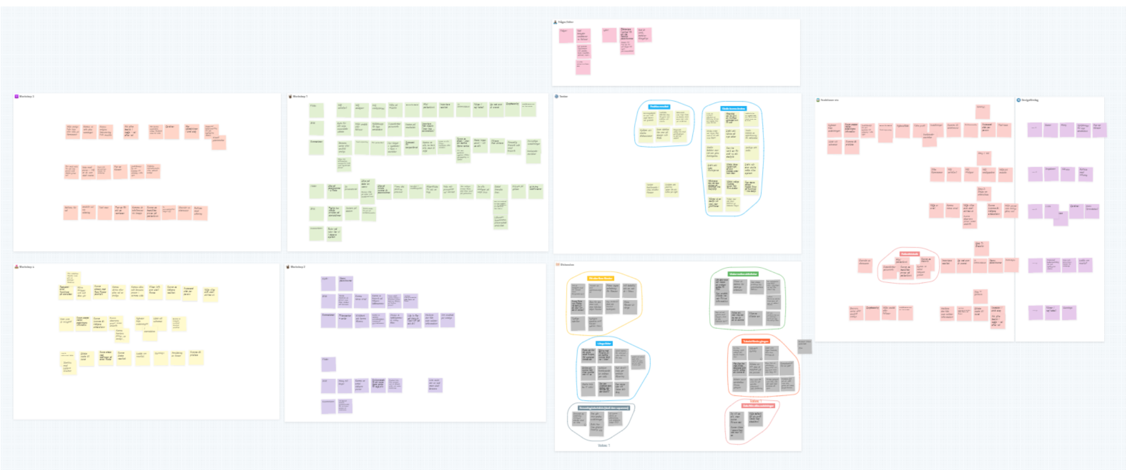


Figure 6.6: Overview of how the affinity diagram was used to analyze the four different workshops, their combined result, and the findings from the discussion points

6.5 Designing

The design process started when the programs were introduced. With every interaction, insights were gathered and stored using either notes or audio recordings. Whenever a possible improvement was observed, its quality was assessed to determine if it was something to develop further. In case the idea had some merit, it was either discussed with the developer team or became a part of the user study. If the idea passed this stage, it became something to consider during ideation. Since there had been ongoing development of MikroLIS for some time, most ideas had been either already implemented or discarded by the developers. This meant that just a few specific ideas were worth pursuing. Despite throwing away most ideas, the ones left could potentially have a significant impact on the design. A very specialized system where each functionality is being used countless times a day, any small improvement could help. As the project is design-focused, and it also being the lacking area within the system, most ideas revolved around changing the program's arrangement and style.

6.5.1 Ideation

The ideation phase, like the design process as a whole, began right away. But the use of methods like sketching, braindumping, and mind-mapping took place quite late in the project. Since such a large emphasis of the project had been placed on understanding the system and its users, ideation took a backseat role. The goal of the project was to mainly identify guidelines, creating something new was not the main goal. Instead, it served as a way to express the findings visually to the developers and to evaluate them with the users. The program had also been partially developed, making these initial ideation methods less useful. There was not a need to radically change the program, but simply improve parts of it.

Sketching was used during the workshop, and naturally, the method was also applied to the final design. Based on all the user study insights and requirements collected, a sketch of the program's appearance was created. This was done quite basic, placing down the necessary functionality and observing what would fit and where. The sketch was moved from pen and paper and instead developed digitally. By going digital, the structure could be refined, whilst still not focusing on things like color.

6.5.2 Prototyping

The first stage of prototyping was developing a color palette. A big request from the developers was to find a way to modernize the design, and the first step to accomplish this is to introduce color. Digging deep into color theory would have been useful, but it quickly becomes a rabbit hole. Instead, the goal was to get the basics right. Some examples included color contrast, what feelings colors express, complementary colors, and keeping it familiar. Color selection methods by G. Gunn [3][2] were used to develop and expand on the color scheme used by Sahlgrenska. This was done to make the program gain an identity, whilst still being familiar as a program within the digital hospital environment.

Two other big topics to look at to make the program feel more modern, apart from changing the structure, were to introduce more icon support and to expand upon the font clarity. The icons used during the workshop had been gathered from various places, but for the prototype, the base icons were chosen from the standardized icons from Google [26]. Some of the icons were however altered to better fit the theme of the page.

The prototype was created using the free online picture editing program Figma [25], which also allows for prototyping. This was done due to its familiarity to me as a designer, but also to allow the design to be intractable. To make sure the navigational aspects of the design were able to be mimicked by the designers, importance was placed on making the prototype navigable. Another advantage of using Figma as a tool is its ability to give cascading style sheets (CSS) information on the design. This makes it easy for any designer to simply copy the style to the actual program, which in this project also uses CSS. Figma also allows for responsive scalability to be created for the design. This was decided, In consultation with the developers, to not an of high importance. It was thus not included in the prototype.

7
Results

The following chapter presents the results from the user study series and how they translated into guidelines and a design prototype.

7.1 Findings during the user studies

The results from the three user study sessions are presented below and how the findings from the first one were carried over and used for the following ones.

7.1.1 Questionnaire

The questionnaire served mainly as a tool to get to know the workers at the laboratories and understand their opinions of the systems as a whole. A small section regarding possible improvements was also done to get additional inspiration going into the interviews with relevant questions.

Who were the participants that answered the questionnaire?

The results indicate that the questionnaire managed to reach a broad range of users of the system. For example, all possible age brackets had at least one participant as a representative, this can be seen as figure 7.1. However, the answers contain no representation from the bacteriology lab. I suspect that the questionnaire was not distributed by the department manager, even after multiple requests for it to be done. This is a large set of users not being shown in the data.

The topic *lab system experience* also covered all possible options. Participants having a lot of experience were represented, but also the users that started with the system within the year. A possible caveat is however that about half the participants had prior experience with a LIS at a different hospital. When cross-referencing prior experience at another hospital with a usage time of Sahlgrenska's LIS, half of the *novices* had worked at another hospital. This reduced the number of users with less than 1 year of LIS experience from 4 to 2. The experience data can be seen in figure 7.3. The users also perceived their computer abilities as quite high, scoring an average of 7.85 on a scale from 1 to 10. This is in line with the hypothesis that the users can handle the program well.

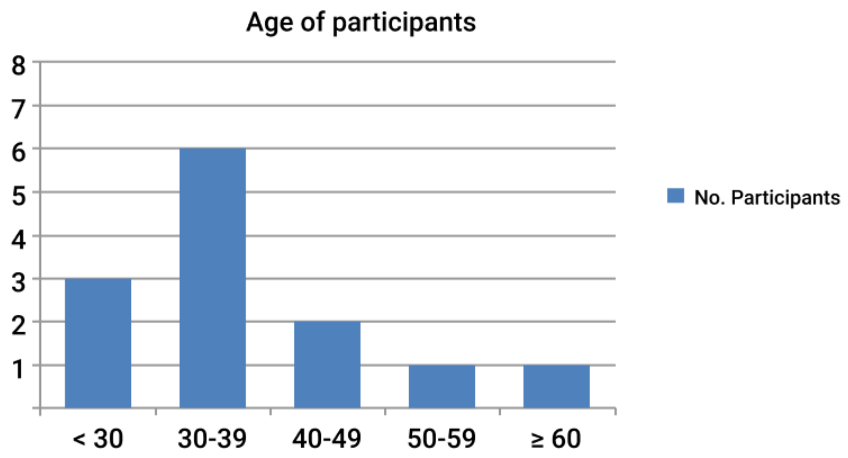


Figure 7.1: The age of the participants - a range from below 30 years to above 60 years old.

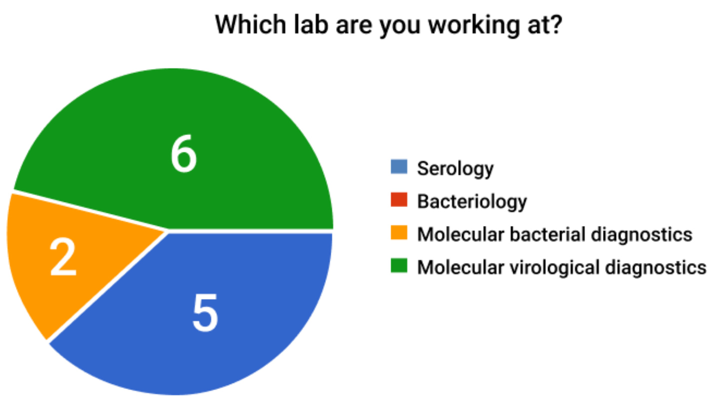


Figure 7.2: The laboratory the participants works at.

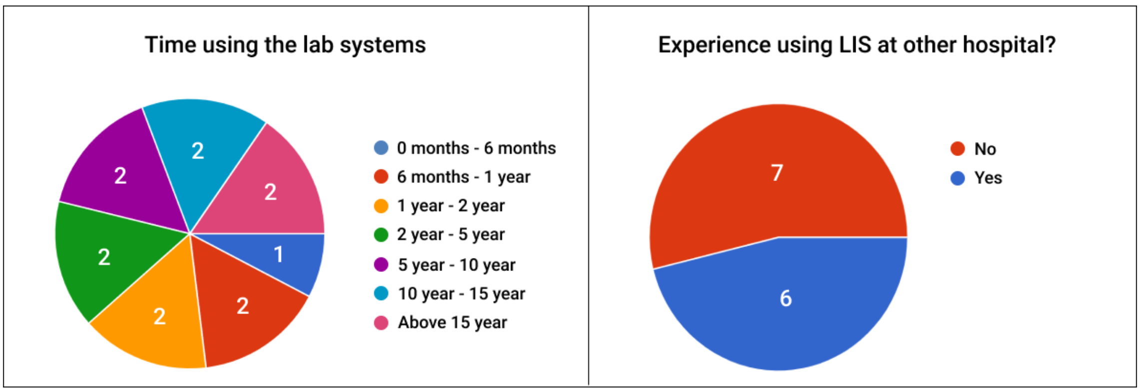


Figure 7.3: How much experience the users had with a LIS.

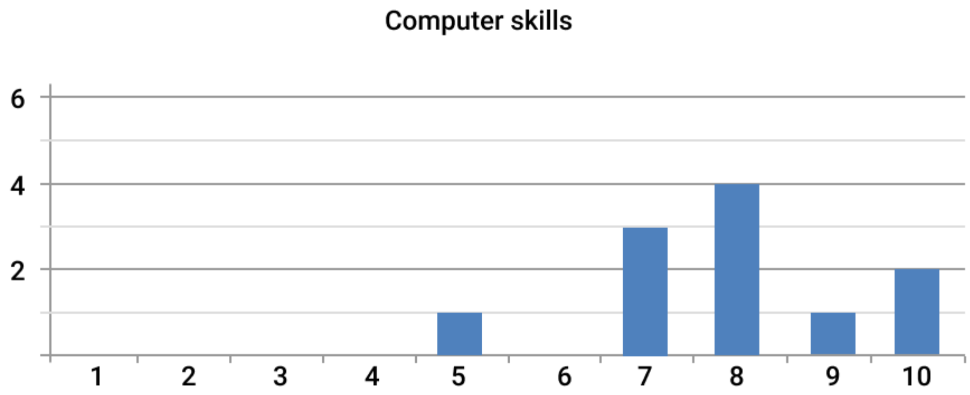


Figure 7.4: How the participants would rank their computer skill.
1 = Novice & 10 = Proficient.

Looking at the specific programs, the participants once again had high experience with each program. Most participants had used two programs, with the most common combinations being MikroLIS and one of the older programs (MikroLIS + GMP or MikroLIS + BaktLIS). This ensured that each program would get enough answers to make an educated guess for the overall opinion of it. The amount of answers too low to make any definitive conclusions, but high enough to at least avoid one or two outliers skewing the result. The results were still analyzed with the knowledge that the sample is low. The usage data can be viewed in figure 7.5.

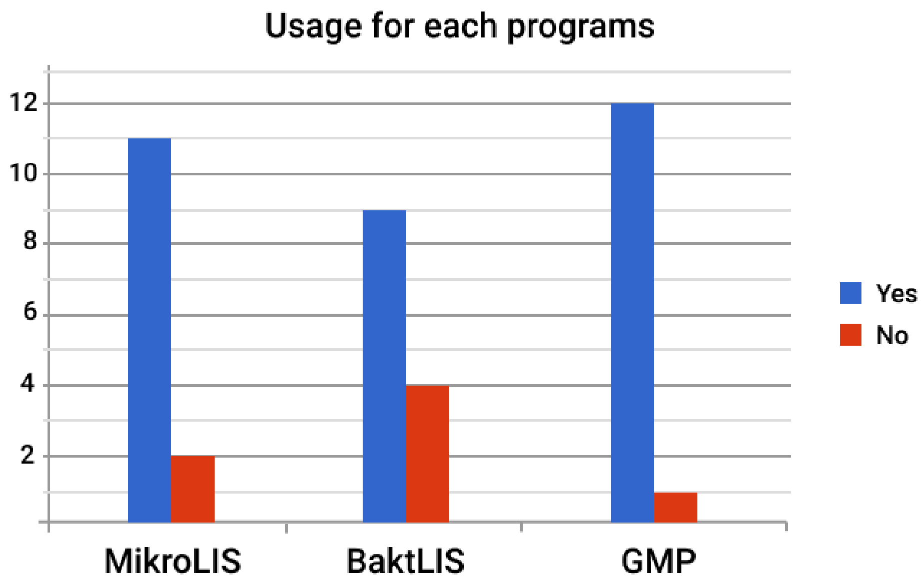


Figure 7.5: How many participants that have used the different programs.

When exploring how well each program is working currently (see figure 7.6), you can see that the users are appreciative of the newly created MikroLIS. It scored slightly higher than GMP and got a much higher score than the not as appreciated BaktLIS.

When looking at reasons for why the participants did not give MikroLIS top score, they refer to the program as occasionally getting slow and that the connection to the old programs stops working. These are some known issues while the programs are being incorporated, and can hopefully be fixed. The two most pressing concerns for MikroLIS were given as *The program is running slowly or freezes - 5 votes* and *Being able to remember buttons and short-commands - 5 Votes*. The second issue is something that directly concerns the user interface and thus became a topic during the interviews.

The reasons for why BaktLIS is considered problematic were given as *Illogical - pressing ESC to save instead of Enter?* and *The program is limiting in its usage*. These topics were once again discussed further during the interviews. GMP, which got a higher score, got many comments saying that the program was slow or buggy, especially under the higher pressure during the pandemic. It was also described as *Frail - a miss-click can cause all answers to be sent out without getting a chance to look at them*. The program being slow due to an increased amount of data is another indication that an improved modernized program is needed. And the frailness issue is possible to solve with a better interface, which makes it a topic to discuss during the interviews.

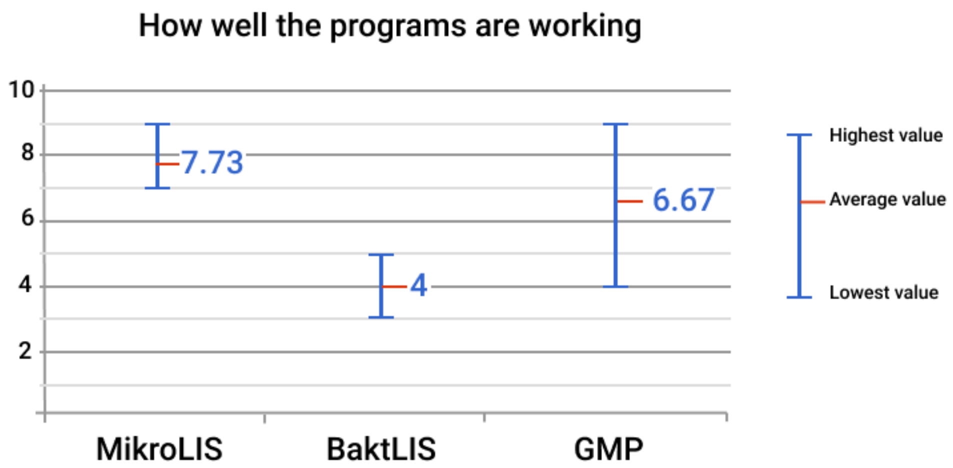


Figure 7.6: How the participants felt that the program is working. 1 = Poorly & 10 = Perfectly

Whether the pandemic had impacted the program's usage in any way was asked for each program. No participant had experienced any increased usage of BaktLIS during the pandemic. Not too surprising given that the illness is caused by a virus. Multiple participants did however confirm that their usage of MikroLIS and GMP has either increased somewhat or increased significantly. This is in line with the cause for the program slowing down. The older systems were not designed to handle the level of usage, and regularly have to index the database to allow more data. Indexing had previously only been done monthly and is now done closer to a weekly basis.

