Next Generation User Interface for Digital Microscopy in Hematology

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Abstract

This project was performed in collaboration with CellaVision, a company that provides digital solutions for medical microscopy in hematology. Together with a hardware for blood analysis, CellaVision provides a software where cell images are displayed for further analysis. The user interface of this software was the focus of this research. With the aim to provide a suggestion of improvement for the user interface, the project followed a user-centered design process. Information was gathered by performing a heuristic evaluation on the system, conducting expert interviews and doing contextual inquiries with end users. After generating an overall concept, a low fidelity prototype was created and tested with end users. A more detailed, high fidelity prototype, was then created and further tested. A final concept was developed as a suggestion of improvement. After performing quantitative tests with the high fidelity prototype, the result displayed an improvement of the usability of the user interface, showing a System Usability Scale value of 84.1 for the new user interface versus a value of 33.3 for the old user interface. From the result it was concluded that user centered design can result in a product with higher usability compared to a product developed without the user in focus. A user-centered design process contributes to a result with a solid base, matching the user goals and requirements. This project will hopefully motivate future design processes to work in close collaboration with the end users.

Keywords: CellaVision, interaction design, user interface, user-centered design, graphical user interface

Sammanfattning

Detta projekt har genomförts i samarbete med CellaVision, ett företag som utvecklar och säljer digitala mikroskop för analys inom hematologi. Tillsammans med en hårdvara för blodanalys, erbjuder CellaVision en mjukvara där bilder av blodceller visas för vidare analys av experter. Användargränssnittet för CellaVisions mjukvara har varit fokus för detta projekt. Med syftet att presentera ett förbättringsförslag för detta användargränssnitt, följde projektet en användarcentrerad process. I informationsinhämtningen genomfördes en heuristisk utvärdering av systemet, expertintervjuer hölls samt kontextuella undersökningar med slutanvändare. Efter dataanalys och framtagning av ett generellt koncept, skapades en low fidelity prototyp för att kunna testa konceptet hos användarna. Sedan skapades en mer detaljerad, high fidelity prototyp, som genomgick fler tester och resulterade i ett slutgiltigt koncept. Efter att ha testat high fidelity prototypen i kvantitativa tester visade resultatet på en ökad användbarhet av användargränssnittet. Användbarhetsvärdet (System Usability Scale value) blev 84.1 för det nya användargränssnittet jämfört med ett värde på 33.3 för det gamla användargränssnittet. Resultatet visar att en användarcentrerad process kan bidra till en produkt med högre användbarhet jämfört med en produkt som är utvecklad utan användare i fokus. En användarcentrerad design bidrar till att produkten matchar användarens mål och förutsättningar i användandet av produkten. Detta projekt kommer förhoppningsvis motivera framtida utvecklingsprocesser att ske i nära samarbete med användaren.

Nyckelord: CellaVision, interaktionsdesign, användargränssnitt, användarcentrerad design, grafiskt användargränssnitt

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Lund, December 2016

Lovisa Lundin and Emilia Wu

1 Introduction

Medical errors are currently increasing in frequency all over the world (U.S. Food & Drug, 2015). In the US, medical errors like faulty use of medical devices are the eighth leading cause of death. One root cause is that user interfaces are often poorly designed. In the 80's, the Food and Drug Administration, FDA, presented that almost 50% of the human errors with medical devices stemmed from the lack of good design of products (Sawyer et al. 1996; U.S. Food & Drug, 2015). Poor design can, according to the FDA, also contribute to inefficiencies in systems, even when well-trained users operate (U.S. Food & Drug, 2015).

With an increasing geriatric population and a growing demand for healthcare it is becoming even more crucial to enable efficient solutions. Increased pressure on healthcare, forces healthcare providers to search for sustainable solutions for future health care systems. Adding efficiency can however not compromise the safety and thereby, system user interfaces have to be error proof. In a big laboratory, it is not unusual to have several system brands with different purposes. All laboratory staff have to learn all of the systems and each time when they have to switch from a system to another, they will experience cognitive stress. If the system user interface has a poor usability, it will result in even more stress (Söderström, 2003). It is therefore of great importance to design the user interface with as high usability as possible; to minimize cognitive stress, make the user interface error proof and adapt it to the end user.

1.1 Background

1.1.1 CellaVision AB

CellaVision is a company focusing on hematology which means the science of blood and its diseases (Gahrton and Lundh, 1997). The healthcare today, including the hematology laboratories, is under a lot of pressure. Reducing costs, obtaining faster testing of an increasing number of samples with less staff and an increasing pressure of reliable results are some of the challenges that need to be fulfilled. CellaVision is the world-leading provider of automated digital analyzers for microscopes in hematology. Their business is to help hematology laboratories improve and transform the process of analyzing blood and other body fluids. The automated microscope system that CellaVision provides, makes the analysis process increase in speed, it creates a more streamlined flow and improves the reliability of the results and care of the patients.

CellaVision provides analyzers with supporting applications and software that replace conventional microscopy. Since 1994, they have developed products and in 2001, the first analyzer was sold in Europe. The work of improving the analyzers is continuously proceeding, however the user interface of the software has been almost the same since the start.

The manual microscopy has about 84% of the market in the field of target users for CellaVision. Thus, the market share is increasing for automatic microscopy and CellaVision is the product category leader as of today and has penetrated about 14% of the 15 000 large medical laboratories in the world.

CellaVision's target market is the mid-size and large mature laboratories with high volume of testing requirement.

1.1.2 The System

1.1.2.1 Blood sample workflow

Firstly, a blood sample is taken from a patient. When it reaches the laboratory, it enters the cell counter device. If it is flagged as abnormal by the cell counter, it goes into a manual microscope or a digital automatic microscope. In CellaVision products, the blood sample is read by a digital automatic microscope and the preliminary result is presented in a software on a computer screen. The user interface of this software is the focus of this project. Every year, 4 billion blood samples are collected and entered in cell counters. From that 15% of the samples are selected to proceed to microscopy. 85% end up in the traditional manual microscopy and 14% end up in the automatically digital microscopy from CellaVision, see Figure 1.

Figure 1: Blood sample workflow in laboratories. The blood sample goes through a cell counter and 15% of the samples are flagged as abnormal and are further analyzed in either a manual microscope or in CellaVision's automated microscope.

1.1.2.2 Users

The automatic digital hematology analyzers are found in laboratories and the main users are biomedical scientists. The biomedical scientists working with CellaVision's system work in clinical hematology laboratories at hospitals. All these users go through education before they are able to work in the system. The users are therefore considered as semi-experts of the system. The main focus for the biomedical scientist is the human body and more specific, how the cells, organs and body systems function (Biomedical Sciences, 2016). Biomedical scientists working in the laboratory field with CellaVision's products, perform and manage the tests ordered by doctors. For the system investigated in this thesis, the biomedical scientists analyze blood cells by studying them through microscope images. The system presents a qualified result but needs to be confirmed and signed by a biomedical scientist before it will be sent back to the prescribing doctor. It is therefore of great importance that the user interface is made with the user in mind to avoid mistakes that can affect the patient (U.S. Food & Drug, 2015).

1.1.2.3 Workflow in CellaVision's product

The initial phase of the workflow in Cellavision's products is the part when the blood sample is read by the machine. Microscopy images of the sample are taken and once the initial analysis is done, the order is placed in a list of orders, called database view, see Figure 2.

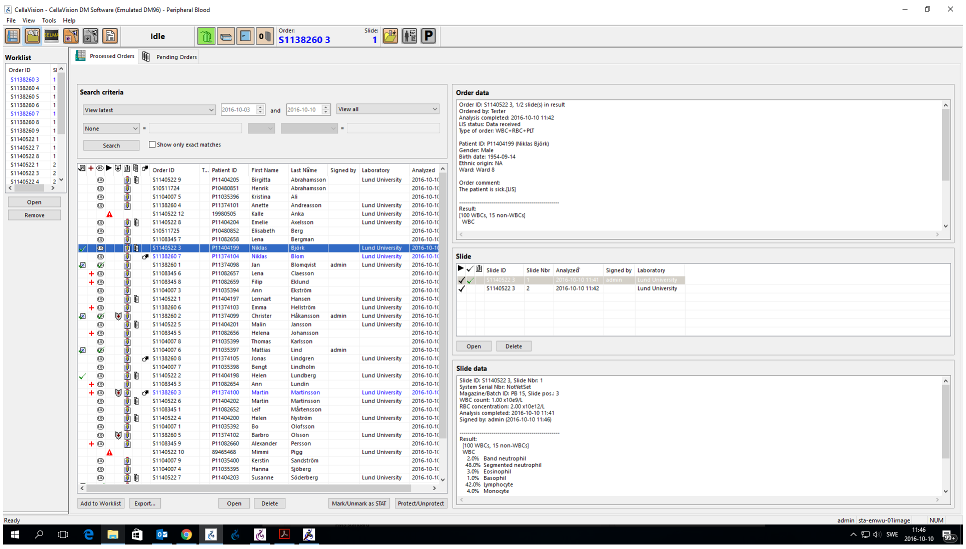


Figure 2: The Database View in CellaVision's system. In this view, all orders are presented in a list together with order information.

In this Database View, the user can view all orders together with information relevant for the order such as patient ID, date of analysis, name of patient and more. The list is by default sorted by date of analysis but can be sorted by the headlines of each column. Above the list there is a search and filter function that enables the user to search in the order list. In the Database View, there is also more detailed information about each order in a box called Order Data, and a box called Slide Data containing specific data for each slide within an order. There is also a smaller box called Slide containing a list with one or more slides, depending on how many slides an order contains. These three boxes with Order Data, Slide and Slide Data are located on the right side of the order list. On the left side of the order list there is a small list, called Worklist. The user can add orders to the Worklist and then use the Worklist to work from when analyzing the different orders. Using the Worklist is optional and the user can open one order at the time from the order list or one slide at the time from the slide list if preferred.

Once an order is open for further analysis, the user enters a view called PB-verification. Within this view the user can analyze white blood cells, red blood cells and platelets. When analyzing the different types of blood cells the users examine images of the cells and classifies them, using their expertise within the field. Once the user is done verifying the order, the user signs the order and the analysis is complete.

1.2 Project purpose

The user interface for Cellavision's product was created in the 1990's with minor updates during the years. It was initially developed by engineers and created to satisfy the basic needs of the system. No user-centered design or usability studies have been done focusing on the user interface of this system. It is however crucial for a user interface to have as high usability as possible.

This concludes in the following purpose of the project:

- Identify the users of Cellavision's products, their differences and review their goals and work situation.
- Analyze the user experience for the different users of the existing user interface.
- Investigate what improvements that can be made to improve the usability and user experience of the user interface.
- Develop a new concept for the user interface that could improve the user experience for all users using Cellavision's products.

1.3 Report structure

After this introductory section, the report will describe relevant theories for the project. Furthermore, the following phases are presented in a chronological order; concept phase, elaboration phase and detailing phase. Each of the sections describe both methods and results. The report will finish with a section presenting the final concept, followed by discussion and conclusion.

2 Theory

2.1 User-centered design

User-centered design is a term that describes a design process where the end-user influences how the design will be developed (Abras et al., 2004). The driving force of a project with user-centered design is the end users and their goals. There is an ISO standard to follow in order to ensure a user-centered design process. The ISO standard is called ISO 9241-210:2010(en) and addresses the branch of Human-centered Design for interactive systems. To ensure that a design is user-centered throughout a project, the ISO standards suggests six key principles (ISO, 2010):

1. The design is based upon an explicit understanding of users, tasks and environments.
2. Users are involved throughout design and development.
3. The design is driven and refined by user-centered evaluation.
4. The process is iterative.
5. The design addresses the whole user experience.
6. The design team includes multidisciplinary skills and perspectives.

The benefits that can be withdrawn from employing user-centered design into a product development project are many; the system or product are often perceived as more efficient and satisfying. This can for the company lead to an increase in sales and higher loyalty from the customers(Usability First, n.d). In user-centered design, the user is involved in all steps of the process: research, design, adapting and measuring. As seen in Figure 3, the process is iterative in both the small steps and in the overall process and the user should always be considered.

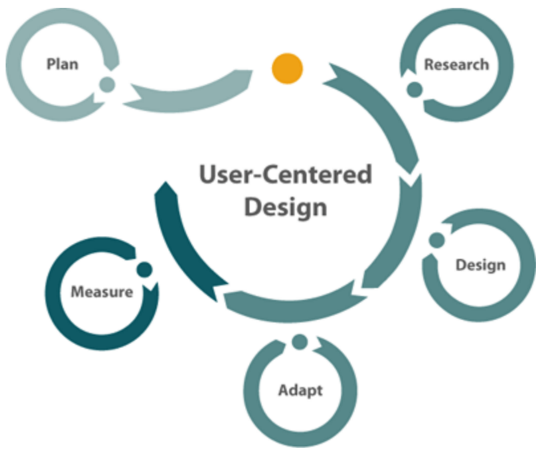


Figure 3: The iterative user-centered design process that shows both the small and big iterations with the users in mind (Greydanus, 2015).

When applying user-centered design, one have to consider the different types of users that can occur. As Eason(1987) and Arvola(2014) point out, there can be three types of users: primary, secondary and tertiary. Primary are the ones actually using the system, secondary are those who use it through an intermediary and tertiary are those who will be affected by the use of the system in any way. For this project, the biomedical scientists are the primary user. They use the digital microscope and analyze the result in the software interface. The doctors are the secondary users due to the fact that the system affects how the doctor will continue to treat the patient. The doctors are in indirect contact with the system. The patients are therefore the tertiary users. For a user-centered design, it is of importance to recognize the different users and decide if it is necessary to involve all groups or not. For this project, the primary users, the biomedical scientists, are in focus and therefore the other groups will not be considered (Abras et al., 2004).

2.2 Seven fundamental principles of design

In Donald Norman's book: The Design of Everyday Things, seven design principles are introduced to use when designing for good usability and especially when working with user-centered design. The principles are used throughout the design and innovation process of this project and especially when creating concepts and prototyping (Norman, 2014 p. 72):

- Discoverability. It is possible to determine what actions are possible and the current state of the device.
- Feedback. There is full and continuous information about the results of actions and the current state of the product or service. After an action has been executed, it is easy to determine the new state.
- Conceptual model. The design projects all the information needed to create a good conceptual model of the system, leading to understanding and feeling of control. The conceptual model enhances both discoverability and evaluation of results.
- Affordances. The proper affordances exist to make the desired actions possible.
- Signifiers. Effective use of signifiers ensures discoverability and that the feedback is well communicated and intelligible.
- Mappings. The relationship between controls and their actions follows the principles of good mapping, enhanced as much as possible through spatial layout and temporal contiguity.
- Constraints. Providing physical, logical, semantic and cultural constraints guides actions and eases interpretation.

2.3 Usability

Usability is a qualitative measurement of how easy the user can use an interface. If the user easily uses the interface and it does what the user needs, the interface is useful. To improve usability, the most basic and useful method is user testing (Nielsen, 2012). A user interface with high usability is effective, efficient and safe to use, provides accurate features, easy to learn and easy to remember how to use (Preece, et al. 2011 p. 19).

2.4 User experience

User experience is the user's overall experience when using a product, system or service. The first thing to achieve is to meet the goals of the customer and user, as Norman and Nielsen (2016) say: "without fuss or bother". One can later on work with the simplicity and elegance of the product, system or service to create a better user experience and improve the usability of the system.

2.5 Graphical user interface

A graphical user interface is the intermediary on the computer which the user interacts with to affect a system. In human computer interaction, the user interacts with the graphical user interface to achieve something. Initially, the interface on a computer was not graphical, it was text-and-keyboard oriented and one had to command the computer what to do with text instead of using graphical applications to interact with the computer. The graphical user interface often uses metaphors for objects familiar to real life so the user instinctively knows how to use it and what it does (Rouse, 2006).

2.6 Summary

You are interacting with a computer through a graphical user interface and your experience of the graphical user interface is called user experience. If you want to improve the user experience of the graphical user interface, you can apply user-centered design and include the user in the design process to meet the goals. One way is to measure the usage of the interface and then increase the user experience by improving the usability.

3 Methods

3.1 Design process

The project and design process has been influenced by Mattias Arvola's book Interaktionsdesign och UX (2014). The main phases in a design process according to Arvola are the Concept, Elaboration and Detailing phases. See Figure 4 to see how the phases are connected.

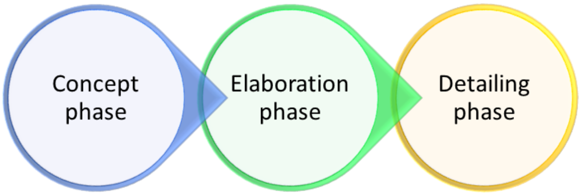


Figure 4: The three phases in the design process of this project, inspired by Arvola (2014). The process starts in the Concept phase, continues into the Elaboration phase and ends with the Detailing phase.

The project started with a concept phase where the aim was to specify the project purpose and gather more information about the users. When the information gathering process was completed, a concept generation phase began and it resulted in a concept proposal. The concept proceeded into the elaboration phase where the concept was prototyped into a low fidelity prototype in order to process and visualize the generated idea. From testing it with the users, valuable feedback was collected. After modifications, the detailing phase was entered with another round of information gathering and a high fidelity prototype was created and tested. When all details were specified, a final concept was established within the scope of this project. See Figure 5 that describe the design process for this project.