The possible improvements for the different programs, answers to the last question in the survey (can be found in the appendix A), were also used during the interviews as topics to be discussed. The ones mention about MikroLIS were directly addressed within the final design, like *more clearly mark what is acute work to avoid having to go through everything to check* and *use a traditional menu navigational system, it is easier and quicker to find what you are looking for.* The ones mentioned for the older programs were also considered as possible improvements to make to the design. But unfortunately, no intention to fix them within the older programs were made as part of the project, as the focus laid on developing the new system instead.

7.1.2 Interviews

The results of the interview were compiled into themes using the affinity diagram method. As mentioned, these themes share great resemblance with the question topics that served as a foundation for the whole interview. These interview topics were derived from the observation done prior to the study. They also take inspiration from the research conducted on electronic medical records interface designs [74], a comprehensive study in a related area. This does by no means imply that these topics will cover everything problematic with the programs. But it is reasonable to believe that it covers a large section. Importantly, it also helped cover any knowledge gaps experienced up to that point in the project.

A challenge with analyzing data for different programs was keeping track of which program the insights belonged to. When going through the requests for improvements, one might focus on the wrong program and not get the right understanding. To address this issue, the interview started with the participants declaring what program they use. Despite this, in the cases when the participants used multiple programs, some difficulties distinguishing the information occurred. Possible improvements related to a specific program were not sorted into the affinity diagram question categories, but instead got sorted for each program. The notes related to MikroLIS were directly discussed and passed on to the developers, whilst the others were considered when doing the final design, but not investigated further.

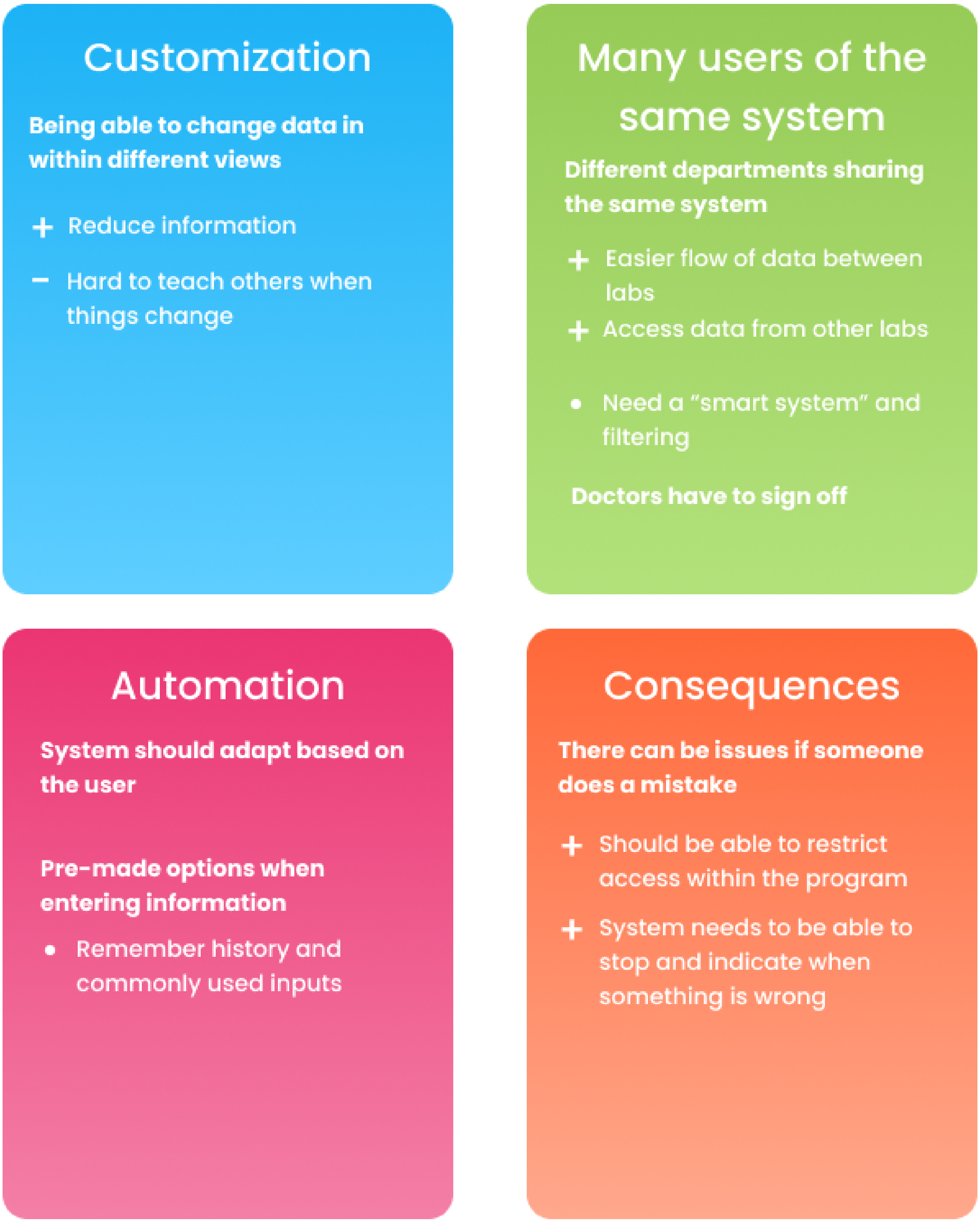


Figure 7.7: First four groups of findings from the interviews

Figure 7.8: Findings group five through eight, from the interviews

Figure 7.9: Final two groups of findings from the interviews

There were as mentioned also a lot of insights that related directly to the specific programs. These vary from comments regarding a user's opinion about a program to specific requests about new features. There were also two larger categories of possible improvements and positives with the different programs. The feedback helped create an understanding of the program and guided the design. Unfortunately, many of the comments were also feature-focused, and out of the scope of the project. These have been presented to the developers for further investigation, but will not be analyzed in depth within this project.

The following are some of the interesting examples for each program:

Problems with MikroLIS

- Still very limited and have to use old programs to solve a complex task
- When you navigate back within registration there is a bug where you lose progress

Problems with GMP

- The program gets slow or stops when there is too much data
- A lot of information could be removed
- Too many buttons, aimlessly clicking things to try and find the right location
- Requires very precise input to work, no leeway
- A very old look

Problems with BaktLIS

- There is no manual and no way to look for help
- Difficult to find wanted statistics
- Have to adapt input to allow it to be searchable later

A combination of possible improvements based on both GMP and BaktLIS

- Fewer prompts, simply skip most out of habit
- Remove unwanted information regarding other labs
- Difficult to follow deep searches into the system
- Add support for combinatory searches (name + customer)

Positives with MikroLIS

- MikroLIS helps with data entry and different hints along the way
- Quick access with short-commands
- The program logs everything that has been done within it
- MikroLIS is easy to learn and get started with

7.1.3 Workshop

A set of insights were gained based on all the information gathered from the interviews, the observation, and the developer presentations. These insights took some of the most important findings (up to that point) and structured them as *calls to action*. By using a "How could we" structure, the participants in the study would feel empowered to find a solution, and not just see it as an issue. The addition of the word "we" creates a feeling of inclusiveness and makes you start to think of the problem as something commonly shared between all users. To make sure that the question was understood the right way, some of them were combined with a short explanatory text why the issue is relevant in the first place.

Insights - structured as questions to improve an interface

1. How can we make history and past choices visible and easy to understand?
2. The program needs to be fast, and therefore uses shortcuts. How can we make these easy to learn or find?
3. It is important to know where you are in the program. How can we make it clear where you are and how to move forward?
4. How can we allow the user to have control over their data? (Filters, sorting, etc.)
5. If you make a mistake, the consequences can be great. How can we reduce the number of permanent errors/correct mistakes?

6. ”The phone is ringing”, how can we design to allow a person to pause their task and navigate to a new place, without losing their progress?
7. It is difficult to understand the program as a new user. How can we make it easier to learn in the beginning?
8. How can we reduce the amount of information on the screen without removing/making it more difficult to access important features?

7.1.4 Evaluation

The results from the evaluation were easily analyzed as they were already sorted. Each participant was asked to give a response within the SWOT categories (strengths/weaknesses/opportunities/threats). This made it easy to see what opportunities to improve the design the users felt most important and which weaknesses had to be addressed right away. A set of *actions* were created based on the feedback.

The six actions created were as follows:

- Change color in the navigation menu to increase contrast and make them easier to look at
- Take a closer look at electrical orders and how to design for them
- Add a notification feature to registration to indicate that a patient has a prior test that is relevant for the current one
- LID number needs to be improved during registration
- Add information during registration related to were a test was initially recorded
- Create examples for customization options

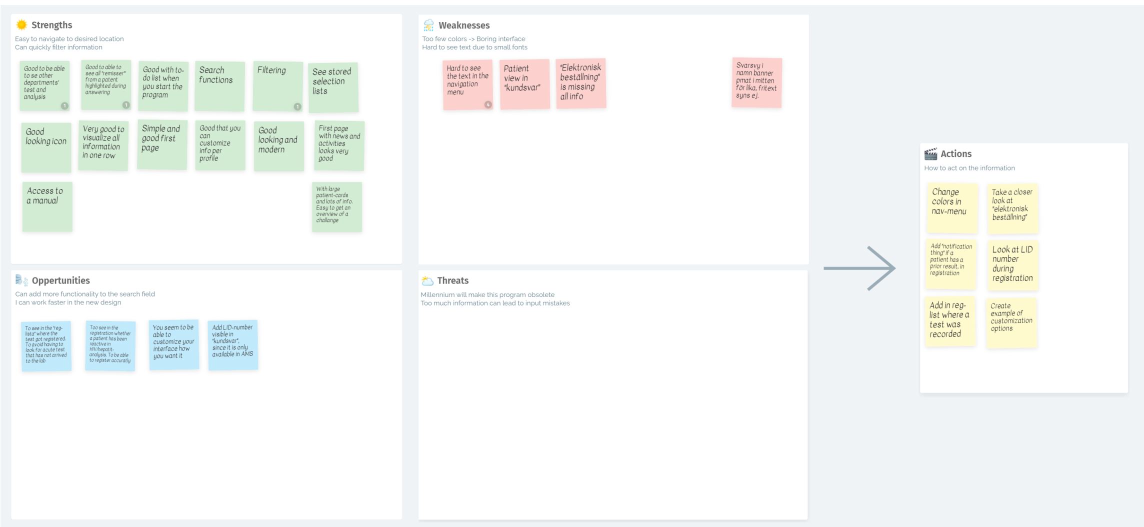


Figure 7.10: Structure used to illustrate the the SWOT analysis digitally

7.2 Guidelines

Applying modern user interface guidelines to any program will most likely improve its quality. The guidelines, in their nature, have been studied and found to be effective for normal programs. There are however often more than one standard that could be followed, and one risks creating confusion by mixing different ones. These standards are also adapting and improving as the computers become better. The best solution is to find one or possibly a few standards and keeping to them as much as possible, whilst being consistent for the whole program. There are of course situations when standards are not the best solution and a designer has to adapt and break the standard. Deviating from what has been studies has to be a contentious decision that is evidence-based. For most programs, the evidence can be on the level of user feedback or results for a usability test. The most important thing is that the choice is not made on a hunch that is likely to be wrong.

The guidelines presented in this section have been conceived through observation of the system, or via consultation with the developers. They have then been investigated within the user study series, tested in the design prototype, and finally analyzed during the last part of the user study series. The guidelines are based on mentioned essentials of interaction design and standards for user interface design. On some occasions, deviations have had to be made, but in most cases, these guidelines are simply a way to highlight what is most significant for laboratory informational systems.

The guidelines presented below are in no specific order.

7.2.1 Creating an efficient program

Laboratory personnel have been observed to rapidly navigate their advanced programs with ease and have shown an ability to find the quickest way to solve their task. They are true experts of their craft, but this means that efficiency becomes of the utmost importance. The users have articulated how any inefficiency is exaggerated by repeating the nature of their tasks. Thus the first guideline is to create a very efficient system where tasks are solved as fast as possible, to the level of counting the number of clicks it takes to complete a task. The appropriate action to take when designing for these guidelines is to closely analyze every step in a task to see if any of them can be automated. If not, create as little manual input as possible by having the system suggests alternatives and auto-complete follow-up sub-tasks.

The experienced users have also been observed to prefer keyboard navigation due to its speed advantage compared to a mouse, as well as ergonomic advantages. Accommodate the design to support rapid keyboard navigation using the standard navigation keys *TAB* or *Enter*, as well as supporting a large set of short commands for the most commonly used functionality. Place input elements in a structure that makes tab navigation easy to predict and that follows a linear structure, one-click after the other.

7.2.2 Easy navigation through the program

The program needs to be easily navigable, another part of the guideline to keep the program efficient. The use of keyboard navigation should once again be supported, both through sub-tasks, but also when swapping between pages in the program. The users of the LIS explained how the mostly stick to one page when working in the program, but that when someone asks a question or they a call, they abruptly have to stop their task to navigate to another place in the system. This rapid swapping creates a need for easy navigation back and forth between the functionality in the program. The guideline also covers easy navigation through large sets of data.

The creation of a tab navigational system similar to a web browser is an attractive solution, but that lacks the necessary security needed for medical work. Creating multiple tabs of the same window, for example, "registration" is not allowed. Tab management is also a concern since a tab should never be closed without completing the task. Thus, a better solution is a layering approach, where programs are "opened" on top of each other, and the others going idle. When a task is closed, the prior one is re-activated and presented again with any stored data. To keep track of the stack, a suggested solution is a restrictive breadcrumbs approach, where you can never navigate back further than a task that needs completing. Also, emphasize using clear titles within the system to make sure any re-opened page is quickly recognizable. Other considerations are scrolling lists instead of slower "page swapping" within the list, the use of a navigational menu, and access to quick searching within the program.

7.2.3 Modernizing the design

Modernizing the design was a big topic that the whole project got structured around. Based on requests from developers and repeated calls from users during the studies, this was certainly a topic to focus on. The system in use is very old, a recurring issue worldwide, in Sweden, and at Sahlgrenska, based on the research done on similar systems. The most obvious issue for the systems at Sahlgrenska is the old computer operative systems the programs run on. The solution for this is the reason for creating a new system in the first place. By moving to modern technology, a large part of the issues are solved. But when porting the program to new updated software, modern design decisions can be made as well.

It was difficult for the users to express why they felt that the design of the older programs looked outdated. They were too adapted to the design to be able to look beyond it. It was described as *ancient* by multiple different participants during the study, but the reasons was simply explained as a feeling. The solution was to give examples of how modern systems usually tackle design decisions, and that way get confirmation of design decisions. The most appreciated ideas were compiled as solutions for this guideline.

To create a more modern feel one should focus on removing smaller windows, reducing clutter on the screen, and utilize modern ways of displaying data (lists, graphs, maps, etc.). There is also aesthetic improvements that can be made like introducing more colors than simply using gray, applying icons and visual indicators, and working with attractive fonts in different sizes. The older programs simply did not allow for this level of detail in the program, something modern programs have no problem doing.

An issue when modernizing a program that has been used for a long time is doing to radical changes. What can be seen as modern solutions in general might be wrong for a large set of users. For example, by changing how a program to simplify learning, a large part of the user base is still required to learn something new. Whilst if the "inferior solution" was chosen, most people could have picked it up right away. That was especially true for this specialized system with lots of experts. Doing a change had to be justified both in terms of it being an improved solution, as well as how long it would take to re-learn. Would it be a sufficient improvement compared to learning time, given that the system has a limited life-span.