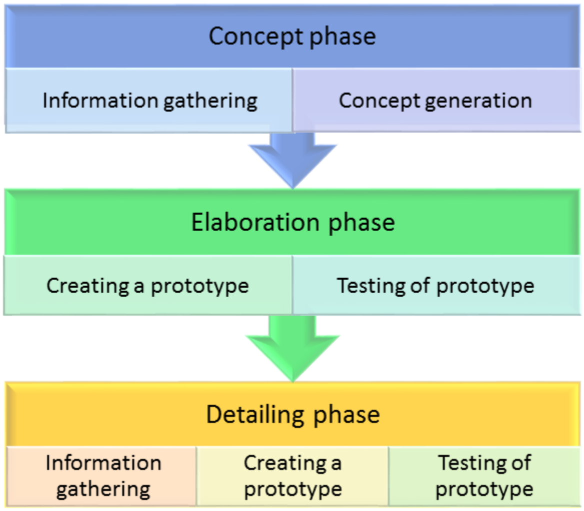


Figure 5: Detailed information of the three phases in this project describing the Concept phase, with information gathering and concept generation. Continuing with the Elaboration phase including creating a prototype and testing of prototype. Finishing with the Detailing phase of information gathering, creating a prototype and testing of prototype.

3.2 Triangulation

Triangulation means that three different methods approaching the same subject are taken into consideration. It can be applicable in many areas of a research. Triangulation is used to ensure that the collection of items is rich, comprehensive and well-developed. This can be identified in several different areas (Denzin, 1978; Patton, 1999). Two of them are methods and sources. E.g. using several methods to collect data in a study will validate and verify the data to be trustworthy but also help to facilitate deeper understanding (Arvola, 2014 p. 44). As with information sources, the reliability will be strengthened if several user categories are considered. As for this project, a triangulation of the methods (heuristic evaluation, expert interviews and contextual inquiry) and information sources for data collection have been made to consolidate the outcome for the further on study.

4 The Concept Phase

The initial phase of a design process is the concept phase. This step aims to create an understanding about what is wanted from users and stakeholders for the final product. Users and stakeholders may think they have an idea of what they need, however their idea might not be in line with what they really need and therefore it is important for the researchers to make a thorough investigation. The researchers need to figure out why the project is important, who the users are, which users to include in user tests etc. The concept phase involves collecting data, analyzing it and generating initial ideas (Arvola, 2014 p. 39).

To gather information about the current situation, several different methods can be used. In this project, a heuristic evaluation was done on the current state of the system. Also, expert interviews were conducted with experts from CellaVision and contextual inquiries were done with users in hospital laboratories. Affinity diagrams were chosen as a method to analyze all the gathered information. Once the information was analyzed, goals were formed leading into a phase of generating ideas. To enhance creative thinking, brainstorming was performed. Several ideas were generated, processed and eventually the researchers was left with one final concept.

4.1 Information gathering

4.1.1 Heuristic evaluation

As a first part of the triangulation, heuristic evaluation was performed. To evaluate a product, a heuristic evaluation can be done. A heuristic evaluation is a procedure that speeds up the process to give researchers an overview of the problem. For this project, heuristics with design focus have been used (Nielsen, 1995b). Important is that a heuristic evaluation does not guarantee to be either optimal or perfect, but helpful for the immediate goal. (Kubose et al., 2003) It is a good method to use when trying to discover both major and minor problems in systems, in this case a user interface (Nielsen, 1995a).

The ten heuristics to be examined are (see all with clarifying explanation in Appendix B)(Nielsen, 1995b):

- 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

Heuristic evaluation is performed individually by the evaluators and only after evaluation, the evaluators are allowed to communicate. It is important to keep the evaluation unbiased and independent. Additionally, it is essential to choose the evaluators carefully. It should not be the end user and preferably they should have some expertise in the usability area. It is recommended to iterate the evaluation twice; first time is to learn the product and use it for approximately two hours and the second time the evaluators will apply the heuristics chosen when using the product and document the thoughts and problems that come across according to the heuristics. (Nielsen, 1995b)

The evaluators in this project was decided to be the researchers. The evaluation was performed in the beginning of the project, before the researchers had used the product, to get the result unbiased and trustworthy. A session of freely using the system was first performed and it lasted about two hours. After that a heuristic evaluation was conducted based on Nielsen's checklist, "10 heuristics for User Interface Design"(see Appendix B), (Nielsen, 1994). The evaluators used the software system from start to end(when a sample appears in the order list until it is signed) with one heuristic at the time and the iteration of using the system was made ten times. The problems and thoughts were documented during every iteration about the specific heuristic and after the session, debriefing between the researchers resulted in a complete list of the major and minor problems in the user interface design of the system.

4.1.2 Expert interviews

As a second part of the triangulation, expert interviews were conducted. An interview is a tool which can be used to collect data where one person, called the interviewer, ask questions of another person, called the respondent. (Whiting, 2008). An interview can be conducted in various different ways. Semi-structured interviews consist of the same questions asked in the same order, for the different respondents, and the interview is led by the interviewer. Yet, the questions should be open and give room for the participant to give personal and detailed information. Except from asking questions, the interviewer should avoid leading the respondent to certain answers (Whiting, 2008).

To get a deeper understanding about the development and history of the interface of the system, it was decided to do a semi-structured qualitative interview. Before collecting data from a participant, it is important that the participant consent with taking part in the study. The researchers have the responsibility to inform the participants about what the study means, risks, benefits and what the result may lead to. An informed consent provides test persons with sufficient information about the study so that they can make an informed and voluntary decision to take part in the study. It should be clear if the participation is anonymous or not and the researchers should inform what they will do with the test results. The participants should also be given the chance to take part of the final result of the study later on. Informed consent can be done both verbally and in written form.

An important element of preparing an interview is to perform pilot testing of the interview. A pilot interview allows the researchers to find limitations and weak interview design and enables the researchers to revise the interview if needed before starting the interview sessions (Turner, 2010). A pilot interview with the interview questions (see Appendix C.1) and the informed consent (see Appendix D.1) was done with a person that has similar interests as the real participants, also working at CellaVision.

After all preparations were done, the interviews were conducted and seven respondents took part in interviews. The expert interviews were held with people working at CellaVision. The supervisor at CellaVision recommended suitable interviewees and the departments represented were global marketing, innovations engineering and global sales. The interviews were held face to face in a meeting room. One of the researchers had the interviewer role and the other took notes during the interview. The roles were consistent throughout all the interviews. Before the interview started, the interviewer explained what the research is about and what role the interview plays in the study. Also, the participant and researchers signed a written informed consent. The interview was recorded to make sure the researchers were given a possibility to listen to interesting parts of the interview again if needed. The participants were informed about this and were only recorded after agreeing to it. The interview continued with the interviewer asking a set of predetermined open questions (see Appendix C.1). If considered needed, the interviewer asked supplementary questions. To help the participant recognize the real situation, print screens of the different views of the user interface in the systems were printed out on papers. The participant could use the different views to look at, remember and/or as a tool to show and explain to the interviewer. All interviews were completed within one hour. After each interview, the researchers took time to complete a summary of the interview and add thoughts that occurred during, or after, the interview.

4.1.3 Contextual inquiry

As a third part of the triangulation of information gathering, contextual inquiry was done. Contextual inquiry involves observation and interviews, in a real-life environment with the user. The contextual inquiry was done in order to get a deeper understanding about the end user of the system and the user experience (Arvola, 2014 p. 51-52). It was chosen to do a semi-structured qualitative interview and an observation. An observation protocol was made(see Appendix E) in order to ease the note taking for the researchers when observing (Karlsson, 2004).

The interview questions were similar to the ones used in the expert interview phase and were therefore seen as tested from the previous pilot interview (see Appendix C.2). The observation protocol was validated and controlled by a biomedical scientist at CellaVision with good insight of the end users at the laboratory hospitals.

Observations and interviews were done on today's current users working with the system in hospital laboratories. Two hospital laboratories were visited and at both laboratories, three biomedical scientists were observed and interviewed. Before the observation started the observer informed the participants about the conditions of the contextual inquiry and by orally consent with the terms of the study, the observation could continue (see Appendix D.2). The observed biomedical scientist was working in his/her normal work environment, performing day to day tasks in the system. While the participant worked in the real-life environment the researchers observed and interacted. The biomedical scientist continuously explained what he/she was doing and the observer followed the observation protocol and filled in valuable information while observing. Also, interview questions were asked along the observation session (see Appendix C.2).

4.1.4 Data analysis

Once information is gathered it needs to be organized and analyzed. There are several different methods to use when analyzing qualitative data; thematic, content, narrative and grounded theory. Thematic analyze is the first tool that a researcher should learn and is also easier to use as a novice (Braun et al., 2008). Thematic analysis main purpose and benefit is to identify patterns within the data. One thematic analyzing tool is the affinity diagram. It is often used when analyzing qualitative data, such as interviews (Arvola, 2014 p. 52-54). One can perform the analyze step by step (Raven and Flanders, 1996; Arvola, 2014 p. 53):

1. All project members read through the data, marking important parts.
2. Every person reads through his or her markings and write them down on post-its. Every note is coded with the source of the marking.
3. All notes are structured and fixed on the wall.
4. The notes are then moved and categorised into different groups by identifying observations relating to each other. This will continue until no more note needs to be moved.
5. The project members discuss the meaning of the groups, what binds the notes together.
6. The groups or categories are named and can be grouped together in themes or further split into subcategories.
7. Lines can be drawn between themes, categories and subcategories to get an overview of the data.

When analyzing the data in the project, the researchers took inspiration from Arvola's book "Interaktionsdesign och UX" (2014) but adjusted it to fit into the project. First, the researchers read through the notes, marked and wrote down important parts on post-its. If data was unclear, the recordings from the interviews were used to clarify. Then the researchers started one by one and putting the notes on a whiteboard and grouping them together as much as possible. Some notes were same for both participants, but only one was used in the analysis to minimize the amount of post-its. After, the notes were read again and some adjustments to grouping was done if applicable. The groups were then named according to its content. When the affinity diagram was done, it was digitalized for a better overview. To get the most important insight from every data analysis with affinity diagrams, key takeaway points were extracted from each of the categories for every affinity diagram to consider further on in the project.

4.1.5 Results from information gathering

In this section, results from the heuristic evaluation, expert interviews and contextual inquiry are presented. Affinity diagrams from the processes can be seen in Appendix F. The information from the affinity diagrams resulted in several key takeaway points concerning each of the areas of information gathering and they are presented in the following sections.

4.1.5.1 Heuristic evaluation

Key takeaway points:

- Unclear workflow
- Many ways to achieve the same thing
- The system lacks feedback
- Lack of hierarchy in the system
- Almost all necessary functions are available, but hidden
- Lack of possibilities to speed up for frequent users
- Lack of possibilities to undo actions
- Unclear symbols/icons

The system consists of a lot of functions, menus and information that are present at all times. Since the shape, size and color in the graphical user interface are rather indifferent with no clear hierarchy of relevance it can be hard to distinguish the purpose of the various parts of the interface. This also involves the main workflow, which blends in with the other, less relevant functions. A lot of the icons are unclear or inconsistent. Throughout the system, one can achieve the same action in many different ways. There is no proper feedback given to the user. For example, the state of the system is not clarified during actions such as analysis of a magazine, movement of cell images, classification completion or when signing a slide. There are no possibilities to customize or use short commandos to enable faster workflow. Also, it is not possible to undo actions if needed. In some cases it is possible to reset, however the reset function does not allow for single steps back, only a full reset of category.

4.1.5.2 Expert interviews

Key takeaway points:

- Different perception about system's interface pros, cons and user differences.
- Interface developed by engineers, no user-centered design and little involvement of users, no critical judgement of changes in the past.

- A lot of information, functions and unclear design, leading to vague visibility of main workflow and key functions.
- Main workflow is satisfying the aim of the system.
- Many ways to achieve the same thing
- There is no standard way for users to notify Cellavision about desired changes and no way for Cellavision personnel to document and handle user feedback after field visits.
- Important to consider the different users of the system
- The system lacks information that is found in other systems

When interviewing the experts at Cellavision it was discovered that they had different thoughts and understanding about how the users use the system. They also had different opinions about what was considered as pros and cons in the interface. The system was initially developed by engineers without any user centered design. Added functions, symbols and information have not been consequently critically judged before implementation. They have mostly been added without considering usability of the system. The main workflow is satisfying the aim of the system and considered well developed. However, the main workflow blends in with other less important parts. Throughout the system, one can achieve the same action in many different ways. One can, for example, open the same slide in six different ways, all leading to the same action. Often, the feedback from users are not handled in the same way by the personnel at CellaVision. It is important to consider both the surrounding working environment and the requirement from the healthcare sector since it may differ around the world. Also, the cognitive and digital ergonomics is of importance to make sure that the system is adapted to its users. Some of the information required by the user is found in other systems. If this information was incorporated into the system and made visible, it would help the user to work in CellaVision's system to a greater extent.

4.1.5.3 Contextual inquiry

Key takeaway points:

- When getting used to the system, one finds workarounds and gets blind to flaws in the system
- The main workflow is satisfying but have room for improvement of details
- The users at laboratories and their way of using the system differs
- More visibility throughout the system is desired
- The system lacks information that is found in other systems.
- Users do not know the purpose of functions excluded from the main workflow.

Problems that occur when using the system can often be solved with workarounds. It might be hard to acknowledge problems with systems that one is very used to, since there is no other way to use it. The main workflow is satisfying the aim of the system very well, however there are adjustments that could improve the user experience. Healthcare factors, surrounding environment and different requirements lead to non standard user profiles and therefore, work procedures can vary among the users. This is important to consider when adjusting the system to users. Some parts in the system are considered unclear and it is difficult to find desired information. Some information are found in other systems. It would help the user to work in Cellavision's system to a greater extent if this information was incorporated into the system and made easy to access. Functions that are not used often are forgotten or not acknowledged by the daily users. Most of the time, users stick to the main workflow.

4.2 Concept generation

4.2.1 Impact goals

Impact goals are the reasons why a project will proceed. They describe the future effects of the project result and are therefore important to consider throughout the work. Impact goals describe what effects that can be seen from the product when implemented. (Arvola, 2015 p. 76)

When the triangulation of information gathering was done and the key takeaway points were chosen, impact goals were defined for the whole system. The key takeaway points were regarded and impact goals were produced. Key takeaway points that were mentioned in more than one part of the triangulation were discussed and merged into impact goals for the system user interface. In order to determine which of the impact goals that are of more importance to consider further on, a modified version of a functional analysis was made (Arvola, 2014 p. 95). The analysis was applied on the impact goals instead of functions as in the original method. All researchers went through the goals that were written down and marked them as either Necessary(N), Desired(D) or Unnecessary(U). Only the goals marked as Necessary(N) were considered and chosen for the future work.

4.2.2 Product goals

Product goals are the goals for the end product in comparison to impact goals that aims for an effect after implementation. These goals are the requirements of the product in order to achieve the impact goals. Based on the information gathering product goals were specified to enable the effect of the impact goals.

4.2.3 Brainstorm

The next step of a project was to generate ideas to create a concept. Brainstorm is an effective method for generating new design ideas, and commonly used in interaction design. Two key success factors for the method is that the participant know the user goals that should be supported by the product and that none of the ideas are allowed to be debated or criticized (Preece, et al., 2011 p. 373).

The brainstorm session was performed individually among the researchers, where the researchers were freely sketching concepts, generating several new ideas. To narrow down the problem, the brainstorm sessions were conducted in different categories. After as many ideas as possible were generated for each category, the participants showed the ideas to each other. Finally, the researchers ended up with a collection of ideas.

4.2.4 Defining a concept

During the brainstorm session, the task of generating ideas was heading in a divergent direction, with several ideas produced within each category. To define one concept, all the different concepts had to be narrowed down.

4.2.4.1 Evaluation matrix

To narrow down the concepts and excluding the least appropriate ones, an evaluation matrix with the different solutions was performed. This method is recommended to use when comparing concepts to several different attributes. How to perform the evaluation (Arvola, 2015 p. 100):

1. Criteria for the judging have to be decided and can typically be earlier design goals

2. Concepts that should be evaluated within the judging have to be chosen

3. The most promising concept is chosen to serve as a reference concept. This concept gets the value zero for all the judging criteria. The other concepts are afterwards judged against the reference point and if better in one criteria, the concept gets a (+) and if worse, it gets a (-).

4. When the criteria are assessed for each of the concepts, the score for each concept is calculated. Criteria were chosen to use when judging the concepts.

5. The worst concepts are excluded from further consideration.

6. The last step is to decide upon which of the concept or concepts that will go to next step in the design process.

For this project, the evaluation matrix was done for each one of the categories that had taken part in the brainstorming sessions. Firstly, judging criteria and concepts to judge were chosen for each of the categories. Different criteria were applied depending on the categories. The concepts that were not considered as viable were excluded from the matrix. After that, a reference concept for each category was chosen and the evaluation was performed. The summarization of the scores for each concept for each of the categories gave an indication about which of the concepts that fulfilled the criteria best.

4.2.4.2 Workshop

To find out how the different concepts related to the users, two biomedical scientists participated in a workshop where all the concepts from the evaluation matrix were presented. The biomedical scientists had participated before in the project. Possibilities and constraints were discussed considering a single concept, combinations or parts from a concept. The biomedical scientist also got to choose their favorite concept in each category and explain why. Another workshop was held with a user representing the American market. This workshop was held on distance, through email with the same agenda as the first workshop. Pros and cons were discussed and the favorite concept for each part was chosen according to the user.

4.2.4.3 Merging outcome

Acknowledging the scores from the evaluation matrix and the results from the workshops, each concept in each category was considered. Using this, still keeping restrictions, impact goals and specifications in mind, one concept from each category was chosen by the researchers.

After this, the phase of combining the different components into a full concept began. The three different components were combined in various layouts in brainstorming sessions and at all times, they were compared to the goals and specification of requirements. This was done in order to ensure and enable a new concept of the user interface with better usability than the user interface that is used today. Finally, one whole concept was defined.

4.2.5 Results from concept generation

4.2.5.1 Restrictions

To keep the volume of work within the scope of the project, restrictions had to be made. At this stage of the project it was considered appropriate to make restrictions before moving on to the phase of generating ideas. Since the user interface of the considered system contains several different views, it was chosen to focus on one of them. It was discovered that the most problematic view was the one called Database View. This view required most improvement to reach the impact goals and it was chosen to continue the work focusing on the Database View.

4.2.5.2 Database View

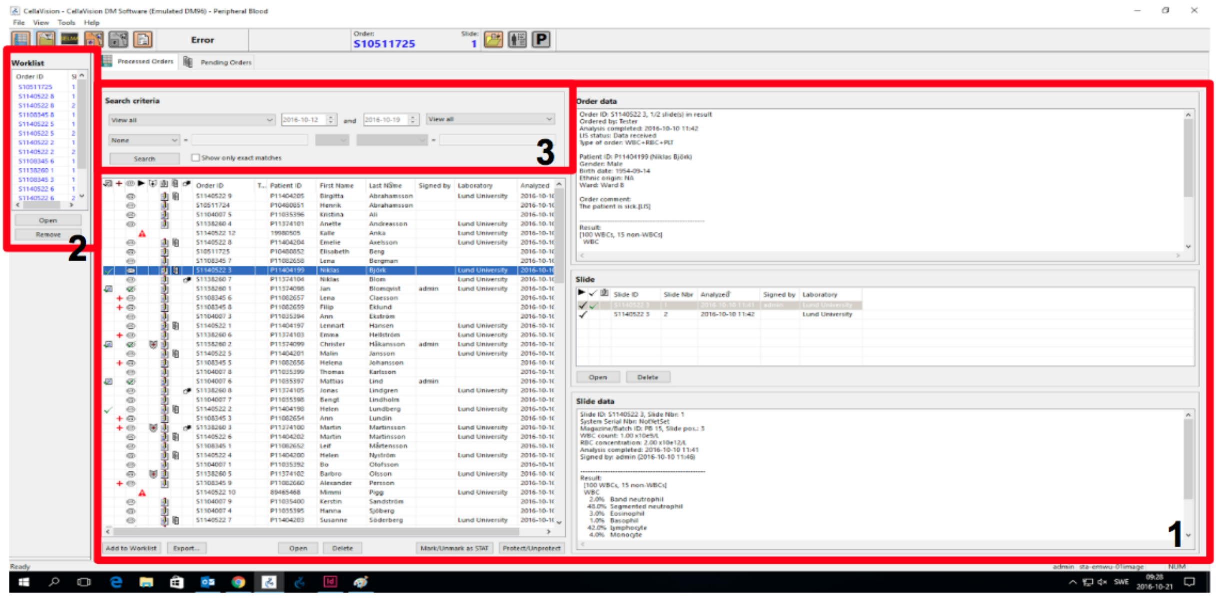


Figure 6: The Database View divided into three parts. Part 1 is the Order List where all the incoming orders come with detailed information to the right of the central list. Part 2 is the Worklist where orders can be put to a queue of orders to be analyzed. Part 3 shows the Search and Filter area with both search field and filter options.

In the Database View (see Figure 6) three main parts can be detected. Part one is the list of orders that are presented in the central part of the user interface. The last analyzed order is put first in the list and waits to be verified and signed by a biomedical scientists. The second part of the Database View is the Worklist that is placed on the left vertical body of the interface. This is a queue where orders can be added that needs to be verified and signed. The third part is the Search and Filter area in the central top of the interface. The user can search for old orders and filter the list columns by e.g. date or status.

The way of working in the Database View varies among different users at the hospital laboratories. All the users are educated biomedical scientists, but they all have different working conditions and habits depending on where they work. Some users have a greater extent of workload and analyze around hundreds of orders per day. Other users have a lower amount of samples to analyze, around 20-40 orders per day. The users that handle a lot of samples tend to use the Worklist to a greater extent. They put the samples in a queue and work systematically down the list. Often, laboratories with a high workload use a setting where the orders are put automatically into the Worklist as they are analyzed by the hardware. Users then analyze one sample at the time and once a order is done, the system automatically jumps onto the next order in the queue for a continuous analysis. These users tend not to go back and use the Order List. User with a lower workload tend not to use Worklist as much. If they do, they manually add a few samples to the Worklist and work from there. Users that do not use the Worklist, access samples for analysis directly through the Order List. Once an analysis is done, the user is brought back to the Order List.

Another difference among user conditions is the routine for the amount of slides per order. Some laboratories have a standard of analyzing one slide per order and other have a standard of analysing two slides per order. Some unusual cases may require to have more than one slide per order even for the laboratories with a one slide routine.

In the Database View a search function is found. It enables the user to search in the list of orders. According to the users, the search function can be somewhat complicated to use. The search function has a filter function with six options in a drop-down menu. Below the filter function, a search field is found. One can choose which category to search in by using a drop-down menu and enter free text in the field next to it. There are two of these search fields and the user can search combining two criteria.

In the system today, all orders are presented in the list, regardless if they have been signed or not. That makes the list full at all times and if an order is forgotten and newer orders have come into the system, the order might be out of the visible window in the list. Another problem is the emergency status on orders that should be prioritized before other. In the main list, the orders are marked with a red cross but if they are added to the Worklist, the status will no longer show. For the users that work from Worklist more than other, this can be problematic since the emergency orders are not marked and therefore hard to distinguish.

4.2.5.3 Impact goals

N, D, U	Impact goals
D	The users should feel that the user interface is modern and up to date
D	The users should feel that the system's interface is adapted to the user
N	**All functions in the system should be of relevance for the user and known by the user**
N	**Users should feel like it is easy to find what they are looking for**
N	**Users should feel like they have all information that they need**
D	All users should feel like the system fits well into all the different daily routines
N	**The main workflow should be clear to the user**
D	The digital ergonomics should be as good as possible for the user
N	**The user should not worry about making mistakes**

Table 1: Impact goal analysis to sort out the most important impact goals. The impact goals were graded with either Necessary - N, Desired - D or Unnecessary - U and only the goals marked as Necessary were considered further in the project.

The impact goals marked as Necessary (N) in the impact goal analysis (see Table 1) were used further use in the project.

4.2.5.4 Product goals

Concerning the Database View, product goals fulfilling the impact goals were withdrawn and covers the Database View overall and the three major areas of problems:

Database View overall

- The system should provide sufficient information for the user. However, information that is not important at the moment should be able to make less.
- The most frequent operations in the system should be easier to perform.

Order List

- Independent of how many slides per order, the orders should be managed the same way.
- The main list should not be truncated and all the information visible should be relevant.
- Orders should be clearly separated from each other and it should be clear which information that belongs to each order.
- The unsigned orders have to be in focus.

Worklist

- The Worklist should be dynamic in the meaning that it should be easy to use for the frequent users and for the user that do not frequently use it, the Worklist should not be too central in the workspace.

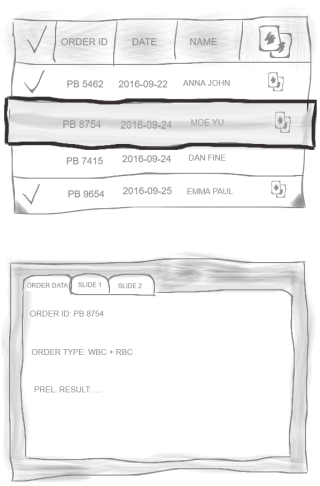
Search and Filter functions

- There should be only relevant filters. They should be visible and the user should be able to switch between the filters without too much cognitive load.
- The filter and search options should be designed so that the user understands the difference between them and it should be clear how to select dates.
- There should be an option to reset the search area if wanted.

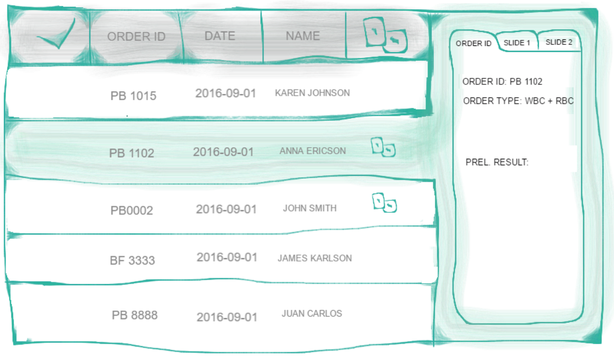
4.2.5.5 Brainstorming

The concepts generated in the brainstorming are presented in each category (see Figure 7, 8, 9, 10, 11 and 12).

Order list



(a)



(b)

Figure 7: Order List concepts 1 (a) and 2 (b). Order List concept 1 (a) shows a concept where the order information is presented below the list and Order List concept 2 (b) shows a concept where the order information is presented on the right hand side of the list.

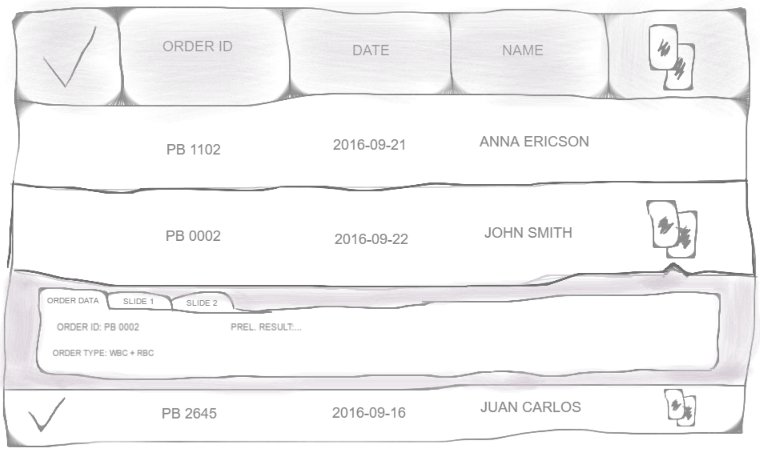
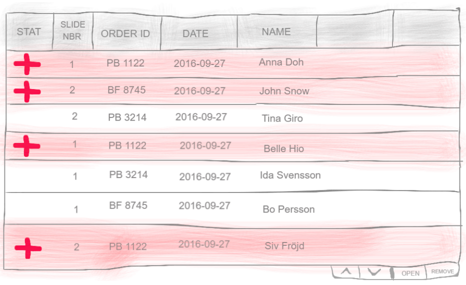
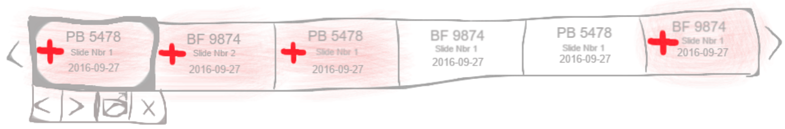


Figure 8: Order List concept 3 shows a concept where the the selected order's information is folded out from the order row in the list.

Worklist

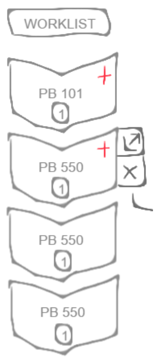


(a)

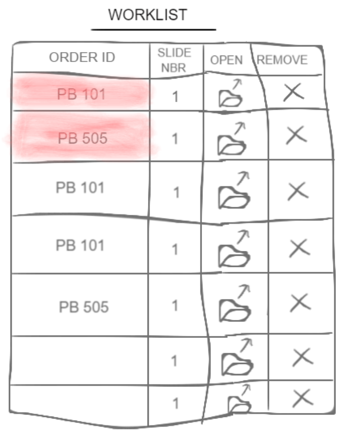


(b)

Figure 9: Worklist concepts 1 (a) and 2 (b). Worklist concept 1 (a) presents a list similar to the Order List with a lot of order information included. The second Worklist concept 2 (b) shows a horizontal list presenting selected information about the order.



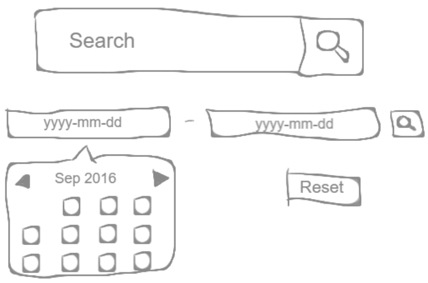
(a)



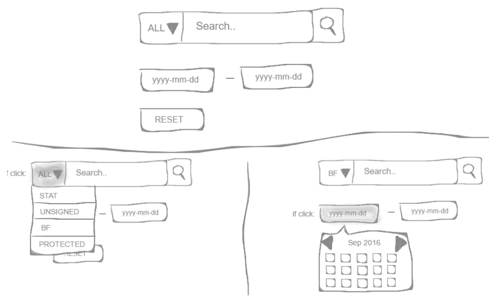
(b)

Figure 10: Worklist concepts 3 (a) and 4 (b). Worklist concept 3 (a) is a vertical list with selected information and a shape that points towards the next one in the queue. Worklist concept 4 (b) is a list with selected information and possibilities to open and delete on the sides.

Search and filter functions

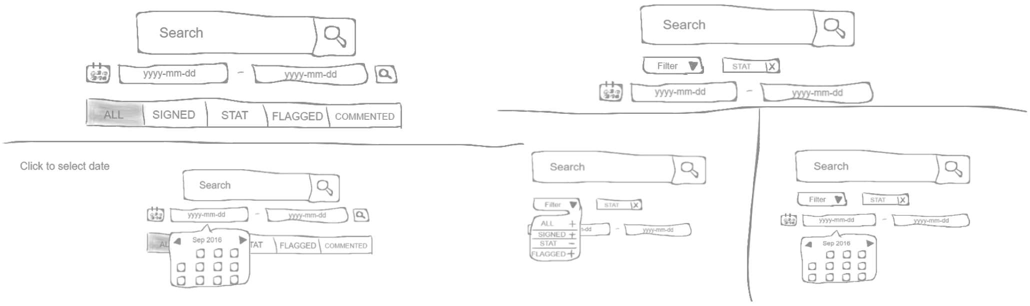


(a)



(b)

Figure 11: Search and filter concepts 1 (a) and 2 (b). Search and Filter concept 1 (a) shows a simple search field with a date picker, no filter function. Search and Filter concept 2 (b) shows search field with possibilities to choose in what filter to search within and a date picker underneath.



(a) (b)

Figure 12: Search and filter concepts 3 (a) and 4 (b). (a) shows a concept with a free text search bar together with a date picker calendar and a filter function with button filter options. (b) also has a free text search bar and a date picker calendar. However the filter function is a drop down menu of filters.

4.2.5.6 Defining a concept

4.2.5.6.1 Evaluation matrix

Here the evaluation matrices are presented in Table 2, 3 and 4. They show how well the different concepts match the different judging criteria applicable to the evaluated part in the Database View. The concepts with the highest value are the best fitted concerning the criteria.

The product goals used in the evaluation matrices.
Product goal number (PG nbr):

1. The Worklist should be dynamic in the meaning that it should be easy to use for the frequent users and for the user that do not frequently use it, the Worklist should not be too central in the workspace.

2. There should be only relevant filters. They should be visible and user should be able to switch between the filter without too much cognitive load. The filter and search options should be designed so that the user understand the difference between them and it should be made more clear how to select dates. There should be an option to reset the search area if wanted.

3. Independent of how many slides per order, the orders should be managed the same way.

4. The main list should not be truncated and all the information visible should be relevant. Orders should be clearly separated from each other and it should be clear which information that belong to each order.

5. The system should provide sufficient information for the user. However, information that is not important at the moment should be able to make less central.

6. The most frequent operations in the system should be easier to perform.

7. The unsigned orders have to be in focus.

	OL 2(reference)	OL 1	OL 3
PG 3	0	0	+
PG 4	0	0	0
PG 5	0	-	0
Correlate to the mental model of the current system	0	-	-
More up to date than previous interface	0	0	0
Summarization	0	-2	0

Table 2: Evaluation matrix for the Order List (OL) concepts that are graded against the different criteria. The reference concept, in the first column, are the concept that the other concepts are judged against. + if better than reference and - if worse than reference.

	WL 3(reference)	WL 1	WL 2	WL 4
PG 1	0	-	0	-
PG 3	0	0	0	0
PG 5	0	-	0	-
PG 6	0	-	+	0
Correlate to the mental model of the current system	0	0	-	0
More up to date than previous interface	0	0	0	-
Summarization	0	-3	0	-3

Table 3: Evaluation matrix for the Worklist (WL) concepts that are graded against the different criteria. The reference concept, in the first column, are the concept that the other concepts are judged against. + if better than reference and - if worse than reference.

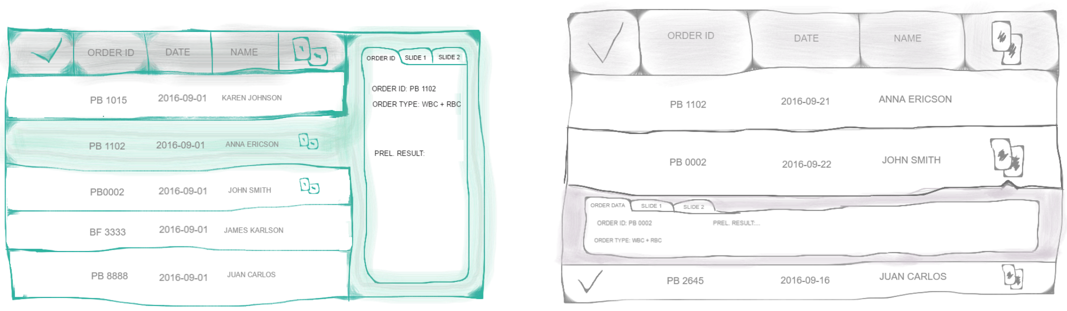
	SoF 3 (reference)	SoF 1	SoF 2	SoF 4
PG 2	0	-	-	-
PG 5	0	-	+	+
PG 6	0	-	-	-
Correlate to the mental model of the current system	0	-	+	+
More up to date than previous interface	0	-	-	-
Summarization	0	-5	-1	-1

Table 4: Evaluation matrix for the Search and Filter (SoF) concepts that are graded against the different criteria. The reference concept, in the first column, are the concept that the other concepts are judged against. + if better than reference and - if worse than reference.