7.2.4 Assisted learning

A concern is how long it takes for a new user to learn the program. With a lot of different special-made solutions, it can take time to learn, and it can require experienced personnel to spend a lot of time instructing how to operate it. During the studies, the participants explained how they have lectures teaching the system before they are allowed to operate it. Then you move on to shadowing an experienced user, followed by operating the program alone, but with supervision. Still, after all these steps, the system was hard to understand for experienced users, and mechanics, short commands, and similar were discovered after several years.

To assist learning, one should apply tooltips over suitable UI elements, have access to help functions/texts, create manuals that can be accessed in the program, and create tutorials. By allowing the user different levels of help within the program, they can solve issues on their own, reducing the need for asking others, or in rare cases not solving a task due to lack of understanding. Another important step in assisting learning is to keep the program consistent. By using the same design and solutions for the whole program, it will be easier to pick up new tasks when you have familiarity with something that works similarly. It is also good to use static elements within the program that never change, like buttons to access help. If these are always available in the same location, the user can easily find and use them.

7.2.5 Customization

One of the most requested improvements mentioned on the older programs was filtration, which is here categorized as a way to customize data. Since there is a lot of data within a LIS, it is important to have good ways to filter data in different ways. Whilst you could simply add options to filter freely, a better approach is to create specially made filters that users can pick from. Other ways that one should be allowed to customize is by sorting data within lists and have the program adapt based on who is logged in.

The system is shared among different laboratories that handle different types of patient/test information. By having the data, and the operations one the data, custom based on the title of the person logged in, you save a lot of time. You should be able to access relevant information from other laboratories when needed, but the standard should be simplified by only showing what is most relevant.

7.2.6 Error prevention

Errors within laboratories can cause very severe real-life consequences. The program needs to make sure that any error that can realistically be prevented, should be prevented. Based on the user studies, the personnel is doing very extensive work to make sure no errors happen. The results also indicate that it is working well, with few errors now and then. Thus, preventing errors within the system is more about reducing the checks a user has to do to make sure nothing is wrong. If you can rely on the system to spot errors, you can speed up work and accuracy. This of course has to be balanced so that there is not the opposite effect where the system is relied upon too much, causing mistakes that way.

Some ways to create a design that prevents errors are different levels of the system response to inputted information. The system should give small indications when something went right, and when something seems off. When something seems wrong, the reaction can be to solve it automatically, mark it with a color, use a question to confirm intent or the most drastic reaction to using a modal window with a warning. These options should be used depending on the severity of the mistake. Asking for verification too often, or using too many warnings can have the opposite effect, making the users simply skip by habit. Thus, avoiding disruptions is preferred, with the system finding a solution. The program should be smart enough to find these automatic solutions when it is 100% certain and should realize when the data is strictly impossible, and ask for a change.

Other ways to avoid mistakes are to have clarity of information within the program, use familiar standard practices, and have good color contrast to aid visibility. This makes the design good enough to make sure no mistakes occur, and thus again reducing the need for the program to intervene with warnings.

7.2.7 Access to the right information

Expert users tend to prefer having as much information as possible, crowding the interface with every piece of information that might be useful. This view is not quite right and can cause problems they might not have thought of. More details can lead to less overview and control [60]. Designing a clear overview of the most important information, and allowing easy access to the rest is a better approach. Not fitting everything on one page does not mean that it should not be easily accessible.

Based on the workshop, the users felt that expandable views might be a good solution to the issue of not overcrowding a page. Other solutions that can be useful are close access to a navigational menu, quick navigation using short commands, or adapting the information based on scenarios. With that said, the users of a LIS are experts and can generally still use a program with more information without any problem.

7.3 Comparing the guidelines to similar studies

When comparing the guidelines to similar studies within the area, some similarities can be observed. A review of recent literature regarding electronic medical record (EMR:s) formulated a set of guidelines based on studies made within the topic [74]. Though this is not the same field as a LIS, the findings are still very much related. Note however that some inspiration was taken from the study, and overlaps can be attributed for this reason. An article describing how to design for expert users [60] also share some similarities to the guidelines presented in this thesis.

Authors Zahabi, Kaber, and Manida describe the importance of consistency within an EMR. Ways to address this topic are said to be the use of basic colors and to have a unified form layout. These advises are presented within this thesis as *assisting learning*. The authors also write extensively about how to prevent errors, and similar to the same guideline within this thesis, suggest using color coding, automatic data entry, verification dialogues, and confirmation windows.

Beyond that, there are additional similarities to be found in the areas of efficient interaction, effective information presentation, and customizability/flexibility. Effective interaction concerns the reduction of steps, customization, and short commands. This has been covered in this thesis under the guidelines of *customization* and *easy navigation through the program*. Effective information presentation relates to the use of icons and higher resolution displays to increase efficiency, a topic covered here as *modernizing the design*. Lastly, the topic of customizability/flexibility is about letting the user see the information based on their specific needs. This is very similar to the topics covered in the guideline for *customization*.

J. Søgaard writes how to design for an expert and presents some similarities to the findings within this thesis. She mentions that one should focus on efficiency and speed, to be able to view a large set of information at once and use a keyboard instead of a mouse [60]. These are all topics covered within this thesis.

7.4 The resulting design

Note: The whole prototype uses Swedish as the chosen language. The data within the system is arbitrary and of no importance to the design. It was therefore chosen that a translation would not be necessary. The prototype is also shown in one size (apart from the login page) since the development of re-sizing was planned to be im-

plemented later on and thus not crucial at this stage

Figure 7.11 is the first screen presented to the user when they open the program. The motive is a costume-made vector illustration of the west coast of Sweden where the system will be used. The login page was identified as the main location to create an identity for the program, to make it identifiable from the other systems used at the hospital. Thus it presents a quite extravagant picture as the background. The idea is to allow this picture to be updated over time, giving the program a welcoming feel when the user opens the program. Though this page allows for some more artistic liberties, the main focus is still the function of logging in to the program. Thus, importance was placed on the login feature itself, making it the center of the page. The text has high contrast with the rest of the imagery. The illustration mainly uses color chosen within the palette to make it feel connected to the rest of the views within the program.

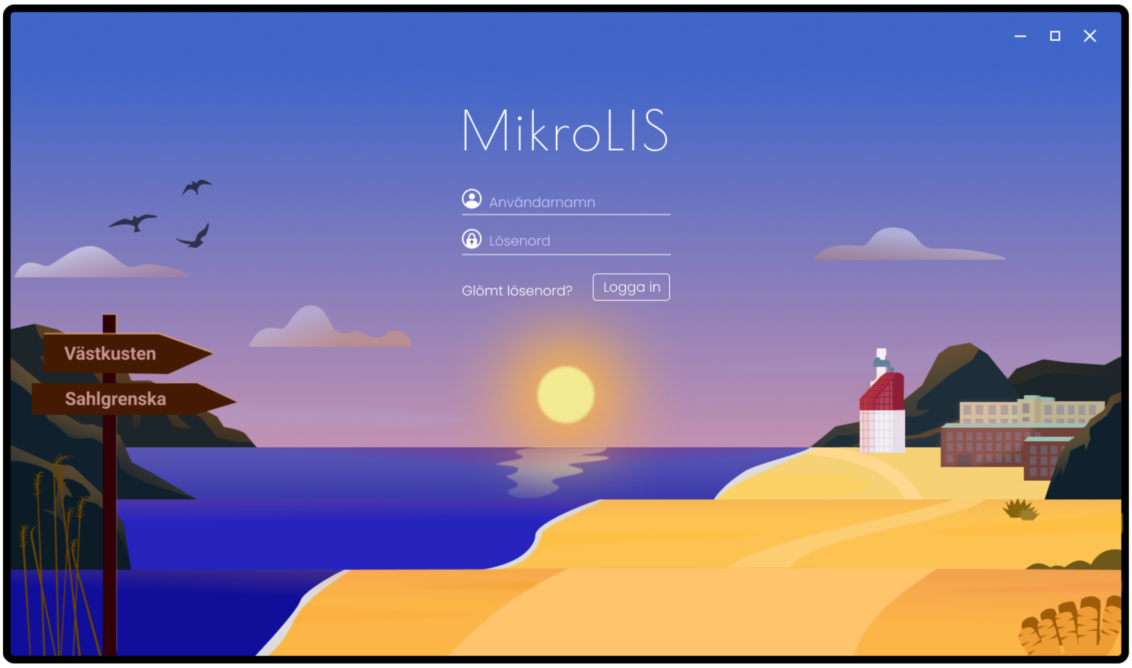


Figure 7.11: Final design - Page 1: Login page

The second page of the prototype is the home page, see figure 7.12. The window has now been maximized to present the prototype as how it is most regularly going to be used. This view was not a main focus of the study but was created to illustrate how to access the three main features of *registrering*, *patientöversikt*, and *besvaring*. The guideline of *Easy navigation through the program* can here be seen as the program uses a navigational menu in the left-hand corner to navigate to any desired location. The user also has quick access to a search field at the top of the view, static for the whole prototype. The search field is intended to allow the user to search for either a location in the program or some sort of data. When for example a registration number is entered, the program will navigate to the desired location where that data is typically used. The user will also have access to a list with tasks to complete. This list will reduce the need to go through the program to search for unfinished work, instead make it quick to see what is not up-to-date and what is time-sensitive to finish.

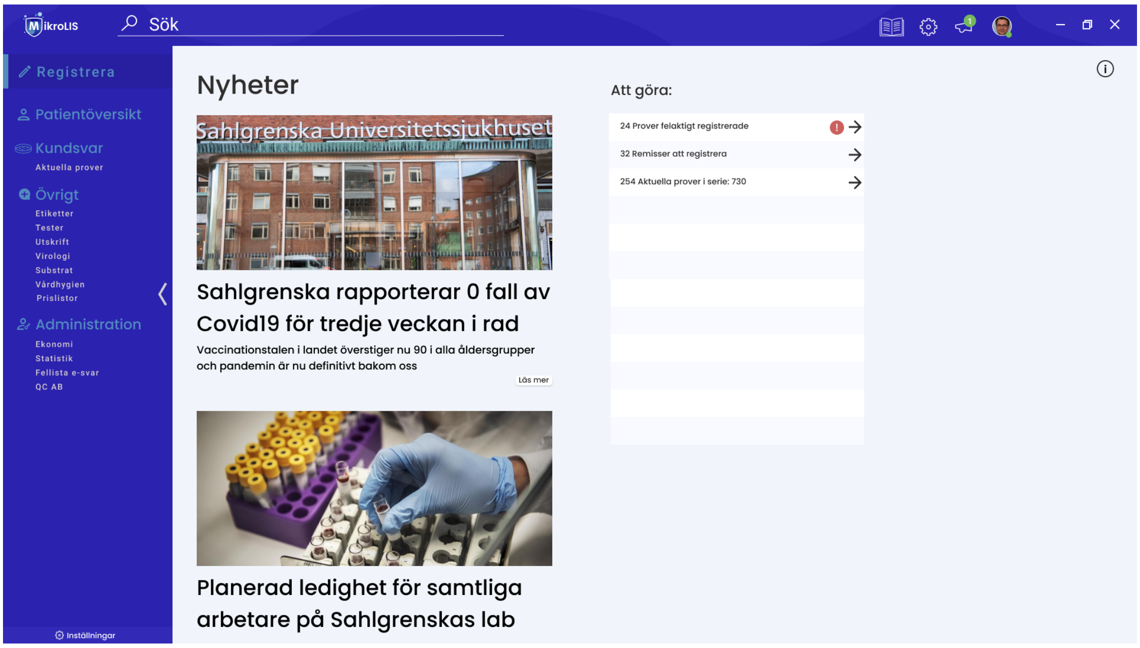


Figure 7.12: Final design - Page 2: Homepage

The third page shows the first main feature studied, *Registrera* (see figure 7.13). This functionality is already in use for many of the laboratories and has been tested and adapted to fit the needs of the user. Thus, the page was evaluated during the user study, instead of looking for a new design altogether. The main focus was instead to make the page fit with the design theme aesthetically. The focus was to create a modernized appearance, in keeping with the guideline *Modernizing the design*. The page has the same static elements of a navigation menu (collapsed to the left) and a navigation bar. The colors chosen are no longer gray and instead follow the chosen color palette. The whole program has been designed as one window instead of multiple smaller ones. The layout of the input fields has not been changed. They already closely match the user's workflow. They have instead been given a new appearance.

There are several ways that the program helps the user, in line with the guideline *Assisted learning*. Firstly, the user can access either a manual or a tutorial using the book icon in the navigation bar. While hovering any element for a short amount of time, a tool-tip is shown to very shortly describe what it is. If the user needs a quick reminder of what for example what should be written in an input field, the button F1 will reveal an explanatory text. All short-commands for a page are revealed in a list when a user clicks the i-icon that is in the top left corner of each view. In case information is not entered correctly, or missed, the system highlights the error and shows an explanatory text. This is covering the guideline *Error prevention*. The view *Registrera* in particular has lots of checks and special solutions to make input quicker and more secure.

The *Registrera* page also introduces the first instance of the customized breadcrumbs feature. Just below the navigation bar, up to the left of the screen, there is the text indicating how the user navigated to the current page. This system shows the program stacking views on top of each other and making the ones below idle. The user can easily navigate to another location in the program, but always have to return and make a decision for the started view below. This ensures that no errors occur but mainly allows for *Easy navigation through the program*, another guideline. This customized breadcrumbs feature is located on all views within the program, making it an important part of moving back and forth at any point.

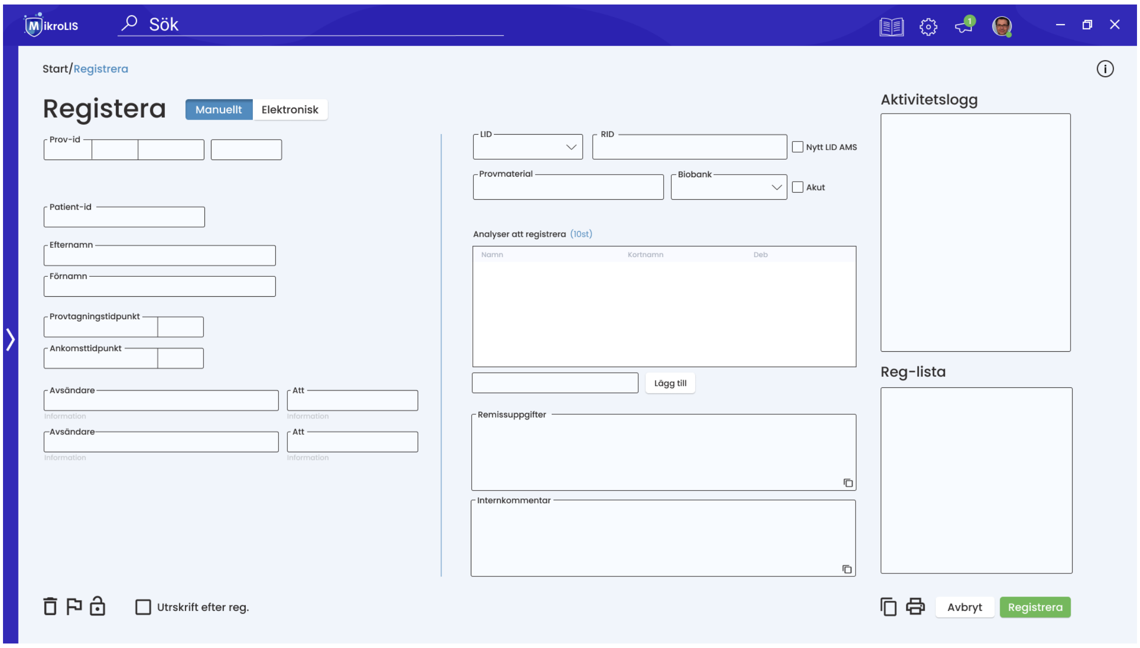


Figure 7.13: Final design - Page 3: *Registrera*

The fourth and firth view in the prototype functions differently but shares many of the same design decisions. The *Patientöversikt*, figure 7.14 shows patient information and prior tests stored in the database for that patient. Whilst *Aktuella prover*, figure 7.15, is where a worker fetches material to work with. The same action is however made from a technical viewpoint. The user is looking up information from the database, gets it presented within a list, and possibly makes a selection from the list.

These two views are all about presenting the right data to the user and making it clear and obvious to interpret. The guidelines *Customization* and *Access to the right information* are closely followed for this view. The views have clear and relevant information presented in rows that are separated by using different colors. Information that is occasionally useful has been collapsed and can be easily expanded when needed. The list has multiple options for sorting or filtering to adapt its content to the user. The user can either select a specific filter from drop-down menus besides the lists or sort it by clicking the title for the columns. The list themselves also only present the right information based on the user who is logged in.

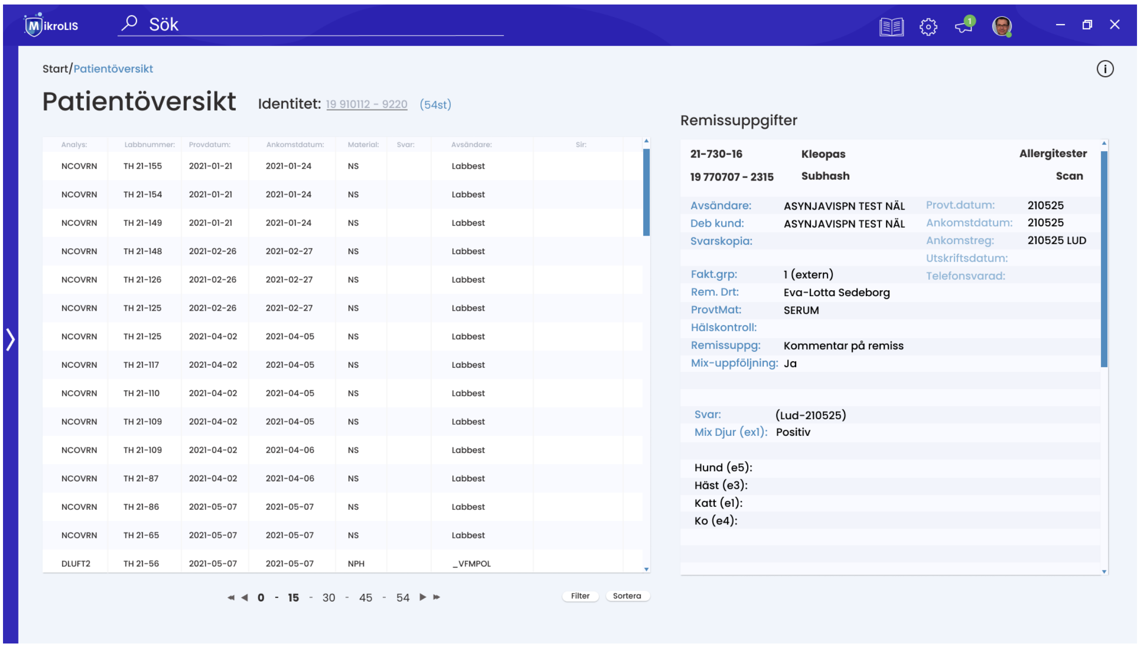


Figure 7.14: Final design - Page 4: Patientöversikt

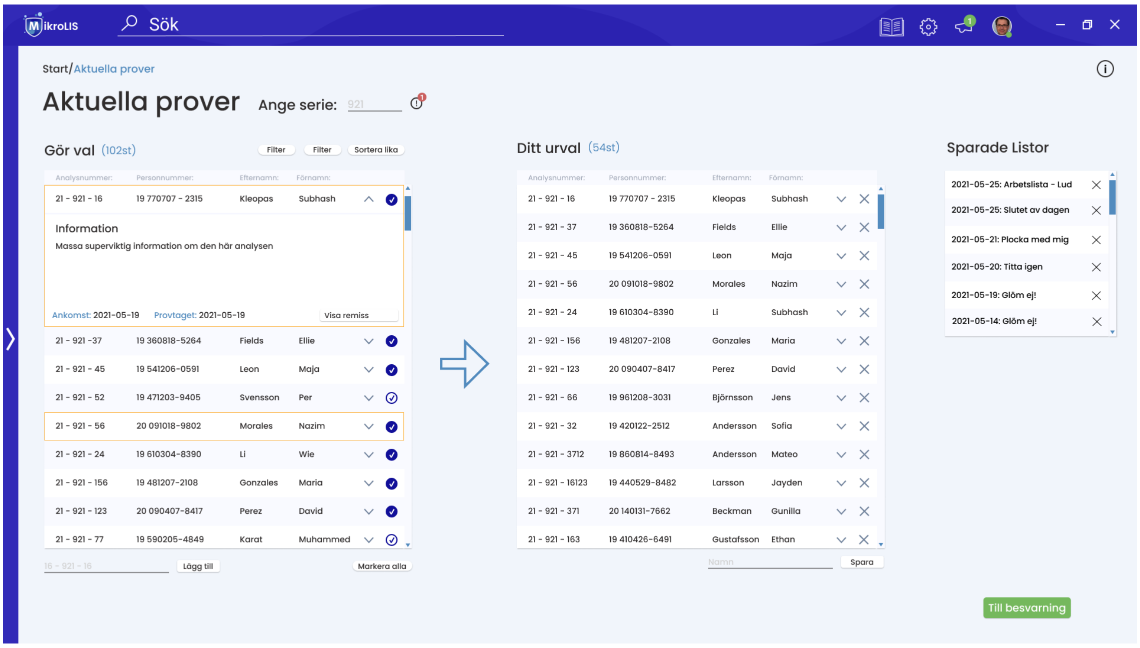


Figure 7.15: Final design - Page 5: Aktuella prover

The last view, *Kundsvar*, is the most advanced within the program (see figure 7.16). Data presented in the view must show various connections and be adapted to the user. The different laboratories have different information that needs to visible in the view, but the program needs to have one structure that works for all. The data presented in the list to the left can change based on the laboratory, with numbers (being analysis series) sometimes being written as letters instead of numbers. The actual results inputted in the view are also very different from user to user. Thus, a measure/result takes the form of a line of data. These can later be opened for closer investigation and allow for data input.

Based on the changing nature of the view, *Customization* and *Access to the right information* are ones again the main guidelines to consider. Though the page also uses different icons and markings to allow simple observation of the data. Examples include the letter icons presented during the period before an answer is transferred to a customer, or when it is sent. A blue rhombus shape indicates that there is something of interest to view. These features follow the suggestions for the guidelineModernizing the design.

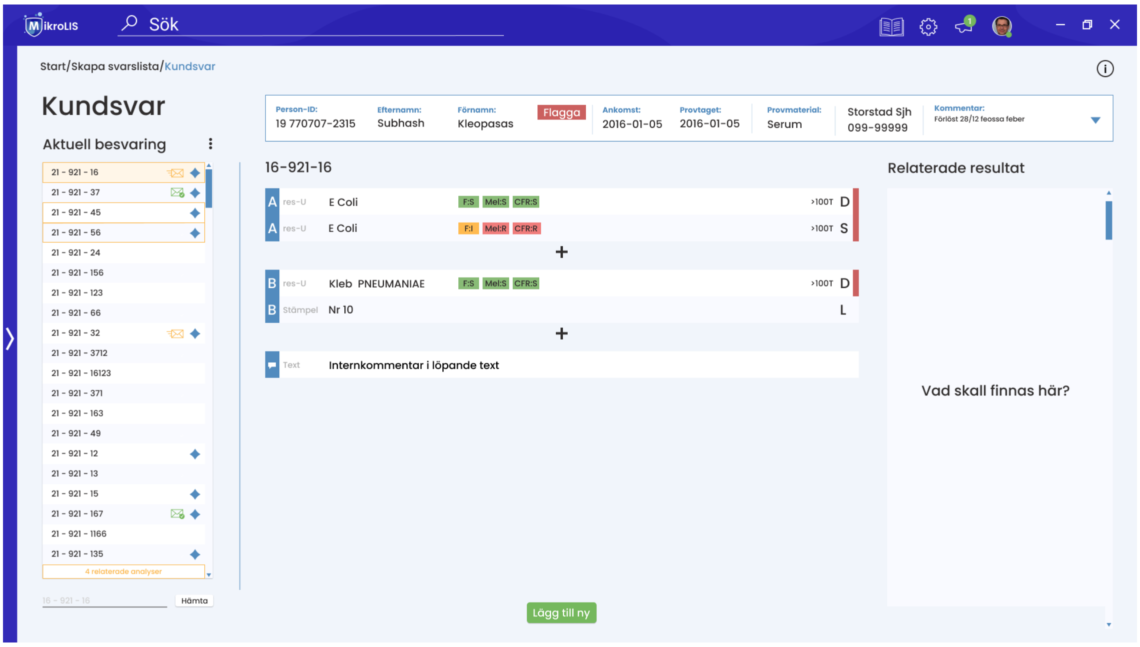


Figure 7.16: Final design - Page 6: Kundsvar

No discussion of the guideline Creating an efficient program has emerged in connection to any UI element within the views. But the program is planned to have full keyboard support, with a well-thought-out path to use TAB to navigate through any window. It will also allow for most of the short-commands used within the older programs, with slight changes to accommodate for possible clashes when the programs are combined.

8
Discussion

The following chapter discusses the project and its results. The chapter also presents possible improvements and future work.

8.1 User study series

The aim of the user study series was twofold, to understand how the personnel and the workplace, and to research how a user interface for a LIS should be designed. It was believed that the initial research conducted through the brief literature study, in combination with the different types of observation methods, would be sufficient to be able to take in the users' feedback. But as it turns out, the task of familiarizing yourself with the system was quite a bit more complex than expected. The observation had given good insights into how the system was being used, but not necessarily covered the fine details of a user's tasks.

Gaps in knowledge were expected to surface during the first user study, it was as mentioned planned to be a session for understanding the program. But the somewhat lacking groundwork made before the first session made it harder to make the best use of the time. Limited understanding of medical terminology, specialized tasks within the programs, and the workplace situation were all expected to emerge. But when the participants in the interview had to stop and explain for example how the environment looked, or basic details of the programs, it felt like the time was poorly spent. It also significantly shortened the time set aside for discussions of the program's design.

A specific oversight was not looking deeper into the older programs, BaktLIS and GMP, beforehand. Observing these programs was problematic due to the need for an authorized user to collaborate. But spending more time and effort into investigating these programs would have been a valuable time investment. The users were very familiar with these programs, and the feedback during the interviews mostly surrounded them. Increased knowledge would have made the user response easier to pick up and could have created more insightful follow-up questions. A time-sensitive project always requires prioritization tasks. But in this case, spending more time on the older programs would have reduced the need for analysis of the interview findings, and would likely have sped up the project as a whole.

8.1.1 Prioritizing the user interface

Articulating that the topic of the project was UX-focused turned out to be a challenge throughout the whole user study series. Some participants might not have been fully been aware of what constitutes UX design, or even what is included in a user interface. Thus, explaining that they should *give feedback relating to the user interface* was quite vague. An attempt was made to explain more in-depth what things were of interest and to actively steer the conversation towards the topic. Still, the conversation often ended up being focused on specific features or functionality. Looking back, this was not a surprise. Even the participants with a clear understanding of the distinctions might have chosen to focus on the functionality of the program, with it being the most critical issue to fix. Functionality is very useful information to understand the users' needs and things to pass on to the developers. Thus, the decision was made to let these types of topics continue. It did however take up a lot of the time during the user study series, particularly the interviews.

Finding a suitable amount level to be involved in the functionality and programming of the program was tough. The older programs required a lot of improvements to functionality, but MikroLIS had already improved many of these issues. Limiting the project and the studies to not involve any of these aspects would be very limiting. Being a part of the development of functionality is a part of the design process, especially within smaller teams. Not understanding the basics of how a feature was planned to be implemented would not have worked. But finding a good threshold of involvement was important to have enough time to create a complete design.

8.2 Guidelines

The guidelines have had inspiration from other authors in the field due to question interviews, which had been inspired by various pieces of literature. This does not reduce the integrity of the study or its findings, but there is important to note any notable influences. The guidelines presented in the thesis are based on responses from participants and it is their feedback that has guided the work. Had the study worked as originally intended, with the participants starting the topics, the results might have been different. Had this alternative path been taken, the results would not necessarily be of higher quality. Due to the hesitation from participants noticed during the interviews, the original structure continued seemingly would have given a worse outcome.

The guidelines are based on the feedback from a small set of users, for one LIS, and at one hospital in Sweden. The participants of the user study series were compared with the participants of the survey and no notable differences could be observed. This sample size was however also quite low and no in depth analyzation of the users of the LIS was done. This means that there is no way to definitely say that the sample was representative of the user base. Based on that the participants were asked to participate in the study, and no random selection was made, the sample could be though to have some biases. One factor to consider is that the users that participated felt confident to give feedback on the system. Thus, users with less experience or ones with low computer ability might have declined. These are important users to consider when designing, which might not be represented.

The design created with the guidelines was only evaluated once, without the users using the system themselves. The program has also not been in operation with any of the recommended changes implemented. It is thus advised that the guidelines are used as a starting point for the development of a LIS, or as a tool to study the topic further. The guidelines are also created for an already experienced set of users. Caution must be taken when applying the recommendations for beginner users. The design is intended to simplify learning of the program but has not been studied in an environment where no users have prior experience. Based on the topic of knowledge gathering, the users indicated that when a problem occurs, they are likely to prefer asking an experienced user as the first way of finding a solution. In case this chain is broken, the system might need even more focus on allowing the users to find solutions within the program itself.

8.3 Design prototype

The design prototype was intended to be a visual aid for the guidelines and a tool to evaluate the findings. It was thus never planned to consist of everything that had been studied. The most important design decisions are presented within the result section chapter of the thesis, but this presents an even more stripped-down version of the prototype. Many of the decisions are either glanced over or not presented at all. The interactions within the prototype presented during the evaluation are also not visible. What was found to be of interest was the direction the design presented for the program as a whole. The three main features presented as the design prototype can be built upon with the same structure. Elements like the static header or the navigation bar will be the same throughout the whole program. Whilst other things like the color scheme or the design of UI elements can be mimicked or adapted for the other views.

Note that the prototype is the first finalized iteration, with slight changes made since the evaluation. This means that it is still subject to change and should only be viewed as a proof of concept.

8.4 Ethics

The following section presents some ethical concerns with the design and the user study series. How these ethical concerns were addressed or prevented is also given.

8.4.1 Data privacy

When digitizing data, user privacy is big ethical concern. The concern is mentioned in the e-health vision from the Swedish authorities [53] and is also in line with general data protection regulations presented by the EU Charter of Fundamental Rights [17]. The project does not directly handle the storage of sensitive information, but has a role in how it is presented. This makes transparency of utmost importance. Any confusion caused by a poorly designed interface, that leads to a mistake, can have severe consequences. Thus, the system is designed extra carefully to make sure no data could be misinterpreted.

Since the program will be used by all the different laboratories, the data will be combined and has to be somewhat restricted. A part of the discussion when creating the design was thus what data the different users will have access to. Only showing the data that is necessary for a worker to complete their task. This makes presenting the right data an important step in the design, and also how to possibly get access to more data when authorized. This issue is presented under the guideline for *customization* and partially within *error prevention*.

The sensitive user data was also a concern when creating the actual design. Whilst I could access data from patients, none of that would ever be presented or used for the design. The prototype was instead filled with made up information that follows the same structure as the actual data.

8.4.2 Creating an accessible design

The study was held within a Swedish hospital that uses Swedish as its official language for its systems. The personnel are expected to know the language, and no further investigation was made into the possibility of translating it into other languages. This is however a big topic for improvement given that it can be created without causing any possible confusion. Translating medical terminology can be tricky, and there is occasionally not a good translation. It would not be acceptable for mistakes to be caused by miscommunication. Further investigation is needed into translating the program into other languages.