4.2.5.6.2 Merging outcome

The result of the evaluation matrix, together with the insights from the workshop with biomedical scientists, the following concepts were chosen to proceed into the brainstorming of the final concept(see Figure 13, 14 and 15). The workshop insights can be seen in Appendix H.1. For the Order List and Worklist concepts, the two representatives were merged before entering the brainstorming session for the whole concept.

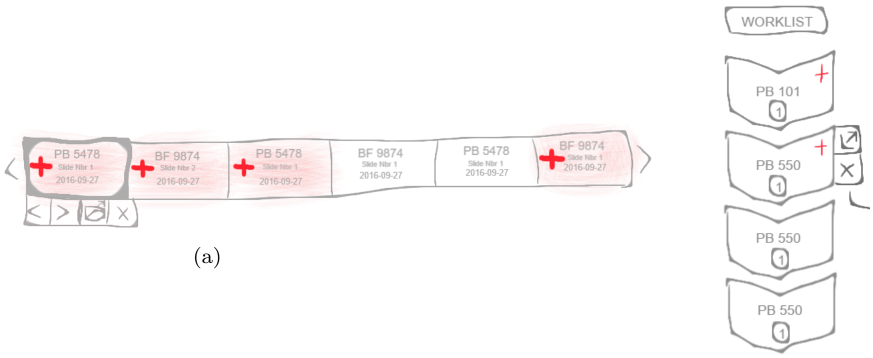
Order list



(a) (b)

Figure 13: Order list concepts 2(a) and 3(b) were chosen to proceed further in the process. Order List concept 2 (a) shows a concept where the order information is presented on the right hand side of the list. Order List concept 3(b) shows a concept where the the selected order's information is folded out from the order row in the list.

Worklist



(a)

(b)

Figure 14: Worklist concepts 2 (a) and 3 (b) were chosen to proceed further in the project. Worklist concept 3 (b) is a vertical list with selected information and a shape that points towards the next one in the queue. Worklist concept 2 (b) shows a horizontal list presenting selected information about the order

Search and filter

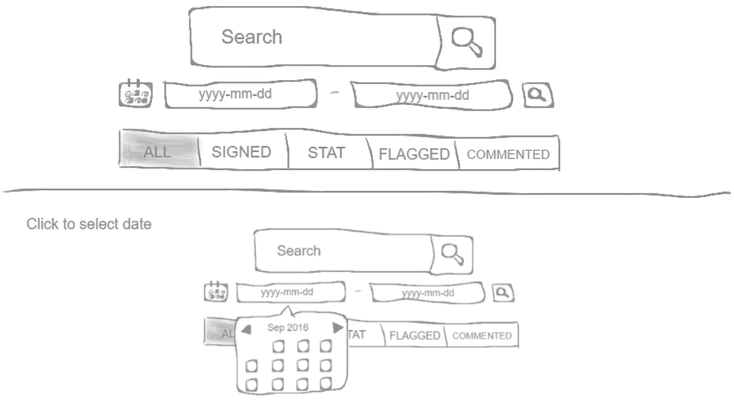


Figure 15: Search and filter concept 3 shows a concept with a free text search bar together with a date picker calendar and a filter function with button filter options. This concept was kept for further developement in the process.

The chosen concepts were merged into a full concept of the Database View. The concept can be seen in Figure 16.

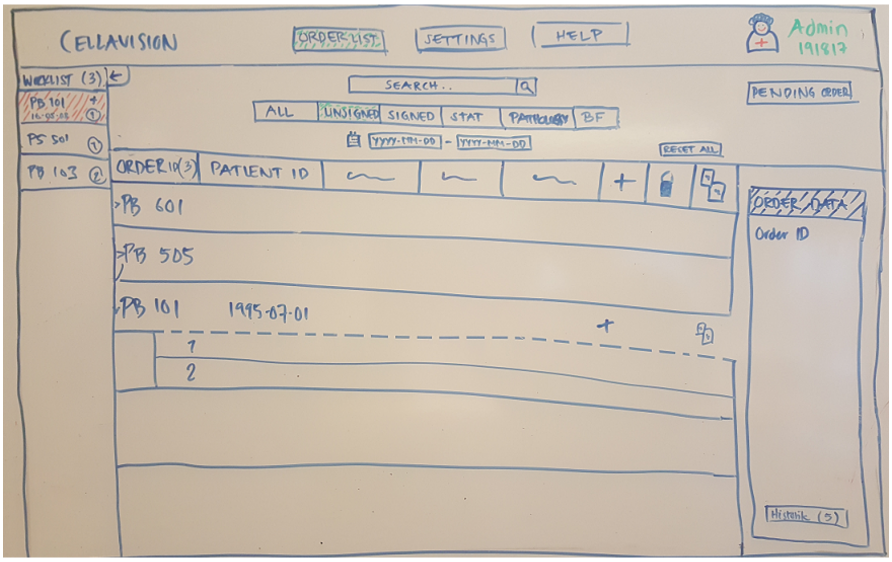


Figure 16: The merged concept of the Database View after the first full brainstorm session. It was drawn on a whiteboard to enable fast and easy changes. The Order List is still central and the slides fold out underneath the order with more detailed information to the right of the list. The Worklist is placed to the left and is dynamic and can be folded in and out. It will be possible to change the order in the list and the emergency orders have an orange background. The Search and Filter area is divided into a search part and filter part with a date picker and a reset button for easy reset option.

Order List

The Order List will contain all received orders with a default mode showing only the unsigned orders. If an order contains more than one slide, the order can be folded out, showing all containing slides. An order containing more than one slide has an indication of an arrow, showing the possibility to fold out and thereby indicating that the order contains multiple slides. To open an order or a single slide for analysis, one can double-click or use the open-button in the order/slide information. If the user wants to add an order or a slide to the Worklist, this can be done using the add-button in the order/slide information, using a hover shortcut add-button or by dragging and dropping in the Worklist. Order and slide data can be shown to the right by a single click on the specific order or slide. In the order data there is also a button called View History providing the user with the patient's previous orders.

Worklist

The Worklist will be dynamic, meaning that is can be folded in and out. Inside the Worklist, the emergency slides are marked with a red cross, all the slides can be moved internally to change the order in the Worklist and the slides are marked with the slide number to indicate if there are several slides in an order. The Worklist is static in length and covers the whole left side of the screen. It will be placed to the left in order to maintain the conceptual model that the users have today.

Search and Filter function
The Search and Filter function is divided into one search part and one filter part, with a clear distinction between the search and the filter function. The search function contains a free text search bar and a date selection bar. The Search and Filter functions can be brought back to default mode by using a reset all button.

5 The Elaboration Phase

In this part of the project, the ideas were further processed and an overall image of the new concept was created. By using methods such as low fidelity prototyping and user tests with the prototype, the ideas could be processed. By testing the concept together with users, the researchers could get an insight about how the proposed concept would work with the user and from there on continue with further development.

5.1 Creating a prototype

5.1.1 Low fidelity prototyping

Low fidelity prototyping in design processes are done in order to make quick and simple representations of new concepts, work flows or structures (Eleonora, 2016). The prototypes are generally characterized by low technology, e.g. sheets of paper. It is important to see that the prototype is just a prototype of low fidelity quality with the mission to test the concept flow, if the concept is intelligible and the overall concept. An advantage of a low fidelity prototype is that the user can criticize it easier if it does not look too laboured, and this is often succeeded through paper prototypes. They are also easy to modify, cheap to produce and simple to test. However, one crucial thing is that the scale of the prototype must match the final screen size through all the prototyping parts to get a result corresponding to the final implemented product. (Arvola. 2014 p. 132-133)

When a solution and a concept that fulfilled all requirements were found, low fidelity prototyping started. It was chosen to build a paper prototype. The prototype was done with the size of A3 papers as a base where sketches and build-on units of papers were added. Several sheets of paper with different scenarios of the Database View were produced in order to visualize the most used interactions that the end user performs. The prototype was adjusted to match design theory, such as the seven fundamental principals of design presented in the theory section. It was also adjusted to match product and user goals.

5.1.2 Result of low fidelity prototyping

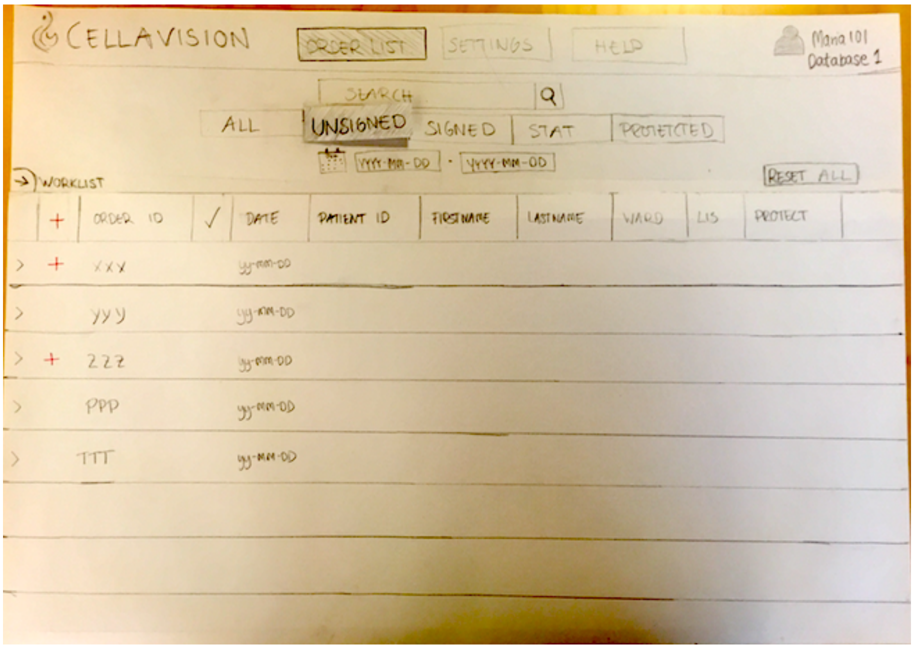


Figure 17: The low fidelity paper prototype showing the base of the Database View. The Worklist and the Order Data are folded in. The Order List and the Search and Filter function are visible.

Figure 17 is the low fidelity paper prototype that was used in the elaboration phase with the testing of concepts. Figure 17 shows the base paper prototype and Figure 18 shows the prototype with all attachments on it.

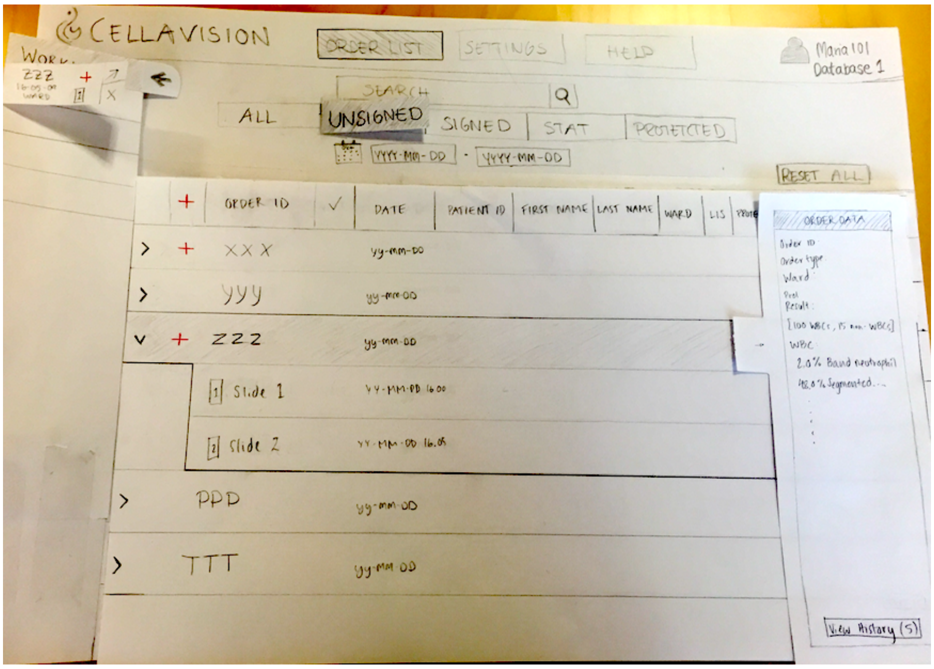


Figure 18: The low fidelity prototype with all attachments on. The prototype presents the Database View with the Worklist and Order Data visible together with the Order List and the Search and Filter function.

5.2 Testing of prototype

5.2.1 Testing

To see how a new concept is perceived, testing of a generated prototype can be conducted (Arvola, 2014 p. 134). In order to establish a user-centered design, prototypes should be tested on the end users (Arvola, 2014 p. 134; Retting, 1994). Informed consent and scenarios for the test should be carefully written together with a test protocol and pilot tests should be performed before the real test (Arvola, 2014 p. 137). The test leader should be well prepared and not give the test person directional instructions and the test person should figure out the way through the prototype with no help and describe what thoughts and questions that appears during the test. The test person should also be informed about that the test only tests the prototype and not the understanding of the test person. It is recommended to divide the test between four different roles. One researcher should be the host, introducing the test person to the test and make the test person comfortable. One researcher should be the test leader, leading the test and keep track of time and scenarios. Another one should handle the prototype and interact with it depending on what the test person does. The last role is the researcher that takes notes during the test (Arvola, 2014 p. 134).

5.2.2 Scenarios and closed tasks

When performing usability testing, the goal is to understand how users interact with the user interface and discover what is causing them trouble. Rather than just telling them exactly what to do, it is more beneficial to put the situation into a scenario. A scenario puts the participant into a context, explaining why the participant is doing something. The scenario should display the most important things that users should be able to accomplish when using the product (Nielsen, 2014). Putting a task to a story makes it more natural to explain what the task means in its context and why it needs to be performed (Preece, et al., 2011 p. 374). The scenario should be formed in a way where the user is encouraged to interact with the interface, without describing steps or giving away clues for how to perform certain tasks (Nielsen, 2014).

Closed tasks are strictly instructional with a clear defined success criteria. Direct tasks that are closed ended are recommended to have when testing technical data (Cao, 2015). Since the task has a correct answer, it allows the tester to measure if participants solved or failed a task.

When performing qualitative tests with the prototypes in this project, a mix between scenarios and direct closed ended tasks were used. Scenarios were used to put the test into context and make the participant comfortable in the position as a user. Then the participant was given direct closed ended tasks to complete. To make sure the tests represented real situations, the most common tasks in reality were chosen as tasks in the test.

5.2.3 Qualitative testing of low fidelity prototype

Before testing the paper prototype with the end users, scenarios were written and tested in a pilot test together with the low fidelity prototype and a test protocol (see Appendix G.1). When the real tests were performed with the end users, an oral informed consent was agreed on. Since there were only two researchers in this project, the roles were divided between these two. One of the researchers acted as the test leader, asking the questions and interacting with the prototype. The other researcher was documenting the test with the test protocol and had the introducing and welcoming role in the test. When testing the low fidelity prototype, it is important to explain to the users that the prototype is not finished in detail. The prototype was shown to end users and they tested the interface with different, often operated scenarios. Six biomedical scientists tested the low fidelity prototype. Some of them had participated in the project before and some of them were participating for the first time.

All the documentation and opinions from the tests were transferred to sticky notes and placed on the prototype and categorized into the different areas of the concept. Furthermore, the opinions were discussed and compared to design theory and goals and some were decided to merge into the concept and some were chosen to be left for future updates.

5.2.4 Result of testing the low fidelity prototype

The results from testing the low fidelity prototype are fully shown in Appendix H.2 and the insights graded as Necessary(N) in the function analysis are presented below. These are the objects that are considered in the future work with the prototype.

- Make the reset all-button clearer and decide the placement
- Number of slides in Worklist have to be visible if the Worklist is not open
- Only lastname in the list
- Add pathology as a filter
- Make it easy to reset the search field
- Make it easy to reset the calendar
- No cell counter data in order data, it will not fit according to users

5.2.4.1 Changes for next phase

Order List
The First Name-column was eliminated from the Order List to declutter and get more white space into the list. It was chosen not to implement the cell counter data into the order data information field due to lack of space and low importance in this particular view.

Worklist
A number indicating the number of slides in the Worklist was added in the Worklist-icon and located on the Open Worklist-button. It was added to give the user better visibility of the state of the system.

Search and Filter function
It was chosen to implement individual reset buttons for the free text search bar and the date search bar. The buttons are placed on the right side close to each search field to make sure it will be clear which bar each button belongs to. A pathology filter was added to the filter functions in order to make the filtering for this important group of orders easier.

6 The Detailing Phase

Once overall principles and designs were defined, the project headed into a detail phase. By gathering more information from users, more details were determined and a specification of requirements was established. Once more details were set, a high fidelity prototype was created and tested. To get quantitative measurements of the usability of the result, a System Usability Scale was applied, together with a comparison between the new concept and the current user interface.

6.1 Information gathering

A list of the specific requirements for the database view was concluded before the detailed prototyping began. The list consists of the requirements that the system needs to have in order to work as a user interface for hematology analyzers. The requirements are derived from CellaVision restrictions, the information gathering process and the product goals. In order to get even more specific detail requirements for the system, more information was gathered by doing low fidelity testing. The information about details were compared to the previous information gathering process and if applicable, it was added to the list of requirements. The list of specific requirements are found in Appendix I.

6.2 Creating a prototype

6.2.1 High fidelity prototyping

A high fidelity prototype looks much more like the final product in comparison to the low fidelity prototype. Prototypes of high fidelity are made up by the materials that are expected in the real product. A high fidelity prototype has many advantages. It can be used for exploration and tests, it is clearly defining the navigational scheme, it feels like the final product and it serves as a living specification. However, it also comes with some disadvantages such as being time-consuming to create and modify. (Arvola, 2014 p. 146-148)

After the low fidelity concept of a user interface was developed, the high fidelity prototype was created. To create images for the prototype, Adobe InDesign CC was used. This desktop publishing software application can be used to produce posters, flyers, books and more, and was considered suitable to produce images corresponding to a user interface. Images for the database view were produced, including all different views that the interface would change to when performing different tasks. To make the images interactive, InVision was used. InVision is a prototyping tool that allows researchers to compose clickable, interactive prototypes using pictures linked to each other. This tool can be used for web, tablet and mobile designs. The scope of the high fidelity prototype was held within the possibility to perform previously tested scenarios that covered all the main functions in the database view. The high fidelity prototype was built based on the low fidelity prototype that had been tested and developed in the previous phase of the project. For the high fidelity prototype, more details were added based on the specification of requirements, together with an appearance more true to the real product.When all the images were produced, they were linked together in InVision and formed into a clickable, interactive interface.

6.2.2 Result of high fidelity prototype

The high fidelity prototype is presented in Figure 19, 20 and 21.

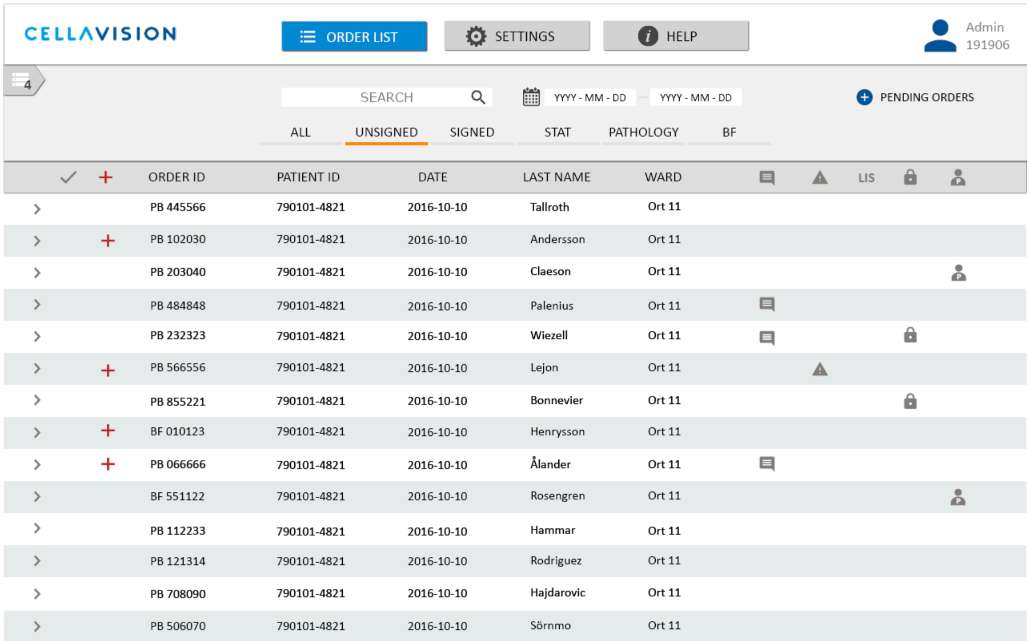


Figure 19: The high fidelity prototype showing the start view of the Database View with only the Order List showing.

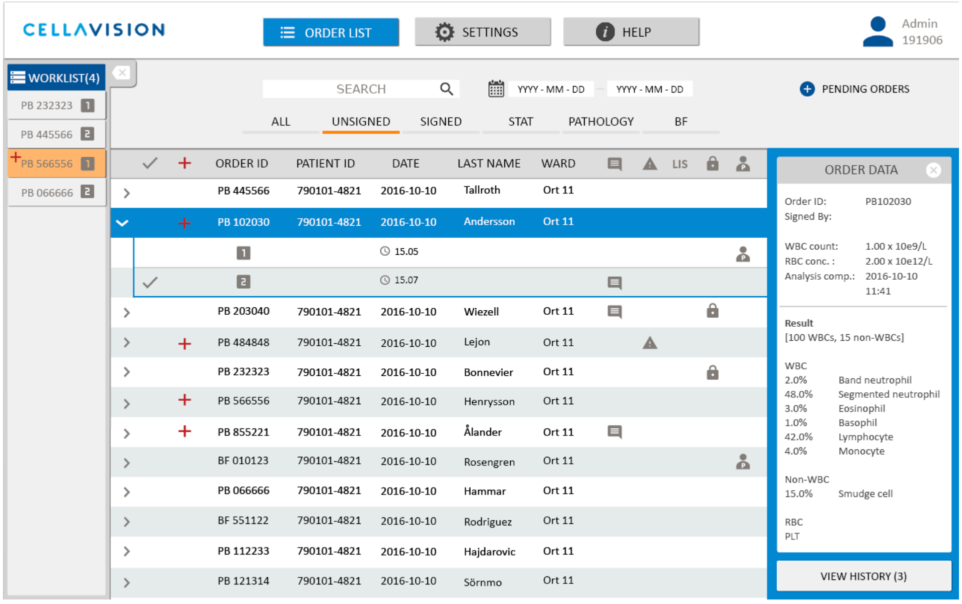


Figure 20: The high fidelity prototype of the Database View with the Worklist and the chosen order's specific data of order and slide.

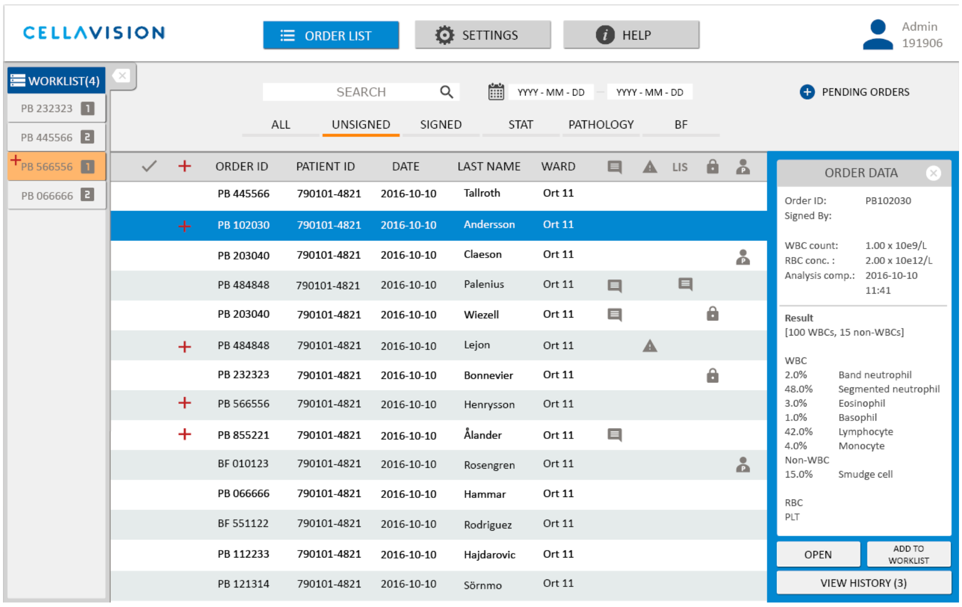


Figure 21: The high fidelity prototype of the Database View for single slide orders. It is shown with no arrows on the left side of the rows. Worklist and Order Data is also shown.

6.3 Testing of prototype

6.3.1 Qualitative testing of high fidelity prototype

In contradiction to low fidelity prototype testing, where the interest is to test the concept of the ideation, high fidelity prototype testing also includes test of the feeling and look of the prototype. It is also possible to test the efficiency of the high fidelity concept through measuring, e.g. time consumption of tasks, and get quantitative data of the prototype. (Arvola, 2014 p. 146-148)

Before testing the high fidelity prototype with the final user, informed consent and a test protocol were written. The previously used scenarios were used (see Appendix G.1). They were all tested together with the high fidelity prototype in a pilot test in order to find limitations in the test setup and to be able to correct those before the real testing. When the testing of the high fidelity prototype was performed an informed consent was agreed on. During the test, one of the researchers acted as the test leader, asking the questions and if necessary, interacting with the prototype. The other researcher was documenting the test with the test protocol (see Appendix G.1) and had the introducing and welcoming role in the test.

Initially in the testing, it is important to explain to the test persons that the high fidelity prototype is not the final product even though it might look like it and that there is still room for improvements. The prototype was shown to seven end users and they tested the interface with different, often operated scenarios. The results from the testing culminated into insights that were graded according to a functional analysis with Necessary(N), Desired(D) or Unnecessary(U).

6.3.1.1 Results of qualitative tests

All insights from the tests are presented in Appendix H.3 and the insights that were graded as Necessary (N) in the function analysis are presented here since they are the subjects that proceeds into the next part of the project.

Qualitative insights graded as Necessary(N) to change:

- Better mapping of the filters
- Drag and drop order to Worklist
- Redesign pathology icon
- Remove the pathology filter
- Redesign header columns
- Make the column header with icon customizeable
- Remove hover for open slide
- Enable: mark several slides and add into Worklist

6.3.2 Quantitative testing of high fidelity prototype

6.3.2.1 Time to completion and difficulty of task

Getting quantitative results for a product or system enables reliable measurements of the usability. One example is to measure the time when performing direct closed tasks in the system. Time is an important factor for health care sectors and measured time for direct closed tasks can give valuable insights about the usability for a system (Arvola, 2014 p. 146).

Quantitative measurements of this character were chosen for this project. Completing measurements for both the old and new interface, enables reliable comparison between the versions and can point out improvements and successful parts. Direct closed tasks, withdrawn from the information gathering process, were written to test with the test persons (see Appendix G.2). To structure the tests, a test protocol was made (see Appendix H.4). To maintain independent and unbiased test results, the test persons for this part of the project had no education of the systems and have not worked with hematology analysis before. The participants were students at university level with an average computer literacy.

6.3.2.2 System Usability Scale

To get quantitative measurements of the usability of a new concept, a System Usability Scale can be applicable. The method was created in 1986 by John Brook and have become an industry standard to use when evaluating the usability of products and services. The questionnaire consists of ten item questions with five response options; from Strongly agree to Strongly disagree (Brook, n.d). Benefits of using this method are that it is easy to scale, it can be used on various sample sizes, it gives reliable results and it effectively separates usable systems from unusable ones (Usability, n.d.). In order to calculate the System Usability Scale score the sum of all the score contributions from each question has to be calculated with a specific equation (Brook, n.d). The final system usability value will range between 0 and 100 (Brook, n.d). The average score of system usability is 68 and it is recommended to reach a value above that (Sauro, 2011). Figure 22 shows the System Usability Score diagram with adjective ratings and acceptability ranges. This diagram was used to compare the obtained value from the System Usability Scale testing with the rating from the diagram and the marked value of 68 (star) that marks out the average (Sauro, 2011).

6.3.2.3 Test session

The test persons first signed a contract of confidentiality, developed by CellaVision and also an informed consent (see Appendix D.3) about the project. The test started with a short background about the project and the test specifications. One researcher was the test leader, giving the tasks and the other researcher took the time of the tasks and handled a hovering board with the mission to cover the interface between the different tasks. The test person orally received the direct closed tasks from the test leader and after, the other researcher removed the board and started the timer. When the task was finished, the time was written on the protocol and the test person estimated the difficulty of the task from 1 to 5 where 1 is Very Easy and 5 is Very Difficult. When all the tasks were done for one system, the test person also filled in the

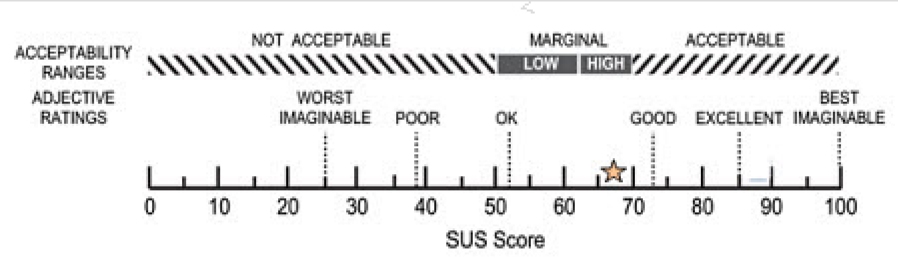


Figure 22: The System Usability Scale diagram for comparison with a star marking the average value of systems with good usability (Carroll, 2013)

form of System Usability Scale questions concerning the interface. The test iteration was then done again but with the other interface.

Six test persons participated in the test, three men and three women. Three performed the task and the System Usability Scale questionnaire on the old interface first and then the same thing on the new concept. Three of the participants started the test with the new interface and then the same thing with the old interface. This was done to eliminate the results being biased due to learning the system in the first round.

Analysis of the result was done within Excel making charts of average time per task and comparison between the old and new user interface. Also, the value of difficulties for each task were summarized and an average number for each task of each of the systems were calculated. An equation to calculate the System Usability Scale value was used and an average value was concluded (Brook, n.d).

6.3.2.4 Results of quantitative tests

Both the old and the new user interfaces were used within the tests and the results are presented in diagrams. The full table with results for each test person can be seen in Appendix H.4.

6.3.2.4.1 Time to completion

The tasks for the tests were:

1. Find patient "Rosengren" in the Order List
2. What is the value for segmented neutrophils in slide 1 in Andersson's order?
3. Search for patient ID 800202-4692 and find the sample that was analyzed between the 10th and 12th of October.
4. There is a Worklist to the left on your screen. Are there any stat orders in the Worklist?
5. Add slide 1 of Andersson's order to the Worklist, when the task is done only slide 1 from Andersson is in the Worklist.

6. Open slide 2 of Andersson's order.

Figure 23 show the time of completion for the six tasks that were presented to the test person. The grey bars show the average time for the old interface and the blue bars show the average time for the new interface. For task 1 and 6, the old interface had shorter time to completion than the new interface. For task 2, 3, 4 and 5, it took shorter time to complete the tasks in the new interface.

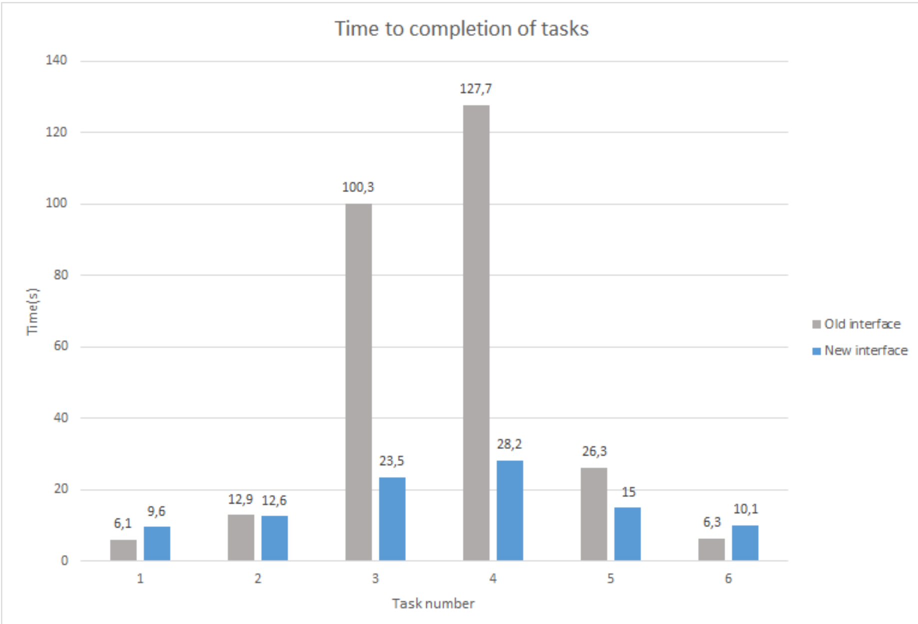


Figure 23: Result of the average time to completion for the tasks performed in both user interfaces. The grey bars show the result for the old user interface and the blue bars show the result for the new user interface.

Figure 24 shows the estimated difficulty of the tasks that were performed by each test person. The grey bars show the average level of difficulty of tasks for the old interface and the blue bars show the average level of difficulty of tasks for the new interface. For task 1 and 6, the new interface is estimated as more difficult than the old interface. For task 2, 3, 4 and 5, the old interface is estimated as more difficult than the new interface.

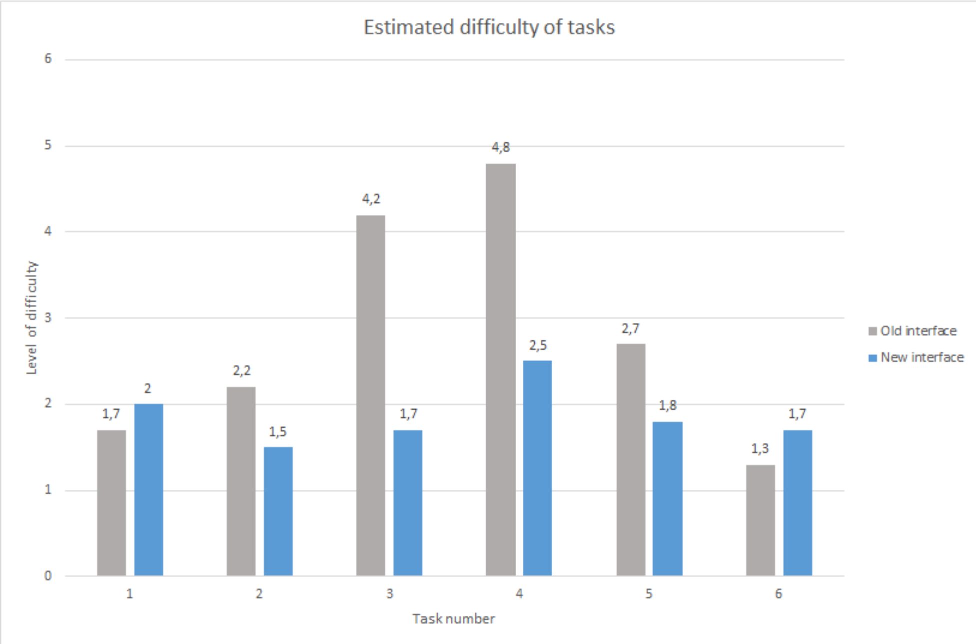


Figure 24: Result of the average estimated difficulty of tasks for both user interfaces. The grey bars show the result for the old user interface and the blue bars show the result of the new interface.