Another big topic when making a program inclusive is creating options for a color blind person. The program was designed with colors that are generally appropriate for the most common types of color blindness. The program does however make use of green and red as indicator when, for example, antibiotic resistance. A possible improvement for this would be to make an option to change these colors on a user by user level within personal settings. This would be a quick improvement for anyone with color blindness, whilst still being able to use red and green for the other users.

Other potential improvements that could be made to make the program more inclusive would be to consider how someone with reduced hand/arm mobility could use the program or someone with impaired ability to view text and numbers. This could be either a person with dyslexia or someone elderly that has a hard time seeing smaller text. These topics have been mentioned during development, and requests from users for an option to change the size of the program have been noted. It has not been extensively covered in the user study or the design. But one could imagine that creating a system with larger text for the ones with impaired eyesight and a program fixing typos, would be not too advanced to implement in the future.

8.4.3 Diversity within the user study

Reaching a diverse group of people to partake in study makes for richer feedback. People have different backgrounds and can see problems from various viewpoints, capturing this is thus very helpful. Unfortunately the size of the studies only allowed for smaller groups of people, and getting representatives from the different laboratories was priority number one. Anyone was welcome to partake in the study, but no specific effort was made to get any specific representation from people with specific backgrounds at the labs. The participants were asked to take note of problems any co-workers had during the day, to get an fuller picture. This makes the study a little more in-depth, but is far from an ideal situation.

8.5 Future work

To allow the developers to easily implement the design, continues updates have been given during the whole project. But to ensure that the final prototype is understood during eventual implementation, a explanatory design document will be created. This document will go into depth into details that are lacking explanation, like margin sizes, font types, and the color palette. This will also be combined with an annotated map to show ideas not fully implemented.

Furthermore, a longer user study with a larger set of participants would be advisable. There are aspects like accessibility and diversity that has not been fully studies, along with concepts like adding options to swap language. The prototype has also only been evaluated once. To ensure that it is what is needed, it needs to go through multiple iterations, letting the users test it with different task and with real data.

There are multiple already existing technological solutions that could be applied to further improve the program. The simplest would be to create a tablet version of the program with touch support. The personnel at the laboratories spoke about using paper lists to complete task and then returning to the program after. If the program was portable, this would reduce the need for paper and printing material. This would require the design to be adapted to fit a smaller screen with another type of input. Other suggested solutions to reduce the handling of paper would be scanning. In case the customer does not have digital systems, instead of manually writing the data into the system, the information could be entered using scanning. The simplest solution would be to simply see the scanned version as a picture. But more advanced solutions would allow for the data to be automatically interpreted and entered. This task could require AI to translate the written text when it comes in different formats. AI could possibly also be used to simplify the result handling by finding patterns in the data, though this is a completely different area of study.

9
Conclusion

The following chapter concludes the report by summarizing the project and answering the research question.

The study is the one of the first to examine the user interface of a Laboratory information system. Similar studies have been made on closely related topics such as electronic medical record systems, which has a different user group. These studies share similarities, but the specific topic of UX design within a LIS has largely been neglected. The systems in use are often old and in need of a modernizing, especially amidst ongoing strain due to a pandemic.

The project began with various types of observation. This later guided a user study series consisting of semi-structured interviews, workshops, and an evaluation. The material collected was analyzed and turned into guidelines. Information from the user study series, together with the guidelines, was later used to create a design prototype with limited intractability. Based on the evaluation, the prototype underwent one additional iteration.

Research question: *What guidelines are most important when re-designing a clinical microbiology LIS to effectively operate for different expert laboratory personnel at Sahlgrenska University hospital.*

Seven fundamental guidelines were created based on the information collected from the user study series, meetings with the developers of the program, and a shorter literature study held at Sahlgrenska University hospital.

- Creating an efficient program
- Easy navigation through the program
- Modernizing the design
- Assisted learning
- Customization
- Error-prevention
- Access to the right information

A deeper explanation for each guideline can be found in the result section 7.2.

Bibliography

[1] Tieto (WayBackMachine). *FlexLab*. URL: https://web.archive.org/web/20130113022406/http://www.flexlab.com/index.html (visited on 06/01/2021).

[2] The Futur Academy. *How to Apply a Color Palette to Your Design – Tutorial*. May 2020. URL: https://www.youtube.com/watch?v=eXcKOqviLE0 (visited on 05/19/2021).

[3] The Futur Academy. *Make Hundreds of Color Palettes from 1 COLOR! - Design Tutorial*. Mar. 2020. URL: https://www.youtube.com/watch?v=u5AnzLg1HxY (visited on 05/19/2021).

[4] A. Adelugba. *How the 60-30-10 rule saved the day*. Sept. 2020. URL: https://uxdesign.cc/how-the-60-30-10-rule-saved-the-day-934e1ee3fdd8 (visited on 05/31/2021).

[5] Z. Agharezaei et al. "Compliance with design principles: a case study of a widely used laboratory information system". In: (Dec. 2020). URL: https://pubmed.ncbi.nlm.nih.gov/33355384/ (visited on 06/01/2021).

[6] F. Alanazi. "Evaluating the Usability of the Labor aluating the Usability of the Laboratory Information System y Information System (LIS) in Coombe Hospital and Hail Hospital". In: (Sept. 2015). URL: https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1074&context=scschcomdis (visited on 06/01/2021).

[7] Anthony. *Why Rounded Corners Are Easier on the Eyes*. Aug. 2011. URL: https://uxmovement.com/thinking/why-rounded-corners-are-easier-on-the-eyes/ (visited on 05/31/2021).

[8] HAN - University of Applied Sciences and AUAS - Amsterdam University of Applied Sciences. *Fly on the wall*. URL: https://www.cmdmethods.nl/cards/field/fly-on-the-wall (visited on 05/16/2021).

[9] A. Arhipova. *Knock Design into Shape. Psychology of Shapes*. URL: https://blog.tubikstudio.com/knock-design-into-shape-psychology-of-shapes/ (visited on 05/31/2021).

[10] Color Wheel Artist. *The Ultimate Guide to Understanding Hue, Tint, Tone and Shade*. URL: https://color-wheel-artist.com/hue/ (visited on 05/31/2021).

[11] balancedscorecard.org. *AFFINITY DIAGRAM*. URL: https://balancedscorecard.org/wp-content/uploads/pdfs/affinity.pdf (visited on 05/20/2021).

[12] D. Benyon. *Designing Interactive Systems - Second edition*. Pearson, 2010. ISBN: 978-0-12-370464-1.

[13] R. Bose. *How to use Ben Shneiderman's golden rules in your design*. Feb. 2020. URL: https://medium.com/the-31-5-guy/how-to-use-ben-

schneidermans-golden-rules-in-your-design-c91dda7b176c (visited on 06/02/2021).
[14] J. Brender. *Handbook of Evaluation Methods for Health Informatics.* Elvisor inc., 2006. ISBN: 978-0-08-053345-2.
[15] CareerFoundry. *How To Run A Design Thinking Workshop.* Mar. 2020. URL: https://www.youtube.com/watch?v=A5agx1J9dJQ (visited on 05/17/2021).
[16] Cerner. *Electronic health record - Millennium.* URL: https://www.cerner.com/se/en/solutions/millennium (visited on 06/01/2021).
[17] European Commission. "Charter of Fundamental Rights of the European Union". In: *Official Journal of the European Union* 326 (2012). URL: http://data.europa.eu/eli/treaty/char_2012/oj (visited on 05/29/2021).
[18] A Cooper et al. *About Face: The Essentials of Interaction Design.* John Wiley & Sons, Inc, 2007. ISBN: 978-1-118-76657-6.
[19] R. F. Dam and T. Y. Siang. *5 Stages in the Design Thinking Process.* Feb. 2021. URL: https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process (visited on 06/02/2021).
[20] Datumizer. *HSV color solid cone.* URL: https://commons.wikimedia.org/wiki/File:HSV_color_solid_cone.png (visited on 05/31/2021).
[21] Cambridge Dictionary. *Guideline.* URL: https://dictionary.cambridge.org/dictionary/english/guideline (visited on 06/02/2021).
[22] Cambridge Dictionary. *Heuristic.* URL: https://dictionary.cambridge.org/dictionary/english/heuristic (visited on 06/02/2021).
[23] Cambridge Dictionary. *Pattern.* URL: https://dictionary.cambridge.org/dictionary/english/pattern (visited on 06/02/2021).
[24] R. Doherty. *The 60-30-10 rule – and how to use it to balance a color palette.* Feb. 2021. URL: https://www.homesandgardens.com/news/60-30-10-rule-design (visited on 05/31/2021).
[25] Inc. Figma. Sept. 2016. URL: Figma.com (visited on 05/28/2021).
[26] Google Fonts. *Icons.* URL: https://fonts.google.com/icons (visited on 05/19/2021).
[27] Interaction design foundation. *What is Color Theory?* URL: https://www.interaction-design.org/literature/topics/color-theory (visited on 05/31/2021).
[28] C. Frayling. "Research in Art and Design". In: (1993). URL: https://researchonline.rca.ac.uk/384/3/frayling_research_in_art_and_design_1993.pdf (visited on 06/02/2021).
[29] Västra Götalandsregionen. *Digitaliseringsstrategi.* Nov. 2018. URL: https://alfresco-offentlig.vgregion.se/alfresco/service/vgr/storage/node/content/workspace/SpacesStore/063e46d9-af55-49d2-9fb5-fa65074d25e8/Digitaliseringsstrategi%20Inva%CC%8Anare%20och%20Ha%CC%88lso-%20och%20sjukva%CC%8Ard%201.0.pdf?a=false&guest=true (visited on 05/15/2021).
[30] J.D. Gould and C. Lewis. "Designing for Usability: Key Principles and What Designers Think". In: (1985). URL: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.84.8860&rep=rep1&type=pdf (visited on 06/01/2021).

[31] R. Hartson and P. Pyla. *The UX Book: Process and Guidelines for Ensuring a Quality User Experience*. Morgan Kaufmann, 2012. ISBN: 978-0-12-385241-0.
[32] IDEO. *What is Design Thinking?* URL: https://www.ideou.com/blogs/inspiration/what-is-design-thinking (visited on 06/02/2021).
[33] IndianScribes. *3 Examples of Transcribed Interviews*. Oct. 2018. URL: https://www.indianscribes.com/example-transcript/ (visited on 05/27/2021).
[34] Mordor Interlligence. *LABORATORY INFORMATION SYSTEM MARKET - GROWTH, TRENDS, COVID-19 IMPACT, AND FORECASTS (2021 - 2026)*. URL: https://www.mordorintelligence.com/industry-reports/laboratory-information-system-lis-market (visited on 06/01/2021).
[35] eHealth Ireland. *National Medical Laboratory Information System (MedLIS)*. URL: https://www.ehealthireland.ie/strategic-programmes/national-medical-laboratory-information-system-medlis-/ (visited on 06/01/2021).
[36] P. Kahn and K. Lenk. "Design: principles of typography for user interface design". In: *Interactions* 5 (Nov. 1998), p. 15. DOI: 10.1145/287821.287825.
[37] R. L. Kahn and C. F. Cannell. *The dynamics of interviewing; theory, technique, and cases*. John Wiley & Sons Inc, 1957.
[38] kliniskastudier.se. *Särskilda regler för medicinteknik*
. URL: https://www.kliniskastudier.se/for-dig-som-forskar/kliniska-studier---steg-for-steg/planering/sarskilda-regler/sarskilda-regler-for-medicinteknik.html (visited on 05/16/2021).
[39] T. Koe. *Rounded or Sharp-Corner Buttons?* July 2018. URL: https://uxplanet.org/rounded-or-sharp-corner-buttons-def3977ed7c4 (visited on 05/31/2021).
[40] W. Köhler. *Gestalt Psychology*. 1929.
[41] LabVantage. *LabVantage Medical Suite*. URL: https://www.labvantage.com/pdfs/knowledge-center/brochures/LabVantage_Medical_Suite_Brochure_Mar2021.pdf (visited on 06/01/2021).
[42] J. Larsson. *Lifecare for family and child care*. URL: https://www.tietoevry.com/en/industries/healthcare-and-welfare/welfare/lifecare-for-family-and-child-care/ (visited on 06/01/2021).
[43] V. Lukić. "Laboratory Information System – Where are we Today?" In: (2017). URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6287214/ (visited on 06/02/2021).
[44] Markets and Markets. *National Medical Laboratory Information System (MedLIS)*. June 2019. URL: https://www.marketsandmarkets.com/Market-Reports/laboratory-information-system-market-232312738.html (visited on 06/01/2021).
[45] B. Martin and B. Hanington. *Universal Methods of Design*. Beverly: Rockport Publishers, 2012.
[46] A. Mathews and D. Marc. "Usability Evaluation of Laboratory Information Systems". In: (2017). URL: https://pubmed.ncbi.nlm.nih.gov/29114434/ (visited on 06/01/2021).
[47] Merriam-Webster. *Heuristic*. URL: https://www.merriam-webster.com/dictionary/heuristic (visited on 06/02/2021).

[48] Jakob Nielsen. *10 Usability Heuristics for User Interface Design*. Apr. 1994. URL: https://www.nngroup.com/articles/ten-usability-heuristics/ (visited on 05/16/2021).

[49] D. Norman. *The design of everyday things*. Basic Books, 2013. ISBN: 978-0-465-00394-5.

[50] Software Point. *LABVANTAGE MEDICAL SUITE WEBSITE*. URL: https://softwarepoint.com/labvantage-medical-suite-website (visited on 06/01/2021).

[51] Software Point. *SOFTWARE POINT LEVERERAR LABVANTAGE MEDICAL SUITE TILL REGION SKÅNE*. Mar. 2017. URL: https://softwarepoint.com/news/software-point-levererar-labvantage-medical-suite-till-region-skane (visited on 06/01/2021).

[52] J. Preece, Y. Rogers, and H. Sharp. *Interaction Design: Beyond human-computer interaction*. John Wiley & Sons Inc, 2015.

[53] Sveriges kommuner och regioner. *Vision e-hälsa 2025*. Mar. 2016. URL: https://ehalsa2025.se/wp-content/uploads/2021/02/vision-e-halsa-2025-overenskommelse.pdf (visited on 05/15/2021).

[54] B. Schneiderman. *Designing for Effective Human/Computer Interaction*. Pearson, 1986. ISBN: 9780134380384.

[55] S. Schooley. *SWOT Analysis: What It Is and When to Use It*. June 2019. URL: https://www.businessnewsdaily.com/4245-swot-analysis.html (visited on 05/20/2021).

[56] L. J. Sepulveda and D. S. Young. “The Ideal Laboratory Information System”. In: *Arch Pathol Lab Med* 137 (2013). URL: https://meridian.allenpress.com/aplm/article/137/8/1129/65418/The-Ideal-Laboratory-Information-System (visited on 06/01/2021).

[57] D. Smith. *Finding a Good Colour Palette through Exploration*. Mar. 2016. URL: https://medium.com/@dannysmith/finding-a-good-colour-palette-through-exploration-b90abde88a1c (visited on 05/31/2021).

[58] M. Soegaard. *Recalling Color Theory Keywords: a way to refresh your memories!* URL: https://www.interaction-design.org/literature/article/recalling-color-theory-keywords-a-way-to-refresh-your-memories (visited on 05/31/2021).

[59] Orchard Software. *Orchard Harvest*. URL: https://www.orchardsoft.com/solutions/orchard-harvest/ (visited on 06/01/2021).

[60] J. Søgaard. *Designing for expert users*. URL: http://usablemachine.com/designing-for-expert-users-2/ (visited on 05/27/2021).

[61] O. Stevenson. *What Is Design Theory? The Only Guide You Need*. Feb. 2020. URL: https://www.shillingtoneducation.com/blog/design-theory/ (visited on 06/02/2021).

[62] Sunquest. *Manage Complexity With Molecular Informatics From The Wet Bench To The Dry Lab*. URL: https://www.sunquestinfo.com/ (visited on 06/01/2021).

[63] L. Swanberg and O. Samuelsson. “UX Redesign of Digital Tool in Primary Health Care”. In: (2020). URL: http://lup.lub.lu.se/luur/download?

func=downloadFile&recordOId=9021832&fileOId=9021846 (visited on 06/01/2021).