6.3.2.4.2 System Usability Scale

Figure 25 shows the average value of the System Usability Scale form that the test persons filled in after using each of the interfaces. The old interface got an average value of 33.3 and the new interface got an average value of 84.1.

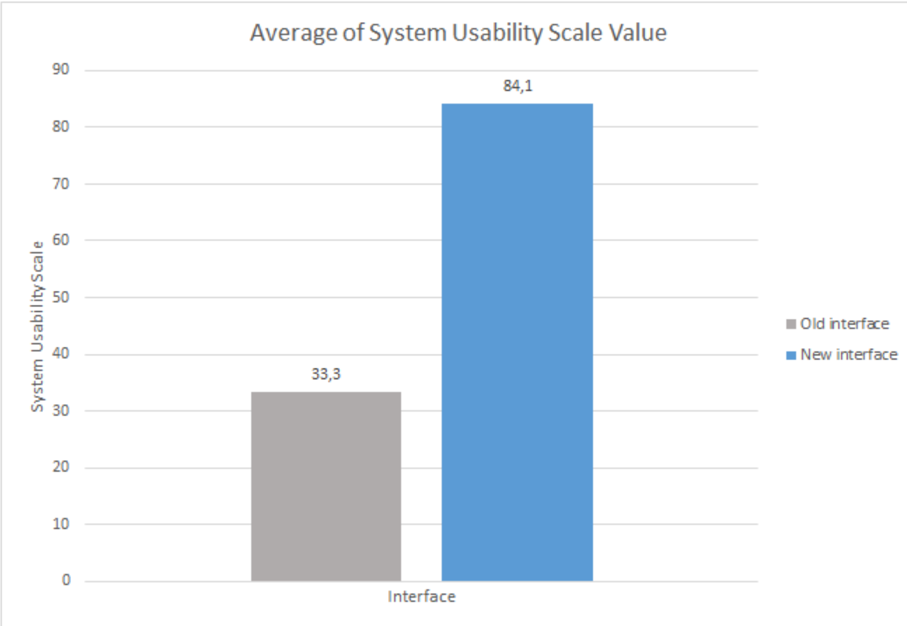


Figure 25: Result of the average System Usability Scale value for both the old (grey bars) and new (blue bars) user interface. The scale goes from 0 to 100 and a value above 68 is acceptable (Sauro, 2011).

Figure 26 shows the System Usability Scale diagram with the star that shows the average System Usability Scale value for products considered having acceptable usability (Sauro, 2011). The average System Usability Scale value for the old interface is marked with a grey circle and the average System Usability Scale value for the new interface is marked with a blue circle. The old interface is in the "Not acceptable" range between the "Worst imaginable" and "Poor" rating and the new interface is in the "Acceptable" range close to "Excellent". It is important to take in consideration that these values and results are for non-educated users within hematology and the system.

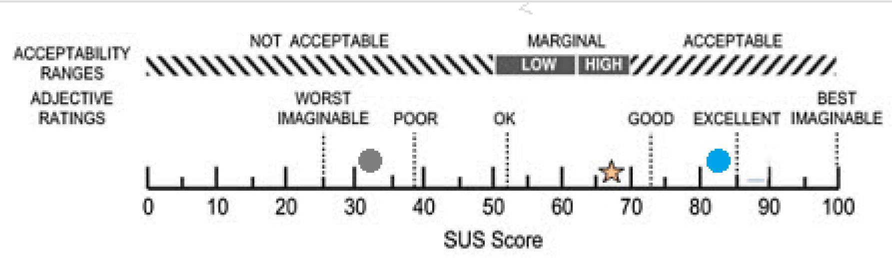


Figure 26: The System Usability Scale diagram with both interfaces in comparison. Grey dot is the old interface and the blue dot is the new interface. The star shows the value of 68 and above that value is preferred (Sauro, 2011).

6.3.2.4.3 Quantitative insights to improve

From the quantitative test, task 1 took longer time in the new interface than in the old interface. It was also estimated as more difficult than in the old interface. For task 6, it also took longer time for the new interface and this task was estimated as more difficult than the old interface. The workflow for task 1 and 6 are further evaluated and possible changes to get better results for time of completion and estimated difficulty are discussed below.

6.3.3 Overall changes from the qualitative and quantitative testing

The insights from the functional analysis that was graded with Necessary (N) and the insights from the quantitative tests are presented below.

Order List

The possibility to drag and drop orders, from Order List to Worklist, was added. Also, the possibility to mark several slides and add from the Order List to the Worklist was added. These features were not possible to implement in the prototype, however they were kept in the concept to be added in a possible real product. The pathology icon still needs improvement. Thus, no other, more suitable icon, was found and due to no possibility to discuss this subject with customers who uses this function, it was left for future work. It was chosen to improve the mapping of the columns. This was done by decreasing the space between the rows so that the information in the columns are clearly mapped together. The background colors of the rows were changed to two more homogeneous colors, still distinguishing the rows from each other but with a more uniform impression.

Worklist

No changes were done in the Worklist.

Search and Filter function

It was chosen to change the mapping of the filters. The three exclusive filters All, Unsigned and Signed were mapped together representing the exclusive filters. The other filters can be combined with one of the exclusive ones and also with each other. These ones were mapped together to indicated that they belong to the same type of filter, and do not have the same property as the exclusive ones. It was also chosen to add the filters: Error detection and More, where the user can chose what more filter the user would like to have present. This was done in order to be able to customize according to the different user interests. To get a hierarchy within the filters, the three exclusive ones were moved and placed above the other filters. The top ones are still written in capital letters and the filters below, that can be combined, are visualized with icons. The Pathology filter was removed and replaced by a filter for Protected orders. This due to the fact that only one user segment uses the Pathology function but not the whole customer segment.

7 The Final Design

7.1 Database View

According to the changes that were stated in the section *6.3.3 Overall changes from the quantitative and qualitative testing*, a final concept was created. The existing user interface of the system is also shown as a comparison(see Figure 27). Below is a suggestion of how user-centered design can improve the user interface(see Figure 28).

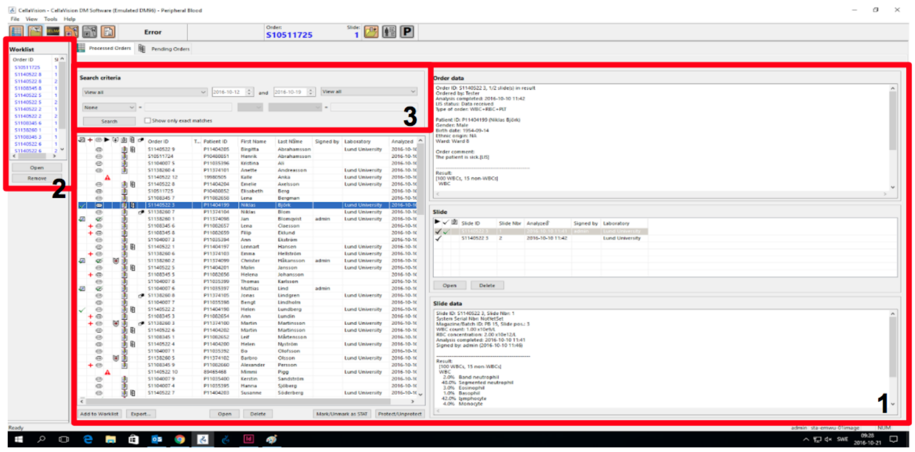


Figure 27: The existing Database View with red marks of the three parts evaluated. 1 is Order List, 2 is Worklist and 3 is Search and Filter function. These areas can also be identified in the new interface (See Figure 29, 30 and 31).

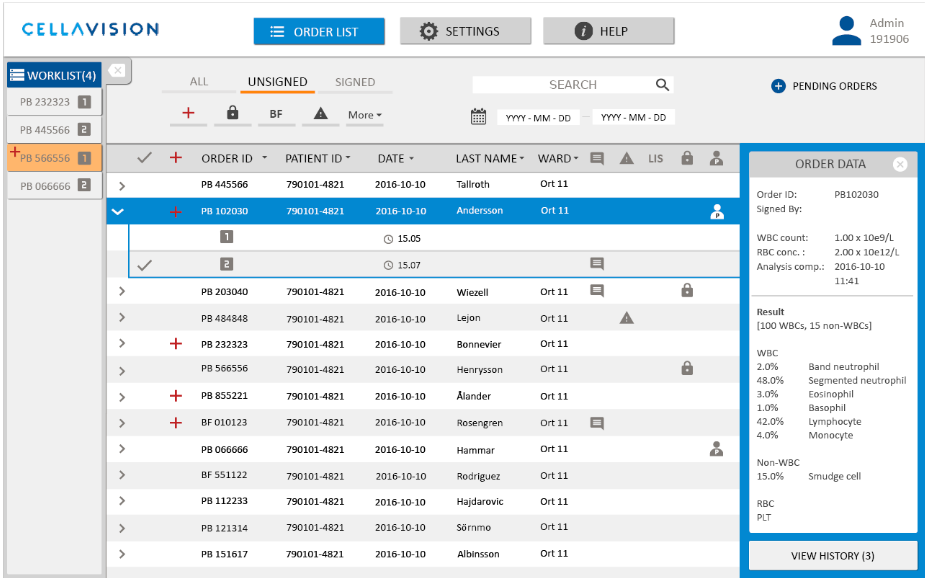


Figure 28: Final design of the new graphical user interface for the Database View with a marked order, Order Data and Worklist present.

7.1.1 Order List

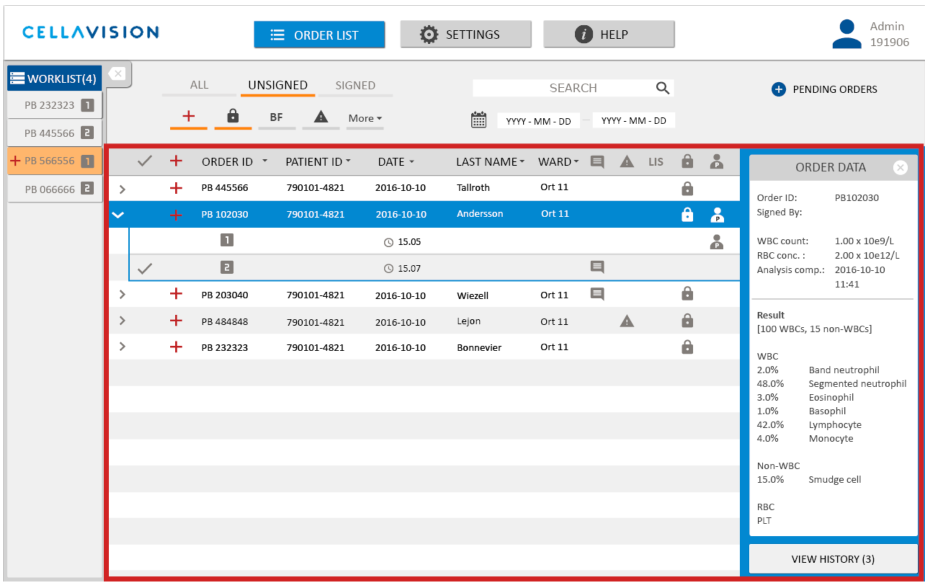


Figure 29: Final concept of the new graphical user interface with red mark of the Order List area, can be compared to red mark number 1 in Figure 27.

In the Order List (see Figure 29), the orders will be visualized in a list just like in the old interface. This can be compared to Figure 27, red mark number 1. If the order has more than one slide it will be marked with an arrow in the left margin. This is to signalize to the user that the order can be folded out. If an order contains only one slide, the arrow will not be present and the order can not be folded out. Next to the placement of possible arrows, icons for signed and emergency orders are placed. These icons are important to see before opening a slide and are therefore put first on the row for a slide. Next, information of the patient and the order are placed; Order ID, Patient ID, Date(of analysis), Last Name and Ward. This is the information that are wanted according to the information gathering process. To the right of the patient information, icons are mapped and the most important icons for the customers are chosen to use.

If there are more than one slide when choosing an order, the order will fold out and display the number of slides on rows below the order. The order row will be marked with blue to indicate that the order is chosen. The arrow will now point down to indicate that the order is folded out. One can click on each of the slides and the blue background color will move to the chosen one. There will also be a field to the right that is folded out when choosing an order. When the user clicks on the order, Order Data will be shown in the right field and when choosing a slide, Slide Data will be shown instead. The field to the right and the order can be closed by clicking on the cross in the field or by clicking on the order data row twice. In Order Data, at the bottom, a patient history button will be located so the user can view previous orders of the same patient. The slide data shows slide specific information about the result and also displays buttons to open the slide and to add it to the Worklist. On the slide rows in the list, a number shows which number the slide has and what time it was analyzed into the system. The slide rows are indented to start further in on the row. On the slides, a hover shortcut button with the function to add to Worklist is shown if the mouse is placed on a slide. If the slide is already added to the Worklist, the hover shortcut button will be displayed with a grey color instead of orange. The user can also double-click on a slide to open it and drag the slide to the Worklist to add.

7.1.1.1 Motivation

It was chosen to present the orders in a list, as in the old interface. People tend to read web contents in an F-pattern, starting with a horizontal movement in the upper part of the content area and then the user scan the left content with a vertical movement (Nielsen, 2006). The choice to put the most important icons as far to the left as possible was made according to the F-pattern reading. Consequently the less important information as ward, comment etc were placed further to the right. This to ensure that the user will see the most important information first when analyzing the order. It is important to map the written information together and the icons mapped separately to make it easier to read for the user(Norman, 2013 p. 113). It is of great importance that the icons are designed with the conceptual model of the users in mind. The contrast ratio of the text towards the background should also be at least 4.5:1 to make it easier for the user to read and this has been adapted throughout the project when choosing colors (Babish, 2016). In order to make it easier for the customer to segment out different orders, the background color alternate between two colors. The single striped rows are also more preferred in contradiction to plain rows(Enders, 2008). The choice to indent the slides compared to the order was made to indicate the mapping of the order and its slides and to ease the understanding of the belonging(Norman, 2013 p. 113). Order information that folds out from the right of the screen have the same placement as in the old interface due to the conceptual model of the users(Norman, 2013 p. 72). The functions have slightly changed but the user recognize where to look for the information about the order and slides. Changing the background color of the chosen order or slide is to give feedback to the user about the selected item and to clarify that the information to the right is specific for the chosen item(Norman, 2013 p. 52,72). For frequent users, the hover shortcut button can be used to speed up the work. This is recommended in Schnidermans 8 golden rules for interface design (Schniderman et al., 2016). It was chosen to use a hover button to minimize the cognitive load and limit visual clutter when the user does not need the function (Harly, 2015). The button will only be exposed when the user aims to do something with the particular order. The ability to drag and drop the slides to the Worklist comes from the workflow in the other views of the system. When the user classifies the cells in the sample, the user can drag and drop the cell to its category. Enabling the same movement pattern for several actions increases the consistency of the system (Schniderman et al., 2016).

7.1.2 Worklist

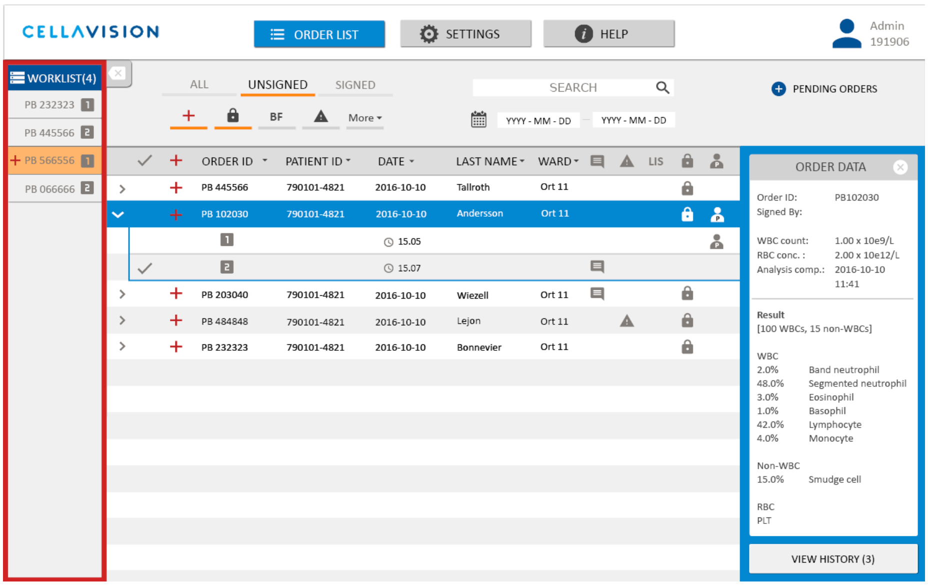


Figure 30: Final design of the new user interface with red mark of the Worklist area. Can be compared to Figure 27, red mark number 2, for the old interface.