[64] sysmex. *Laboratory Information System.* URL: https://www.sysmex-europe.com/n/products/solution-provision/laboratory-information-systems.html (visited on 06/01/2021).

[65] Rochester institute of technology. *Tools for Good Desgin: Size.* URL: https://www.cis.rit.edu/htbooks/dtp/elements/size.html (visited on 05/31/2021).

[66] Techopedia. *Color Saturation.* URL: https://www.techopedia.com/definition/1968/color-saturation (visited on 05/31/2021).

[67] TietoEvry. *TietoEVRY och Hyland Healthcare utökar sitt partnerskap för att kunna leverera digitala patologilösningar i världsklass.* July 2020. URL: https://www.tietoevry.com/se/nyhetsrum/alla-nyheter-och-pressmeddelanden/pressmeddelande/2020/07/tietoevry-och-hyland-healthcare-utokar-sitt-partnerskap-for-att-kunna-leverera-digitala-patologilosningar-i-varldsklass/ (visited on 06/01/2021).

[68] Usability.gov. *System Usability Scale (SUS).* URL: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html (visited on 06/02/2021).

[69] WikiDiff. *Pattern vs Guideline - What's the difference?* URL: https://wikidiff.com/guideline/pattern (visited on 06/02/2021).

[70] A. Williams. "User-Centered Design, Activity-Centered Design, and Goal-Directed Design: A Review of Three Methods for Designing Web Applications". In: (2009). URL: https://davidlamas.files.wordpress.com/2010/04/p1-williams.pdf (visited on 05/16/2021).

[71] E. Wong. *Shneiderman's Eight Golden Rules Will Help You Design Better Interfaces.* Sept. 2020. URL: https://www.interaction-design.org/literature/article/shneiderman-s-eight-golden-rules-will-help-you-design-better-interfaces (visited on 06/02/2021).

[72] XINFIN. *LABORATORY INFORMATION SYSTEM.* URL: https://www.xifin.com/products/laboratory-information-system (visited on 06/01/2021).

[73] M. Zahabi, D. B. Kaber, and M. S. Neubert. "Usability and Safety in Electronic Medical Records Interface Design: A Review of Recent Literature and Guideline Formulation". In: *Human Factors The Journal of the Human Factors and Ergonomics Society* 57(5) (Mar. 2015). DOI: 10.1177/0018720815576827. URL: https://www.researchgate.net/publication/274641779_Usability_and_Safety_in_Electronic_Medical_Records_Interface_Design_A_Review_of_Recent_Literature_and_Guideline_Formulation (visited on 06/01/2021).

[74] M. Zahabi, D.B. Kaber, and M. Swangnetr Neubert. "Usability and Safety in Electronic Medical Records Interface Design: A Review of Recent Literature and Guideline Formulation". In: (Mar. 2015). DOI: 10.1177/0018720815576827. URL: https://www.researchgate.net/publication/274641779_Usability_and_Safety_in_Electronic_Medical_Records_Interface_Design_A_Review_of_Recent_Literature_and_Guideline_Formulation (visited on 05/20/2021).

A

Survey - Personnel background & Laboratory system usage

Appendix information:

In order to establish how familiar the laboratory personnel were with the various laboratory systems in use at Sahlgrenska and to determine their perception of each system, a survey was created and sent out via email. The survey was intended to confirm the validity of creating a new design for the laboratory system, create a baseline for where to focus the user study, and to assess whether the selected user study participants where representative of the overall user group for the system. The survey was divided into two larger parts. The first part determined the background of the participants. The second one focused on the three main programs used at Sahlgrenska's laboratories: BaktLIS, GMP & MikroLIS. The second part was thus divided into three smaller parts with identical questions, where participants answered for the system they know or use.

In this appendix, the questions for each part in the survey are presented. The original study was conducted in Swedish and has then been translated into English.

A.1 Questions

The questions sent out to the laboratory personnel using google forms.

A.1.1 Consent

Before starting the survey, a participant was required to agree to their data being used within the dissertation, presented anonymously. By consenting to the given information, the first section of the study was revealed.

Survey - Laboratory system

The study is held as part of a master thesis with the aim of improving the interface of the laboratory system MikroLIS used at Sahlgrenska University Hospital. The laboratory systems MikroLIS, BaktLIS, and GMP will be the basis for the questions and the form will be adapted based on the program(s) used.

All data collected is anonymous and no information regarding identity will be disseminated in any way. The data collected will be generalized and presented in the dissertation as general conclusions. Thus, no information from this form will be presented at the individual level.

The form will take between 5 and 15 minutes to complete and is divided into two larger parts. The first part is about general experiences of the lab systems, and the second part is about opportunities for improvement for the various systems. One section is dedicated to each program. If a system is not familiar, the survey will adapt and skip the subsequent second related.

Requirements to participate in the study:
Experience with any of the following programs: MikroLIS, BaktLIS, GMP.

Participation in the study is completely voluntary and free of charge. It is also possible to terminate participation at any time during the study, or on request afterwards. For more information or questions about the study / project, contact responsible - Ludvig Andersson: Ludvig.Andersson@vgregion.se.

*Compulsory

A.1.2 Background

The first section of the study, establishing relevant background information of the participant. The answers in this section helped create a sense of who got the survey and decided to answer it. It also helped give a sense of who is working at the different laboratories.

Building up a picture of the participant by asking which department a participant works at, their age, and how often they use the various programs gave a limited but useful a view of the person. This information could later be used to build a more accurate understanding when combined with the data obtained from the program sections within the survey. An example would be if an elderly GMP user answered that the text in the program where difficult to see, indicating that one might investigate customized sizes for text within the final design. This example is something that would be easily missed during user studies where younger users with more computer experience participated, since it is not something they necessarily think about.

Section 1: Experience with laboratory systems

The laboratory systems in question are MikroLIS, BaktLIS, GMP at Sahlgrenska.

1. Which department do you work in?
    - Serology
    - Bacteriology
    - Molecular bacterial diagnostics
    - Molecular virological diagnostics
    - Other...
2. How old are you?
    - Below 30 years
    - 30 - 39 years
    - 40 - 49 years
    - 50 - 59 years
    - 60 years and above

3. In general, how would you assess your own computer ability?

	1	2	3	4	5	6	7	8	9	10	
Novice	○	○	○	○	○	○	○	○	○	○	Proficient

4. How long have you been working with Sahlgrenska's laboratory system?
   - 0 months - 6 months
   - 6 months - 1 year
   - 1 year - 2 years
   - 2 years - 5 years
   - 5 years - 10 years
   - 10 years - 15 years
   - More than 15 years

5. Do you have previous experience with laboratory systems at another hospital?
   - Yes
   - No

A.1.3 Confirming experience with system

To be able to correctly adjust the questions presented to the participant based on his/her experience, a simple question prompt was used. The participants were halted before proceeding and were asked whether they have experience with the program in question. This was done before presenting questions for each program. If the answer was entered as ”no”, questions for that program was skipped in the survey. To make sure the participant did not hastily answer the question due to the repetitive look in the survey, the name of each program was highlighted in the text at different locations. Each question in the respective program's section was also asked using the program's name within question to avoid any confusion.

Section 2: Opinions of the laboratory system **MikroLIS**

Note that this section will be specifically about **MikroLIS**. If you do not have previous experience with the program, you will be forwarded to the next section.

1. Do you have experience with the program **MikroLIS**?
    - Yes
    - No

A.1.4 Opinions of the laboratory system(s)

Each program, MikroLIS, GMP, and BaktLIS, were designed with a more or less identical structure. These sections contained questions regarding how often people use the program, their opinions of it, and points of improvement. The choice to create similar questions for each program was purposeful and allowed simple comparisons between the programs. This approach made it possible to see what program people preferred and for what reason. It also made it possible to see if the participants felt that the functionality launched within MikroLIS so far was satisfactory.

The survey was not designed with the intention to make statistical claims. The number of participants ended up far to low. Statistical claims can be useful for finalized systems, but since the survey mainly aimed to focus on MikroLIS, a program in development, these claims would not be helpful. The functionality of the program and its design will radically change, rendering any statistical claims useless after some time. By not focusing on statistical claims, the questions could be designed to be more investigatory, and asked in a way that would give insightful but differing answers. The answers intended for these types of questions would be helpful during the project as guidance for where to investigate further.

Section 2: Opinions of the laboratory system **MikroLIS**

Note that this section and its questions are specifically about the program **MikroLIS**.

1. How often do you use MikroLIS?
    - Majority of the day
    - Multiple times during a day
    - A few times a day
    - A few times a week
    - A few times a month
    - Other...

2. How well do you think MikroLIS works today?

	1	2	3	4	5	6	7	8	9	10	
Poorly	○	○	○	○	○	○	○	○	○	○	Perfectly

3. Do you feel that your usage of MikroLIS has changed during the ongoing pandemic?
    - My usage has increased significantly
    - My usage has increased somewhat
    - No change
    - My usage has decreased slightly
    - My usage has decreased significantly
    - I have stopped using the system
4. How well do you feel that MikroLIS has worked during the pandemic?

	1	2	3	4	5	6	7	8	9	10	
Not worked	○	○	○	○	○	○	○	○	○	○	Worked perfectly

5. If MikroLIS has been perceived as deficient, what is the biggest reason for this? (ex: speed, data handling...)
    - Your answer...
6. Do you have problems with any of the following at MikroLIS?

    Multiple choices allowed - (feel free to add your own option if something is missing)
    - Clearly see text
    - Finding things in the system
    - The program is slow or stops
    - I'm losing where I am located
    - I'm unable to remember what buttons or short-commands do
    - The functionality I need is missing
    - Other...

7. If I encounter problems in MikroLIS, I'll probably do the following:

   Multiple choices allowed - (feel free to add your own option if something is missing)

   - Attempt to solve the issue myself
   - Look for explanations in the program
   - Ask a colleague
   - Ask a manager/supervisor
   - Read a manual
   - Contact tech-support
   - Very rarely or never encounter problems
   - Other...

8. What are the main improvement opportunities with MikroLIS right now?

   Multiple choices allowed - (feel free to add your own option if something is missing)

   - Appearance
   - Understanding
   - Effectivity
   - Speed
   - Functionality
   - Other...

9. Do you have other opinions on the user interface at MikroLIS?

   - Your answer...

B

Consent form for user study series

Appendix information:

The study series was conducted within the hospital with approval from responsible department directors, but getting written consent was still an important step during the study, to ensure that any and all participants felt safe with how their data was being handled and used. The study was conducted on private software used within the hospital, without using any patient information. Thus it was decided that it did not have to comply with the newly set up regulation for medical technology within Sweden and the EU [38]. It was still important to follow the guidelines set up by the EU as part of the General Data Protection Regulation (GDPR). The consent for served as approval for all three user study sessions. The first page presented the study and why it was being done. The second page functioned as written information about the participants rights regarding user information collection and storage. The participants were presented this information both in speech and were given a signed written copy.

MikroLIS user study

Improvement of the interface for Sahlgrenska's laboratory system MikroLIS

Information for participation in user study

The study is done as part of a degree project in interaction design at Chalmers University of Technology in the spring of 2021, in collaboration with MTMIS at Sahlgrenska University Hospital. The project is about evaluation, and proposals of improvements to the user interface for the program MikroLIS. The project's method is to involve the program's users and let their opinions guide the development. As MikroLIS will replace the older systems BaktLIS and GMP, these programs will also be part of the study. The project will focus on the main features of registration, patient data and customer responses. This will thus also be the focus of the study.

The study is divided into three sessions, a semi-structured interview, a workshop, and an evaluation. Each session will be conducted in groups of three research participants, a responsible coordinator / researcher, and a secretary. The sessions will be approximately 45 minutes long and will be recorded for documentation within the project.

The first session is a semi-structural group interview. Participants will have access to the programs they usually work with (MikroLIS, BaktLIS & GMP) to be able to point and display during the interview (When the system handles patient information, for privacy reasons, screen will not be visible during recording). Predefined questions will be asked to then lead to a general discussion about opportunities for improvement and wishes for the program's user interface.

The second session is a workshop where the same groups will get to take part in different design proposals that have been developed based on previous responses, opinions from developers, and conventions in interaction design. It will be an opportunity to discuss the pros and cons of the different solutions, combine different suggestions, and select favorites.

The third and final session will be an evaluation of the final design developed for MikroLIS. This will be a prototype, a design proposal with limited interactivity. Participants will be given time to study what has been developed and then let each one ask questions and give criticism. This response will then be the basis for a discussion in the final report.

As experience of MikroLIS is not a requirement for participating in the study, questions will be adapted to the group's knowledge. The second and third opportunity of the study is specifically about MikroLIS and the survey will then be adapted with questions that can be answered by a user who is classified as a beginner.

CHALMERS UNIVERSITY OF TECHNOLOGY

VÄSTRA GÖTALANDSREGIONEN Sahlgrenska Universitetssjukhuset

Ludvig Andersson - Ludvig.Andersson@vgregion.se
Interaction design - Chalmers University of Technology - Sahlgrenska University Hospital

MikroLIS user study

Improvement of the interface for Sahlgrenska's laboratory system MikroLIS

Consent for participation in user study

- I have had reason and purpose for the study explained to me and had the opportunity to receive the same information in written format. I have also had the opportunity to ask questions about the study.
- I acknowledge that even if I participate now, I can withdraw from the study at any time or refrain from answering questions without any consequences. I also have the right to recall all personal information within two weeks after completing the study and thus have all data deleted.
- I understand that my participation involves giving personal opinions about the computer program MikroLIS and (if applicable) related programs BaktLIS & GMP. I will give my own honest opinions without direct influence from another person or company.
- I accept that my interview will be recorded for revocation within the project, but that no recording will be published. I also agree that my data will be stored in a private storage location (google drive) until the related report is completed and approved.
- I understand that excerpts from the interview or other parts of the study can be quoted under hidden identity in the final report.
- I understand that all information I provide in the study will be treated confidentially.
- I understand that on all occasions when results from the study are published, my identity will be anonymous. My name or other possible attributes will be hidden, as well as the people I may be referring to.
- I understand that I am entitled to access the information I have provided by contacting the person responsible for the study, Ludvig Andersson.
- I understand that I am free to contact the person responsible for the study for clarification or additional information related to the study.

Research participant

Signature of research particpants ____________________ Date ____________________

Responsible researcher

Signature of responsible researcher ____________________ Date ____________________

Ludvig Andersson - Ludvig.Andersson@vgregion.se
Interaction design - Chalmers University of Technology - Sahlgrenska University Hospital

C

Workshop - Slideshow

Appendix information:

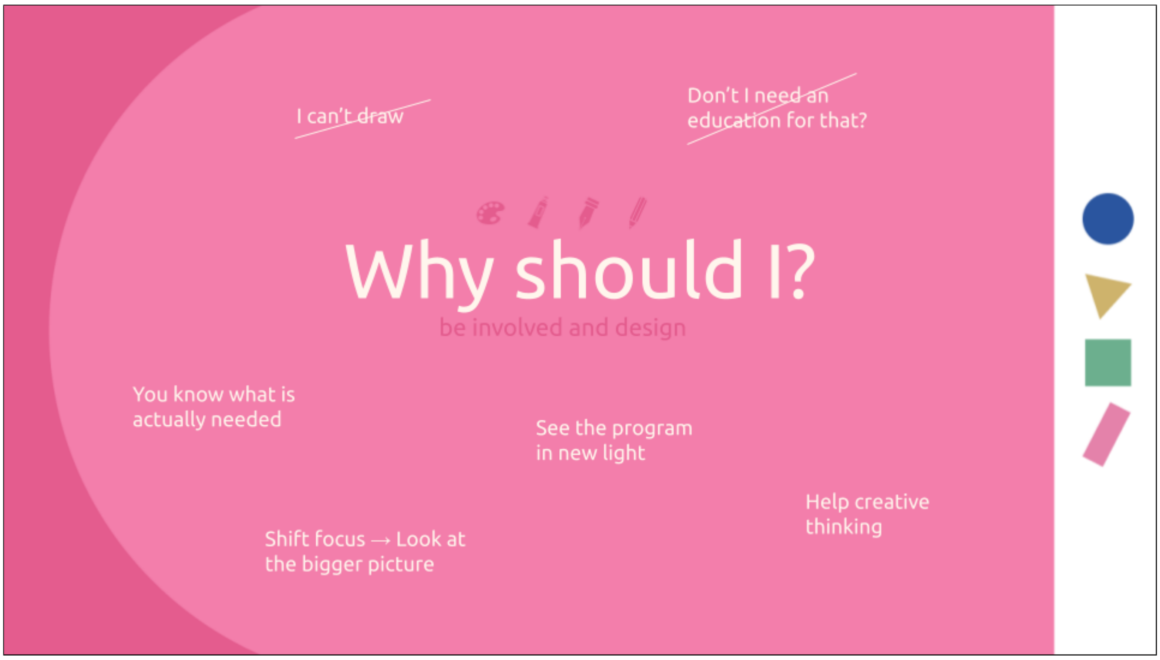
The following appendix presents the slides used to present the content of the workshop. These slides have been created with the intent to quickly and accurately present information during a workshop with limited time. They are also designed in a way to inspire creativity and at the same time reduce stress and pressure associated with doing a unfamiliar task. The user group that participated in the workshop had no prior design experience, and making them feel comfortable was upmost importance get useful sketches during the workshop. All groups either mentioned that they believe themselves to be bad at design, or indicated it using their body language. That is why reinforcement in the form of visuals and encouragements were crucial.

The slides are written using simple and sometimes informal language. The design is intended to be fun and playful, using lots of simple shapes and colors. Everything to make the task at hand seem less serious.

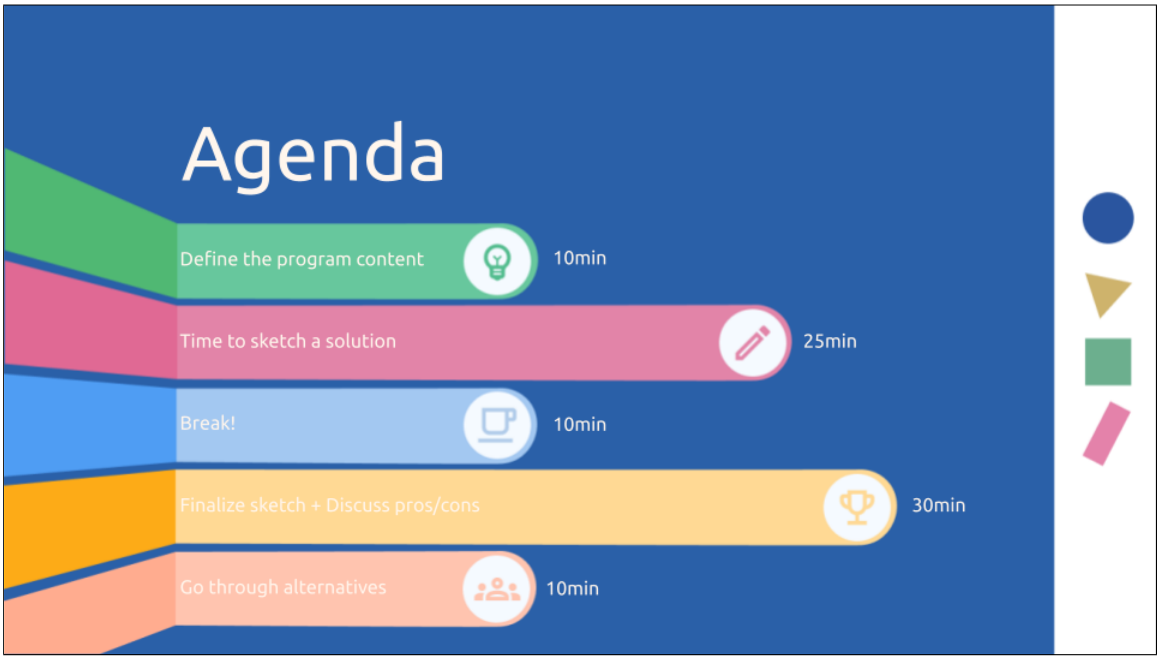
C.1 Introduction

Slide 1: Introductory slide

Slide 2: Introducing session specific motive



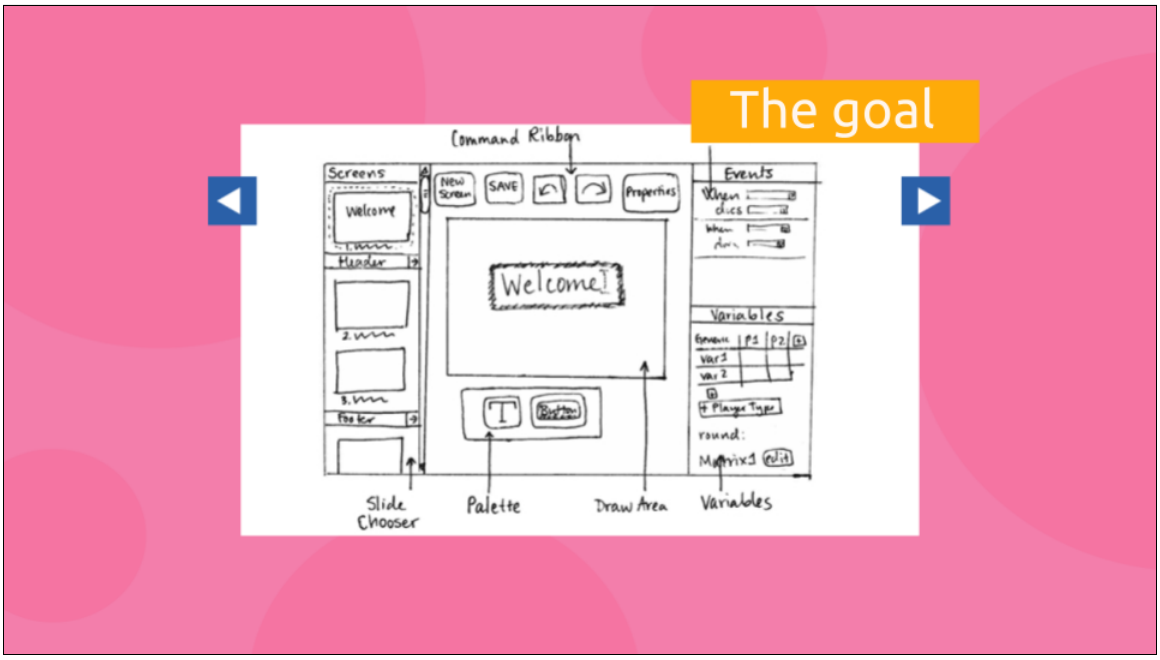
Slide 3: Info & Answering possible concerns

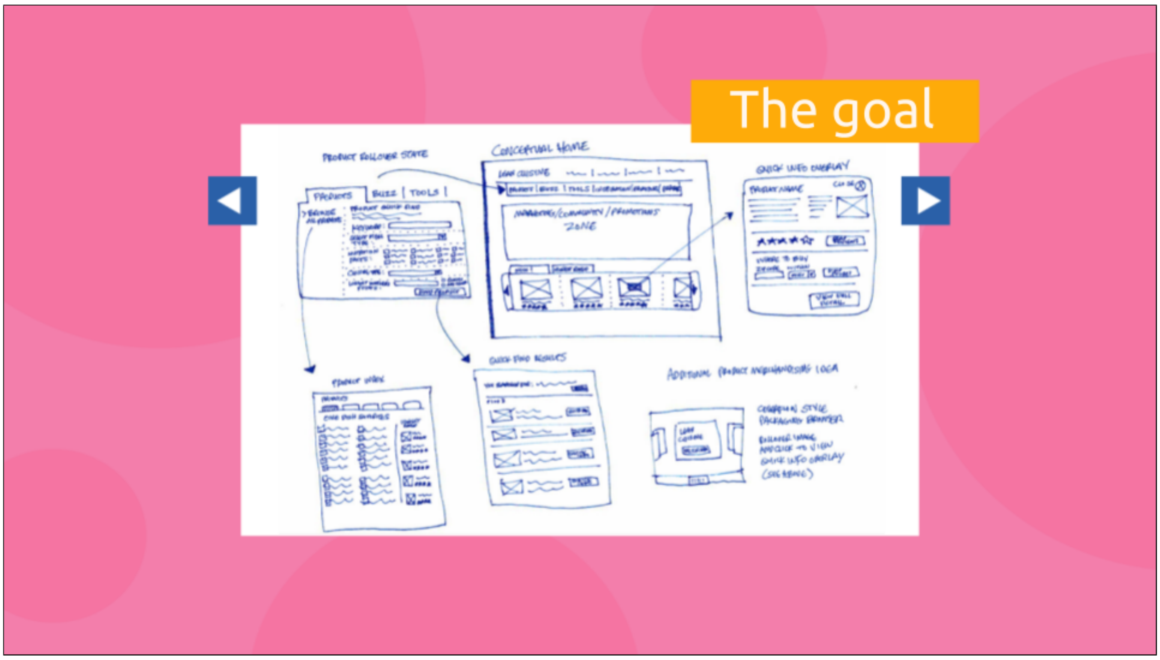


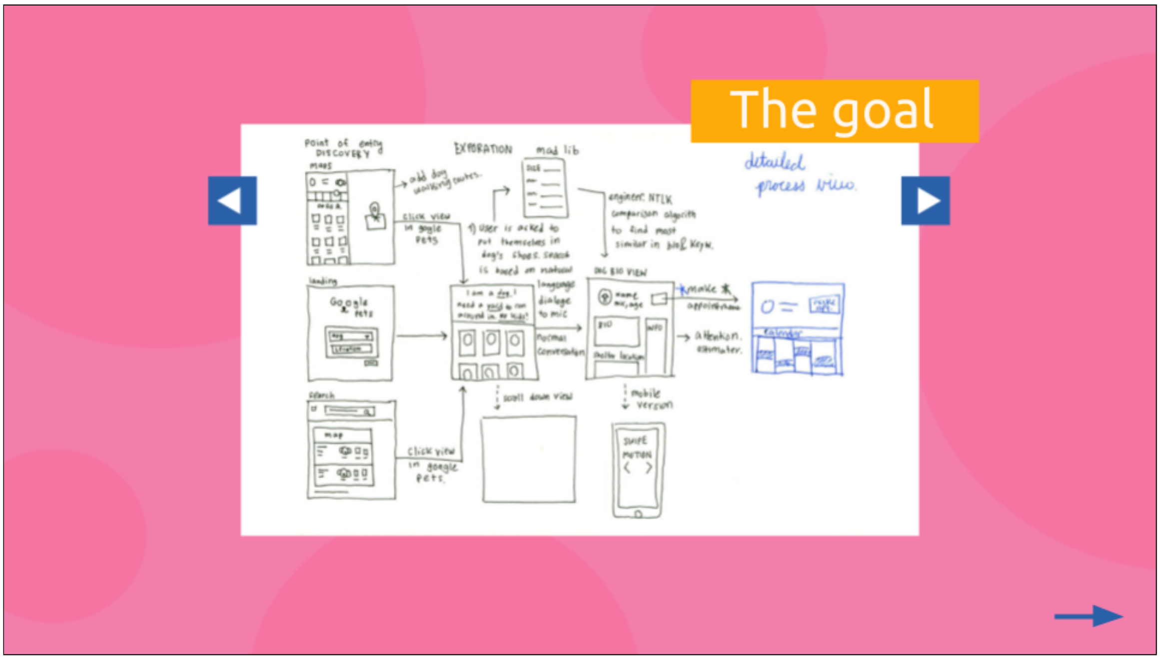
Slide 4: Agenda for the workshop, containing activities and allocated time

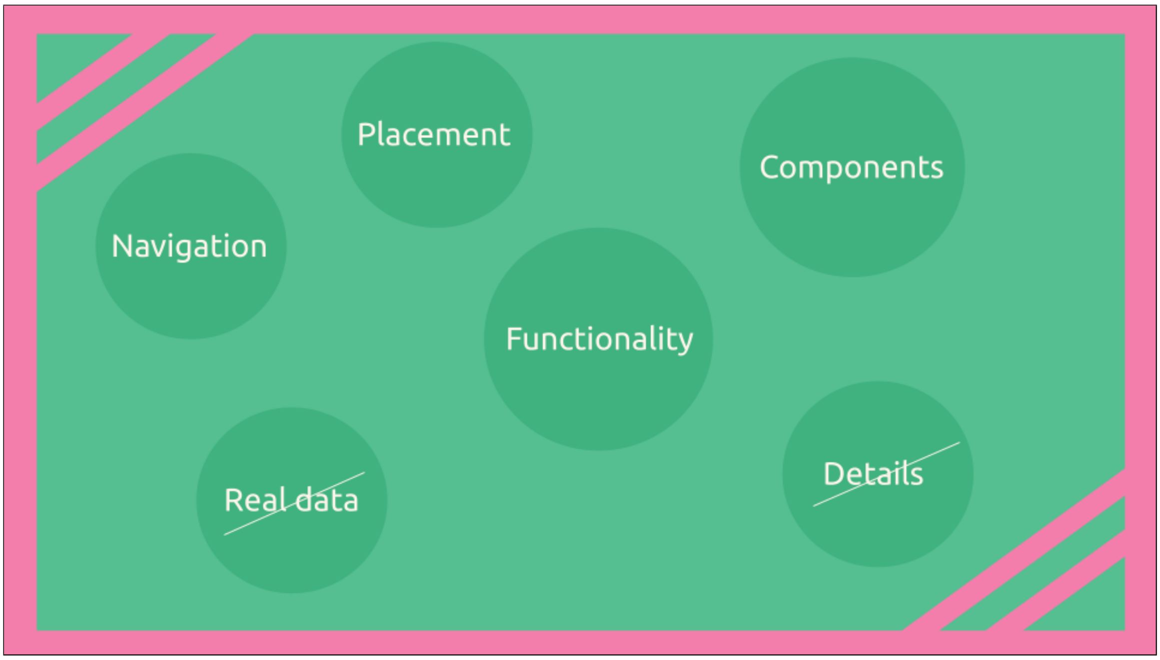
C.2 Scope

Pictures with examples for how their drawings might look. Highlighting aspects like color, annotation, and details level.