The Worklist (see Figure 30) will be dynamic which means that it can be folded in and out on the screen. There will be a number present at all times on top of the Worklist (both when folded in and out), showing how many slides that are in the list. Compare with red mark number 2 in Figure 27 to see the different designs for the old and new interfaces. Into the new Worklist, slides will be added as in the old interface but with information adapted to the users. The information will all be visible with no need to scroll as in the old interface. If a slide is an emergency order, it will be a red cross and orange background on the slide in the Worklist to signalize the status to the user. The slide will also be marked with a number that describes the slide number for the order, if the order has several slides. Order ID will be shown in the slide information for the Worklist. In the Worklist, the slides can be moved and rearranged by dragging the slides to a desired place. This can also be done by a right-click. When holding the mouse over a slide in the Worklist, the slide will be highlighted. The Worklist is static in length and will be able to show more slides than the old interface. Placement of the Worklist will be to the left, the same place as in the old interface.

7.1.2.1 Motivation

The reason for a dynamic Worklist is to satisfy the different users. It was found in the information gathering that the usage of the Worklist varies between the users and therefore the Worklist was chosen to be dynamic. A Worklist that can be hidden opens up the possibility to reduce the number of items present on the screen and this can lead to a reduced cognitive load while working in the system (Harly, 2015; Söderström, 2013). To follow the already existing conceptual model among the users, the Worklist was placed on the left side of the Order List, starting in the upper left corner stretching down to the bottom of the screen (Norman, 2013 p. 72). Additionally, more orders in the Worklist will be visible without scrolling, due to the fact that the Worklist stretches down to the bottom of the screen instead of just to the middle of the screen like in the old user interface. The icon representing emergency orders was chosen to be a red cross, a symbol often associated with emergency services. It is commonly seen on ambulances, hospital signs etc. The other icons in the interface were selected in a similar way. They were chosen to resemble commonly used symbols for the purpose of each icon and to fit well into the conceptual model. The icons are supposed to help the user, by functioning as a signifier that enhances the discoverability and feedback to the user. By having well thought out icons the user has a good understanding and can feel in control when using the system (Norman, 2013 p. 72).

7.1.3 Search and Filter function

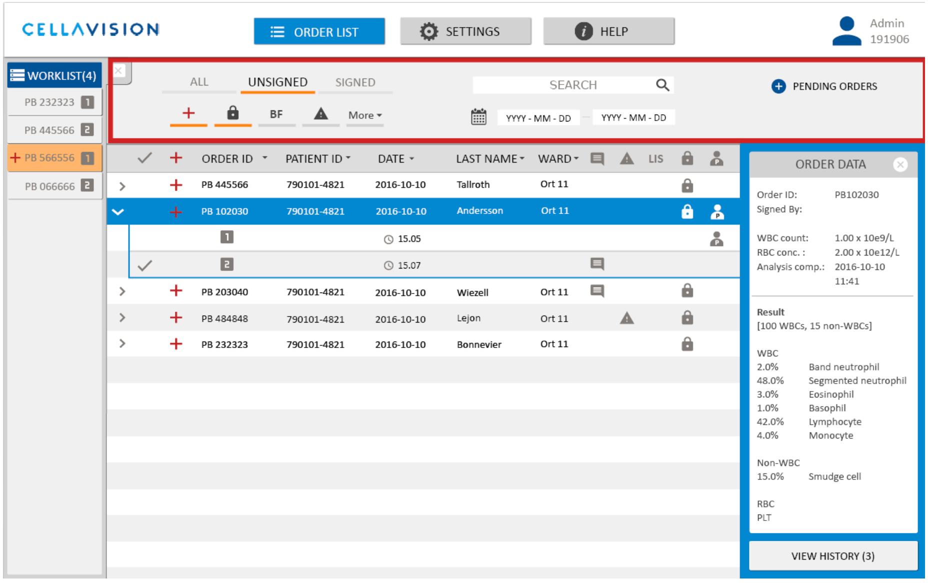


Figure 31: Final concept of the new graphical user interface with a red mark of the Search and Filter function that can be compared to red mark number 3 in Figure 27.

The red marked Search and Filter function in Figure 31 can be compared to red mark number 3 in Figure 27. The Search and Filter function will be clearly divided into a search and a filter part. In the search box, the user will be able to search for what is wanted. The user does not need to specify in what area to search within, as in the old interface. A date picker, a full month calendar, is also implemented into the search function. The user can choose a date from the calendar by clicking on one of the days. There will be a cross to remove the search and dates easily. The user do not have to delete what is searched and reset the calendar manually. The filter function will have six items and they can be selected and combined in various constellations. Three of the filters are exclusive filters, which are mapped together. Those are the filters "all", "unsigned" and "signed". The other filters can be combined with each other and/or with one of the exclusive ones and are therefore mapped together.

7.1.3.1 Motivation

It was chosen to clearly separate the Search and Filter areas because this will make it easier for the user to understand how to use the functions and separate the different usage of the functions. To have a clear mapping of the different purposes of the functions will also give the user a better understanding of the functions and how to apply them in the system (Norman, 2013 p. 113). A datepicker was implemented from which the user can choose a date from by clicking on a certain day. Using a datepicker is an efficient way of selecting a date. This fits well into the conceptual model of how a month is displayed and the user can select a date in one click, compared to writing it manually with numbers. It is important to not display more filters than necessary. The more information visualized, the more cluttered an interface becomes with heavier cognitive load and therefore only the most relevant filters were chosen to have present at all times (Harley, 2015; Söderström, 2003). The filters were mapped according to the different properties of the filters. The exclusive ones were mapped together, while the non-exclusive ones were mapped as another group. This was done to help the user understand which of the filters that could be combined with others and which ones that could not and rules about mapping have been applied (Norman, 2013 p. 72).

8 Discussion

This section will discuss the overall design process of this project, the methods used in the design process, the results of the project and possibilities for the project in the future.

8.1 Design process

The design process chosen for this project was influenced by Mattias Arvola's book Interaktionsdesign och UX (Arvola, 2014), as stated in the method section. The book recommends certain methods to use in the concept, elaboration and detailing phases. Most of the methods have been used throughout the project. However, some methods were modified and other external methods were also brought to the project. This was done in order to adjust the methods to this type of project and to meet the requirements from the company's perspective. E.g. the heuristic evaluation is suggested to use as a survey in the end of the project on the concept prototype. In this project, the heuristic evaluation was instead used as an information gathering method to receive valuable insight of the usability of the existing system. It was chosen to work according to Arvola's process since it is straightforward and the researchers had used it in previous design projects. Other sources than Arvola have also been used. In order to get a triangulation in the design process methods, other sources were used and a lot of the inspiration came from articles presented by NNGroup (NNGroup, 1998-2016).

A design process is a dynamic and iterative process with several phases of going back and change, gather more information and redo the processes. It is important to apply this approach to the project, and not forget to iterate and see if other findings can change the outcome. For this project, the main focus was user-centered design and the users were a part of the study all along. To not get biased and only recognizing the opinions from a specific user group, it was important to visit different users and laboratories. Also, an interview with a representative from the US was concluded to get opinions and feedback from another country with different workflow, goals and laws for the system evaluated in this project.

8.2 Methods

As previously mentioned in the report, it is sometimes recommended to be four people in a research session such as interviews or user tests. However, this team of researchers contained only two people. The different roles were therefore taken by only two people and they performed the tasks of four people. This approach worked well and the researchers managed to act two roles at the same time. Yet, this may have affected the result. The researchers taking on two different roles were busy managing the test and may have lost focus on the impressions from the results coming out of the test. For example, the person taking notes was busy performing another task too, and may therefore not have been as focused on taking in the result. If there had been four people taking on the roles, the researchers may have had less managing tasks to focus on and could have been more responsive to impressions of the tests.

When gathering information to a project, it is important to cover a broad range of information sources. In this project, three different approaches were taken in the information gathering process and information was taken from both theory, experts and users. This has given the project a solid ground and many aspects have been considered. The triangulation of methods has given the project insights about what is important for all stakeholders and how they are involved in the product. It has also led to conclusions of what really is desired by the users and not only what the experts think the users want.

The heuristic evaluation was done by the researchers themselves as experts. This may have had an effect on the result considering that the researchers already knew that they would work with this system and try to change it to the better. The researchers might have had a more judging approach and criticized the system more than needed.

One challenging part of the information gathering process was gathering information from users. The users of CellaVision's products are located all over the world. The researchers did not have the possibility to meet all the users or representatives from all user areas, due to limitations in economy and the time frame of the project. The main part of the information gathering process was made in Skåne, Sweden. The researchers got an opportunity to interview a representative from the US market. Although the researchers aimed to consider all users of CellaVision's products, the result represents mostly the southern Swedish market. Furthermore, all user tests of the concepts were performed in Skåne, Sweden and further modifications of the concepts were based on the tests. This results in a final concept that may have had a greater focus on the Swedish market. To get a more world-wide representation, interviews, observations and user tests should have been performed with users representing all user areas in the world and also all kinds of laboratories. The difference in geographical area and laboratory size affect the users in terms of their working conditions and their different requirements while working. Some users may have an extensive demand for analysis of blood samples and require a fast and efficient workflow. Other users have a requirement of always analyzing two slides, versus single slide orders, per order and therefore they need an efficient workflow to manage double slides. These are just some examples of what differed among the users that were studied and it is important to be aware of the fact that the usage could differ even more among those users that did not take part in this study. Although the researchers did not have the possibility to cover a wider range of users, the importance of it has been acknowledged and it is an improvement to consider in future projects related to the same topic.

During the development of a concept, several restrictions were taken into consideration. Firstly, the researchers chose to focus on one specific view of the user interface. Since this view is a part of an already existing workflow the development of this view had to stick to those requirements that come from the rest of the system. Also, the fact that the system is out on the market and used by its end users, contributes to an already existing conceptual model of how the system works and what it is supposed to accomplish. Therefore, the new concept had to be developed with the current conceptual model in mind.

CellaVision is a well established company within the field of hematology analyzers and the graphical user interface has to represent CellaVision and match the company standards. This is also a restriction that the project members had to keep in mind during the development. The concept has also been affected by its developers. Even though the researchers used end users and experts to gather information and test, it is much likely that the opinions, tastes and thoughts from the researchers have affected the concept.

When interviewing, observing and testing with users and experts, more than five participants took part in the sessions. This was done according to the fact that when using five participants, most usability problems will be discovered compared to the amount of test participants. If more than five participants take part in the tests, the amount of discovered usability problems will increase very slowly. The most efficient amount of test persons is therefore five participants. (Nielsen, 2012) It is also important to have an iterative process which have been a consistent part of this project. Tests were performed every time the concept was changed and the researchers always connected back to the users to maintain a user-centered design process.

When performing quantitative tests, the amount of participants was six persons. It is recommended to have 20 persons in a quantitative study (Nielsen, 2012). The result can therefore not represent a significant result of the time it takes to complete different tasks, estimation of difficulty or System Usability Scale value, but can work as an indication of the measurements. Also, the average System Usability Scale score is an indication of the usability of the system. Since the final concept is an example of how the user interface could be presented, it was considered that an indication of the time to completion, difficulty of tasks and the System Usability Scale score, was enough to draw a conclusion of how user centered design affects the development. If this concept were to be implemented in a real life product, one could consider doing quantitative tests with more people for a better confirmation of the performance of the system.

8.3 Results

The final concept was prototyped in the program InVision. All the features and functions could not be implemented in the prototype due to restrictions in the prototype tool. In the specification of requirements, all the functions that should be implemented in the possible real interface are presented. The missing functions in the prototype can have given unreliable result in the testing phase of the high fidelity prototype since some of the testers wanted to perform actions that were not possible in the prototype of the new interface, but were possible in the old interface. This can defend the fact that task 1 and 6 took longer time and were estimated to be more difficult in the new interface when conducting the quantitative analysis with comparison of the two interfaces. If all functions were implemented into the prototype, the time of completion and the estimated difficulty of the system could decrease. The result can also point on areas of improvement for the concept relating to task 1 and 6. The changes in the prototype that were withdrawn from the testing phase have not been tested with users and can therefore not be seen as final. The changes are only a suggestion of how to develop and incorporate the test results further.

One crucial aspect to recognize in this project is the fact that the researchers are not graphical designers and the graphical design part of the project have not been the focus. The final result is only a suggestion of how the user-centered design can be applied to create an interface. The main focus have been to develop a new concept of the interface according to the end users and to improve the usability with user-centered design. Thus, the prototype is only a visualization of a possible design with the specific concepts that has been produced. In order to implement the interface for real usage, the design will probably have to be re-done and evaluated by designers.

System Usability Scale is the quantitative analysis of this project that shows the usability value of the old and new interface. The value of the old interface indicates that the usability is low. The new interface got a value above average and close to excellent. It is important to keep in mind that the test participants had never used the system before and the end users of the existing system know the system better and hopefully experience a higher usability. However, this is still an indication of how intuitive the system is and this shows how essential user-centered design is. Since the old interface was produced without great involvement of users, this results further testify the importance of user-centered design and the valuable insights that comes out of it.

System Usability Scale value for the new concept prototype resulted in 84.1. This is a value close to excellent and an improvement with 50,8 points compared to the old interface that got 33,3. The success factors for the project are the close collaboration with the customers, the iterative process and finding the root causes of the problems and wishes of the customers. The key factor was to meet the needs of all customer and find the golden mean in the Database View instead of trying to increase the usability for the whole system. From this point, the main findings from the information gathering process can also be applied on the rest of the interface and the same methods could be used since they resulted in a prototype with high usability.

User-centered design includes the users in the development of products. The users of this system tended to only see their own preferences and this had to be taken into account for the researchers. One conclusion that can be easy to draw from including several different user groups; is the fact the customization is necessary for each customer. This because the different users and various preferences of the systems. For the user-centered design, customization of a system could be done to give the users the tools to create the workspace suitable for them. For this project, one limitation from the company was that all users use the same system and it can therefore not be customized towards the separate user segments and separate interface systems can not be produced. However, the single system itself can be customized with small essential details such as what filters the user wants to have visualized.

8.4 Future

If the researchers had more time to spend on the project, another round of tests would have been conducted to see if the last changes were improving the usability or not. Next step would also be to implement the new user interface into real usage and continue to use the customers in the testing and developing phases. Thus, the other parts of the system also have to be produced and would have to be evaluated in order to create a new implemented user interface. The Database View is only one part of the system but some of the information gathered in this project refers to the other parts as well. Important for CellaVision's future work with developing new interfaces is to include the users more and to work with user-centered design. To get more data on how the interface works, data analysis of the system in the laboratories could be used, e.g. use statistics to measure how often buttons are used and how long certain tasks take to accomplish. Also, collect data for what items or actions that are never used. The company wants to be in front of development and innovations and that should include the user interface and usability of the system as well. This area have to be prioritized higher in order to provide an interface that is up to date and to avoid the situation of providing an old interface with low usability. For future work with the system, the amount of time to develop other views of the system will probably be less compared to the time spent on the Database View from the interface in this project. Most of the information gathering is done but some additional could be made to get a hold of the whole system.

8.5 Ethical aspects

One ethical aspect to consider is the patient data that is present in the system for the user. Should the patient data; name, birth, date and ward be present for the biomedical scientist at all time? Their job is to analyze the sample of blood and to give the doctor a solid ground to make decisions about further treatment of the patient. Is it then really necessary for the biomedical scientist to have all the personal information? Could it result in a more objective analyze if the information was presented in independent code? In the health care sector, it is of high priority that personal data do not spread to people who are not involved in the treatment of the patient. When showing all the personal data in the system to the biomedical scientists, they get hold of information that might not be useful for the analyze. That could be an unnecessary way of possible spread.

From an ethical aspect it is crucial that all gathered information is handled with confidentiality and that participants taking part in interviews and other studies are kept anonymous. It is also important that the participant is informed about his/her rights when taking part in a study. In this project, all participants agreed with an informed consent of their contribution to the study.

The outcome of the analysis in the user interface affects the tertiary user, the patient. It is therefore crucial that the result is correct and that the error rate is as close to zero as possible. If the user interface is redesigned, it is very important that the redesign is tested thoroughly. This to eliminate all possible errors so that the patient does not get false results. This can happen if the biomedical scientist interpret the information in the user interface in a faulty way.

9 Conclusions

From the scope of this project, the main conclusion based on the design process and its results, is the great importance of working with user-centered design. The project purpose was to elaborate the existing user interface of the CellaVision system and with a user-centered process improve the interface addressed to the end user goals. When including user-centered design in a process, the differences between the end users' background and work situations can be explored. This can point out main differences in workflow and opinions about the system that can be withdrawn to improvements of the usability. In this project, the users work with different requirements and with various workflow. This is important to recognize in order to design a system that can be used by all possible users. The existing old interface has not been developed with a great impact from the users and the usability is therefore not as high as preferred. In this project, several different users have been taken into consideration. The developed user interface can therefore be used with a higher possibility to fulfill the user goals.

The final concept of the interface was graded with the System Usability Scale and received 84.1 (excellent), in contrary to the already existing interface that received 33.3 (poor). These values show the advantage of working closely together with the end users and the importance of including the users in the design process. In order to get high usability of an interface the methods in this project can be used to increase the user experience of the interface.

The final concept of this project is a suggestion of how to design an interface according to the users with user-centered design. The concept is only a prototype but can be seen as a guideline in how well the process with end users can proceed and hopefully motivate future design processes to work in close collaboration with the end users.

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Appendices

A Work distribution and time plan

A.1 Work distribution

The work distribution between the project members have been equal. Almost all parts of the project have been performed by the two project members together. Times when the tasks have differed between the project members have been during interviews and tests. Then, one has taken the role as the interviewer or test leader and the other has taken the role of taking notes. The project members have also written parts of the report separately but those parts have been read and discussed by both members.