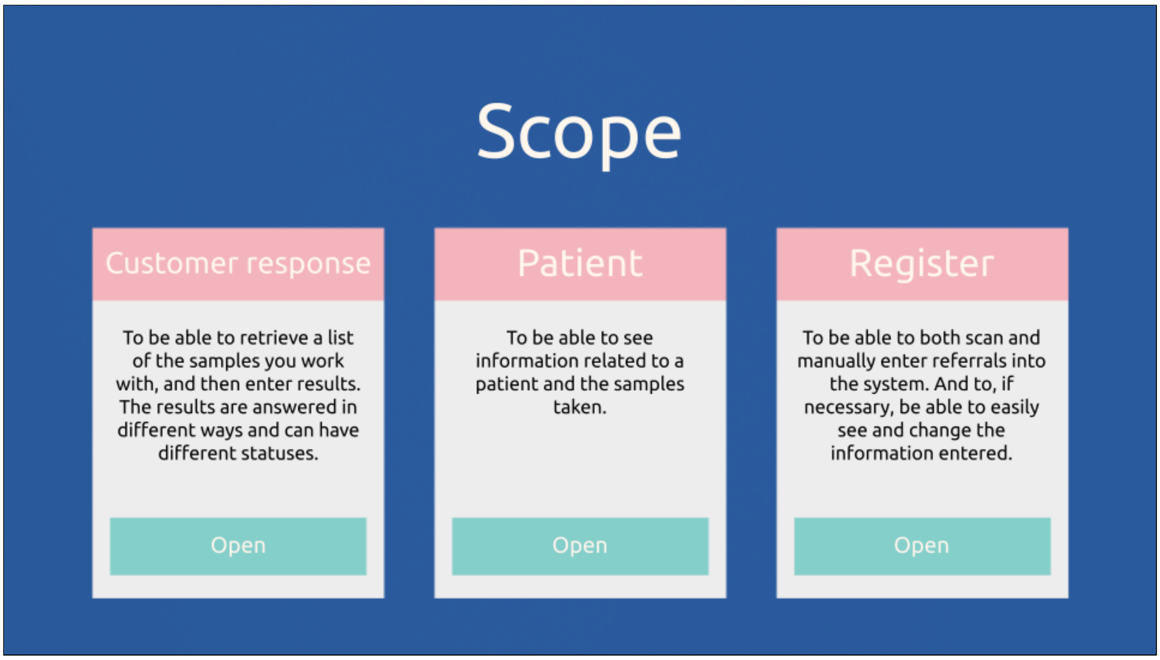



The goal

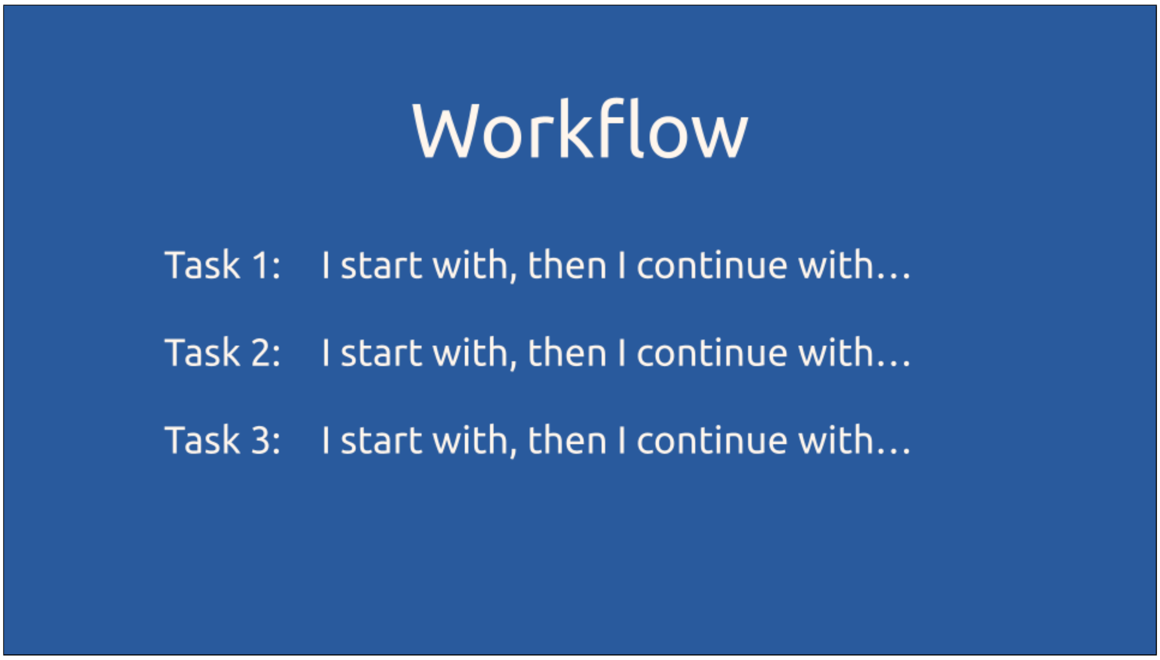

The goal



Slide 9: A summarized view of what they were expected to focus on and what not to



Slide 10: Showing the scope of the project, and highlighting the functionality they should draw

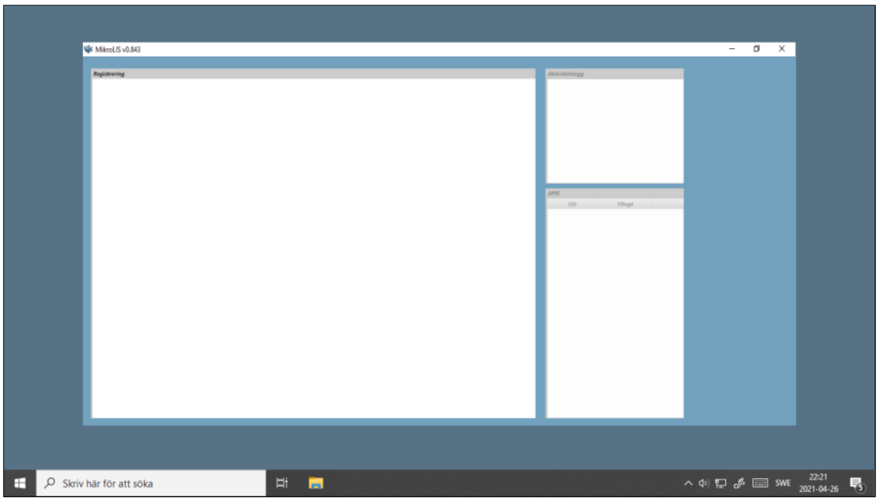


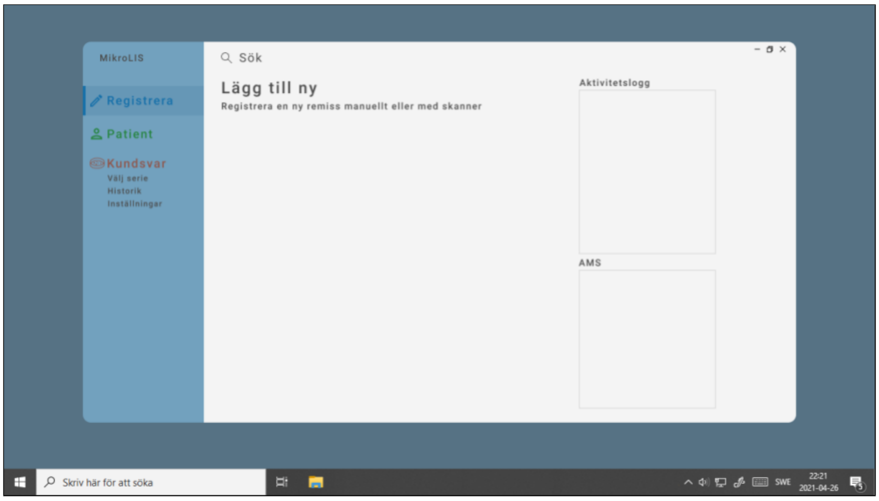
Slide 11: Explanation that breaking down the task into smaller sub-task might simplify their drawings.

A section showing different programs to take inspiration from followed, these have been excluded for containing copy right protected material.

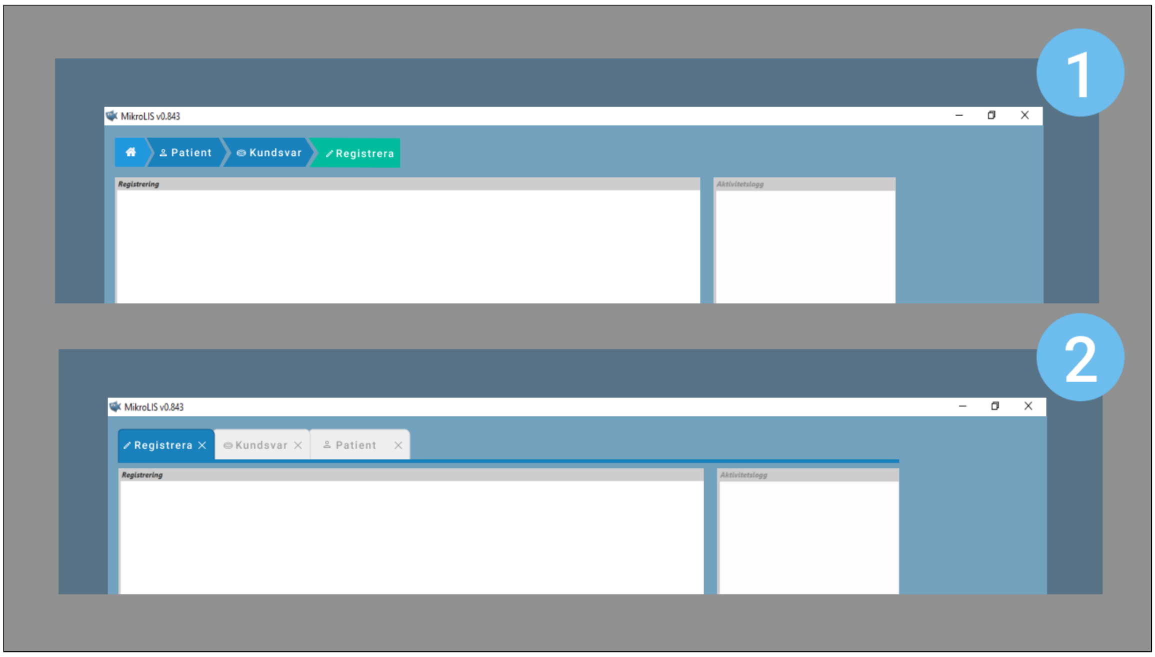
C.3 Discussion slides

Discussing preference using the old system to have multiple smaller windows, or merging the content into one window.

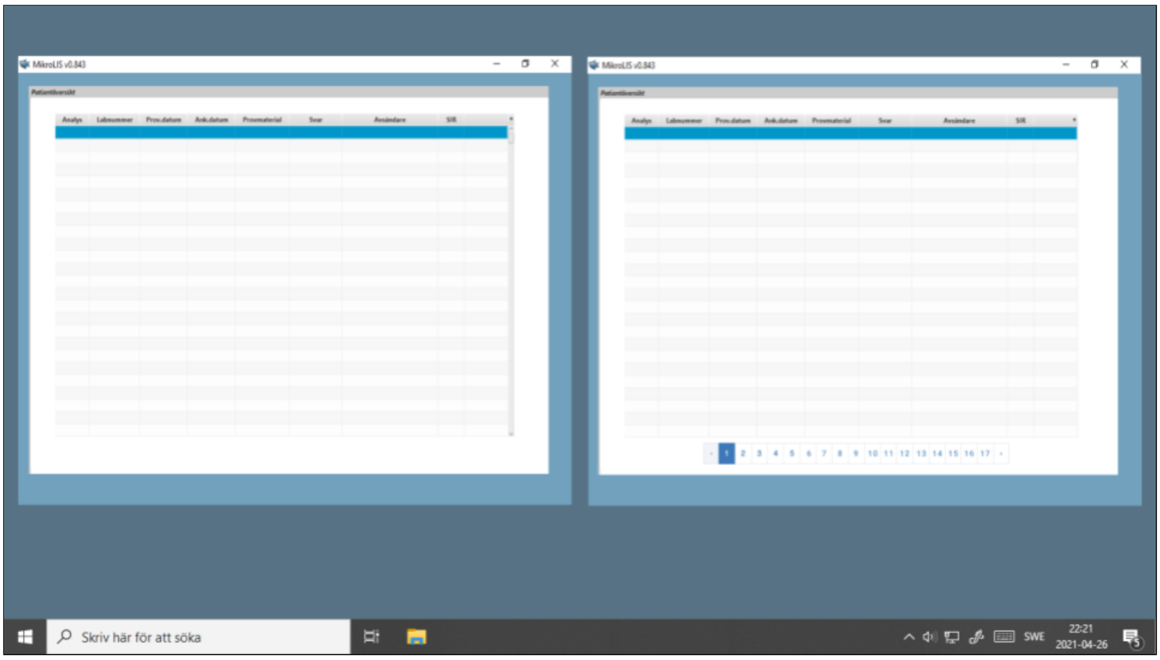




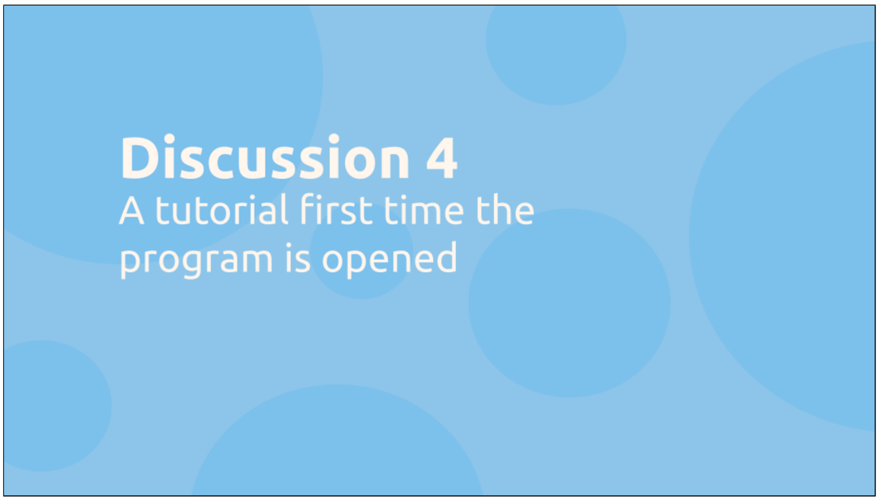
Discussing preference of using tabs, or to have breadcrumbs where windows are stacked on top of each other.

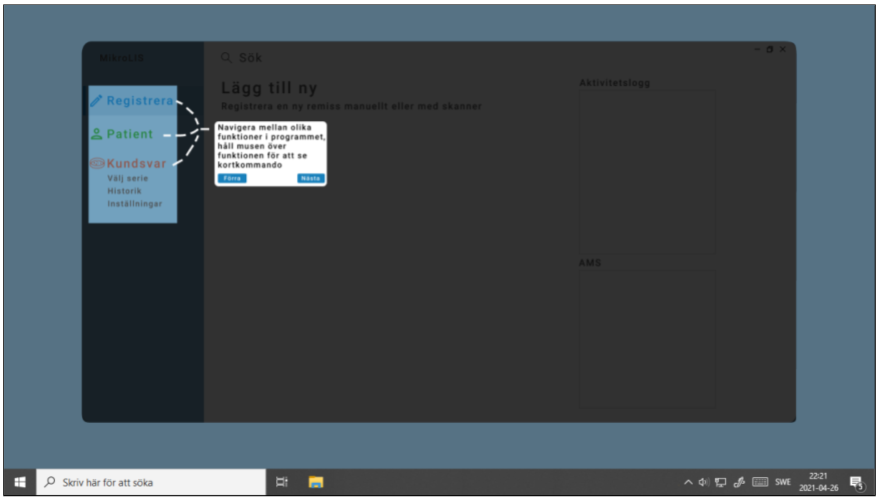


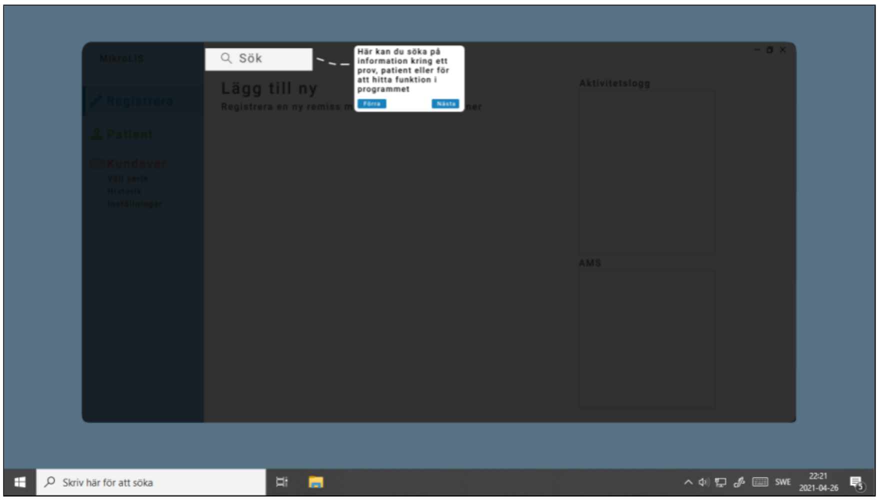
Discussing how the system should handle longer lists. Either with a list that scrolls, or using pages



Discussing if a tutorial would be beneficial the first time a user opens the system







Two additional questions were discussed without pictures showing a representation in the program. These were:

- How do you work with the ”work list”, should it be together with the answering function, or separate?
- Multiple labs will share a system, how should data related to a patent be presented? Only relevant, everything, or perhaps toggleable?