A.2 Work plan and outcome

- Literature study
- Learn the system and decide methods for information gathering process
- Prepare information gathering and conduct the methods
- Analyze the data and conclude goals for the project
- Perform the concept generation with brainstorming
- Design a low fidelity prototype, test and evaluate
- Design a high fidelity prototype, test and evaluate
- Conclude a final design of the interface

The time plan ended up matching the project very well. The first part of the project, the concept phase, took the most time to conclude and this was as planned. The project members had previous experience from working in a design process and therefore the project plan was easy to follow and the time estimated for each task was well balanced. It was even decided to add more sorts of tests of the high fidelity prototype since the project was running before time schedule.

B Heuristic evaluation - checklist

The checklist consist of the following:

Visibility of system status
The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

Match between system and the real world
The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

User control and freedom
Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

Consistency and standards
Users should not have to wonder whether different words, situations, or actions mean the same thing.

Error prevention
Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

Recognition rather than recall
Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Flexibility and efficiency of use
Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

Aesthetic and minimalist design
Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

Help users recognize, diagnose, and recover from errors
Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

C Interview questions

C.1 Expert interview

Background of respondent
1. What kind of education and background do you have?

2. What is your position at CellaVision?

3. What does your role at CellaVision include?

The respondent's insights
4. What was your first impression of the interface when you were exposed to it for the first time?

5. What is you own perception of the interface of CellaVision's system today?

6. What is your specialty regarding the interface? Meaning, in what areas do you have a better insight compared to you colleagues?

7. According to you, what are the main
   a.pros of the interface?
   b.cons of the interface?

8. Describe your perception of the end user of CellaVisions products. Who do you think this is?

9. What do you believe is the biggest problem for the users using CellaVision's system?

10. Do you think anything in particular should be:
   a. added to the interface?
   b. taken away from the interface?
   c. changed in general?

Other
11. Who decides if changes should be made in the system?
   a. Where does the information about wanted changes come from?
   b. What is required for a change to be made?
   c. How does a change in the system affect your job assignments?

12. If anything was possible, how do you think the perfect interface would be like?

13. Do you have anything you would like to add to this interview?

C.2 Laboratory interviews

1. What kind of education and degree do you have?

2. What is your position at the laboratory?

3. What does your role at the laboratory include? Assignments etc.?

Working in Cellavision's system
4. Did you get some kind of education before working with CellaVision's systems?

5. For how long have you been working with Cellavision's systems?

6. How many slides do you analyze in Cellavision's system per day?

7. For how long do you work in Cellavision's system at the time?

8. When working in Cellavision's systems, how do you feel that the environment around the working space is?

9. Working in Cellavision's system, what do you think is:
   a. Good?
   b. Bad?
   c. Easy?
   d. Hard?
   e. Missing?
   f. Never used?

The participants working situation otherwise
10. Do you switch between different systems in a regular day of work?
   If Yes:
   a. Are there any big differences between the systems compared to Cellavision's system?
   b. Is there any similarities?

11. On a scale from 1-10, how is you computer literacy? 1- Very Bad 10- Very good

12. Do you know where to turn if you have questions about Cellavision's system?

13. When you think of Cellavision's system, what feeling do you get?

14. Do you have anything you would like to add?

D Informed consent

D.1 Expert interviews

Purpose of research
This research is a part of a master thesis at Faculty of Engineering at Lund University in collaboration with CellaVision, the provider of automatically digital hematology analyzers that you work with. The aim is to collect information about the user experience of the interface of CellaVision's machines with hope to improve future releases of the system.

Procedures involved
The study will consist of an interview with the participant, led by the researchers. The interview will not take more than one hour.

Participation is voluntary
The participation of this study is voluntary and the participant can at all time decide to quit and the collected material will not be used in the research.

Right to confidentiality
The material collected in the interview can be used if the participant don't say other. The participant will be anonymous and the material will not be able to be connected back to the participant.

Persons to contact
If the participants have any questions, concerns, want to add information or want to read the outcome of this master thesis they can contact the research leaders:

Lovisa Lundin: Lovisa.Lundin@CELLAVISION.se

Emilia Wu: Emilia.Wu@CELLAVISION.se

Voluntary participation
I here now verify my voluntary participation in the following:
- Interview according to above
- Audio recording of the interview

Date: Location: Name:

Researchers

Date: Location: Name:

Date: Location: Name:

D.2 Laboratory interviews

Purpose of research
This research is a part of a master thesis at Faculty of Engineering at Lund University in collaboration with CellaVision, the provider of automatically digital hematology analyzers in the laboratory that you work at. The aim is to collect information about the user experience of the interface of CellaVisions machines with hope to improve future releases of the system.

Procedures involved
The study is divided into two parts. One part where the participant will be observed when working in the mentioned system. Secondly, questions will be asked during this for clarification and more input from the participant. The procedure will take no more than one hour.

Participation is voluntary
The participation of this study is voluntary and the participant can at all time decide to quit and the collected material will not be used in the research.

Right to confidentiality
The material collected in the observations and interviews can be used if the participant don't say other. The participant will be anonymous and the material will not be able to be connected back to the participant.

Persons to contact
If the participants have any questions, concerns, want to add information or want to read the outcome of this master thesis they can contact the research leaders:

Lovisa Lundin: Lovisa.Lundin@CELLAVISION.se

Emilia Wu: Emilia.Wu@CELLAVISION.se

Voluntary participation
I here now verify my voluntary participation in the following:
- Observation and
- Interview according to above.
- Audio recording

Date: Location: Name:

Researchers

Date: Location: Name:

Date: Location: Name:

D.3 Quantitative tests

Purpose of research
This research is a part of a master thesis at Faculty of Engineering at Lund University in collaboration with CellaVision, a provider of automatically digital hematology analyzers for laboratories. The aim is to collect information about the user experience of the interface of CellaVision's machines with hope to improve possible future releases of the system.

Purpose of test
The purpose of the test is to collect quantitative data and measurements from the existing user interface of Cellavision's products and the user interface of the new concept developed within this thesis.

Test procedure
The participant will be asked to perform different tasks and estimate the difficulty of the tasks. The time to complete each task will be measured and after all tasks are completed, the participant will estimate the overall usability of each of the systems.

Participation is voluntary
The participation of this study is voluntary and the participant can at all time decide to quit and the collected material will not be used in the research.

Right to confidentiality
The material collected in the observations and interviews can be used if the participant don't say other. The participant will be anonymous and the material will not be able to be connected back to the participant.

Contact
If the participants have any questions, concerns, want to add information or want to read the outcome of this master thesis they can contact the research leaders:

Lovisa Lundin: Lovisa.Lundin@CELLAVISION.se

Emilia Wu: Emilia.Wu@CELLAVISION.se

Voluntary participation
I here now verify my voluntary participation in the following:
- Quantitative user tests

Date: Location: Name:

Researchers

Date: Location: Name:

Date: Location: Name:

E Observation protocol - Laboratories

Workspace setup. How is the computer placement (vs. the machine)?

Next to the machine   Far away from the machine   Placed in separate room

How is the work environment?

Stressful and messy   Calm   Often interrupted   Other

Does the user look at the screen while samples are analyzed by the machine?

Yes   No   Other:

How much time does it take to analyze a glass?

Time:

Does the user have to change his/her posture when analyzing orders?

Yes, when: How: No

What functions, buttons and commands are frequently used in the system?

What functions are never or rarely used in the system?

What does the user consider to be the main workflow in the system?

What way does the user go through the workflow?

What is distinguishing?
Effective:
Surprising:
Confusing:

Where is the user blind to flaws?

Is right click used in the system?

Often   Rarely   Never

In average, how many non-standard analyses are performed per day?

Amount: What kind: Non

F Affinity Diagrams

F.1 Heuristic evaluation

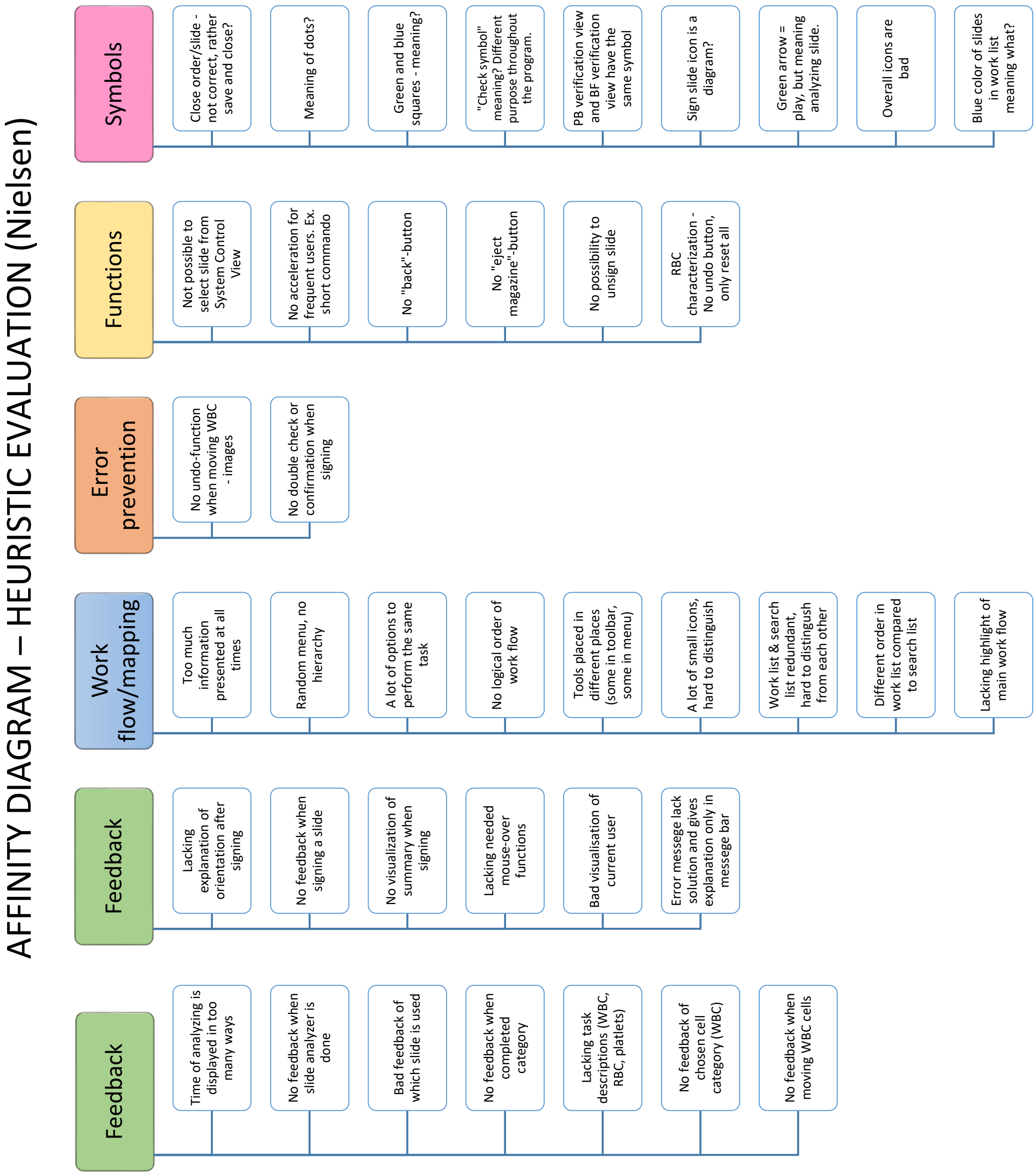

Figure 32: Affinity diagram of the heuristic evaluation

F.2 Expert interviews

Figure 33: Affinity diagram of the expert interviews

F.3 Contextual inquiry

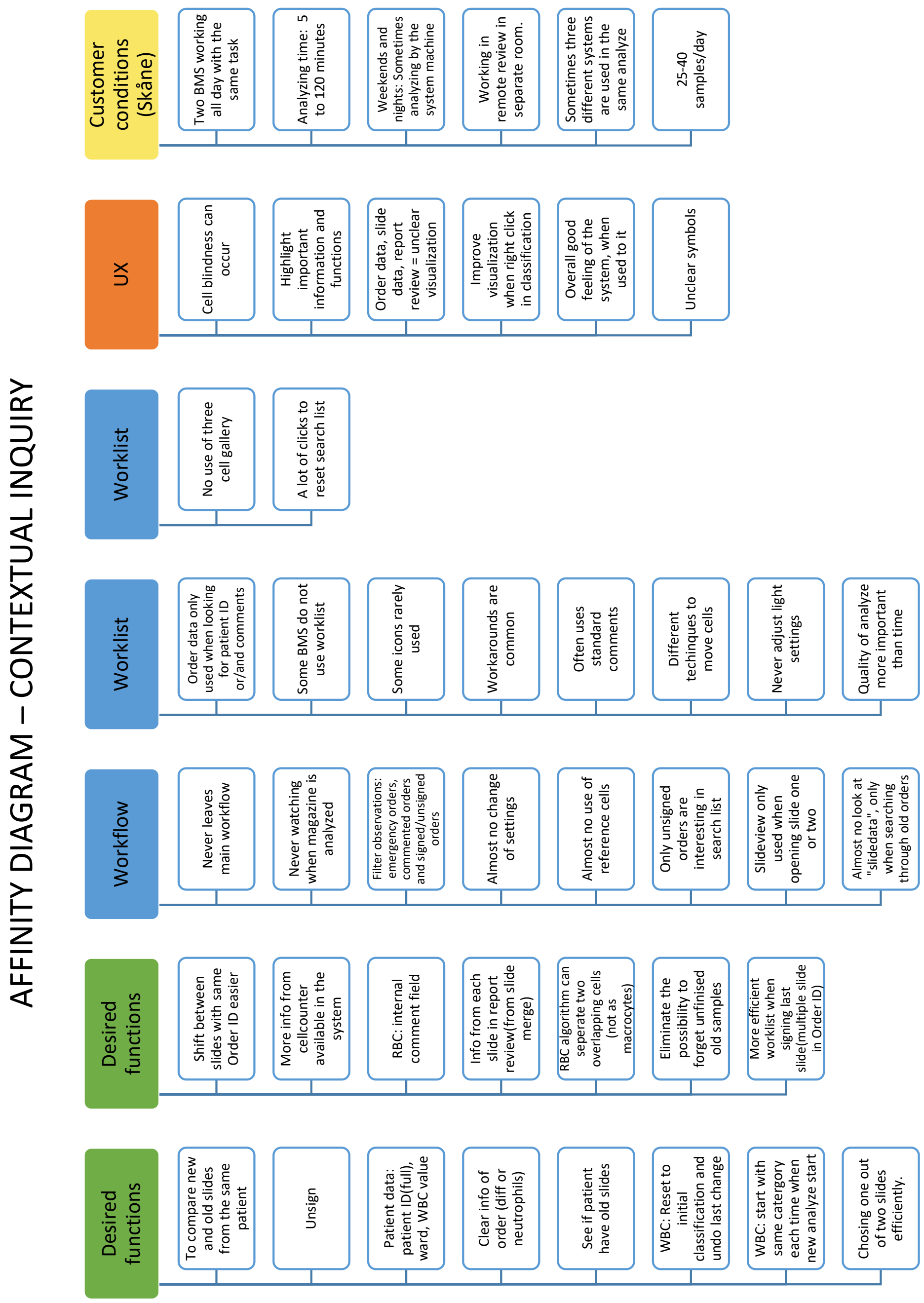

Figure 34: Affinity diagram of the contextual inquiry

G Tasks for tests

G.1 Qualitative tests

Scenario 1
1. You want to look at slide 1 in order PB 102030. What WBC count does slide 1 have?

2. Analyze slide 1

3. Look at the previous samples from the same patient

Scenario 2
1. Search for patient number 800202-4692 among ALL samples. It came in sometime between October 10 and 12.

2. Reset

Scenario 3
1. Open worklist

2. Add slide 1 in order PB 102030 in worklist

3. Open the first order in worklist

G.2 Quantitative tests

Level of difficulty:
1- Very Easy, 2 - Easy, 3 - Neither easy, nor hard, 4 - Difficult 5 - Very Difficult

1. Find patient "Rosengren" in the order list.

2. What is the value for segmented neutrophils in slide 1 in Andersson's order?

3. Search for patient ID 800202-4692 and find the sample that came in between the 10th and 12th of October.

4. There is a worklist to the left on your screen. Are there any stat orders in the worklist?

5. Add slide 1 of Andersson's order to the worklist, when the task is done only slide 1 from Andersson is in the worklist

6. Open slide 2 of Andersson's order

H Insights from tests

H.1 Workshop with biomedical scientists

Order List

Concept 3, with information between the slides, was considered a good idea because the information would appear close to the slide. The fold out information will take up a lot of space from the rest of the list. Considering concept 2, the information on the side was appreciated because there was good enough space for the information that will be shown in that space. How the space will appear has to be figured out. To conclude, concept two was considered to be the best of the options together with the fold-out part from concept 3.

Search and Filter

Concept 3 (with buttons) and 4 (with added filters that could be deleted) were considered to be the best. Concept 3 had a better overview, but a flexible button with a drop down menu could be nice for some customization. A reset button is desired.

Worklist

Concept 2 and 3 were considered to be the best. Unnecessary to have an open-button. Open with double-click. Close with a cross. Information needed: Ward, slide number, order ID, date, emergency order. Good that it is possible to change order of the samples in worklist. Concept 2 is fun and new thinking. Very good to have the possibility to fold the worklist in and out.

H.2 Qualitative tests with low fidelity prototype

Necessary - N, Desired - D, Unnecessary - U

Clarify the number of slides in an order (U)
Make the reset all-button clearer and decide the placement (N)
Number of slides in worklist have to be visible if the worklist not open (N)
Only lastname in the list (N)
Time and Date have to be visible in the list for every order/slide (D)
Present the signer of each slide with Name and not number (D)
Add pathology as a filter (N)
Easy to reset the search field (N)
Easy to reset the calendar (N)
No cell counter data in order data, it wont fit according to users (N)
Visualize the client ordering the analyze (D)

H.3 Qualitative tests with high fidelity prototype

Necessary - N, Desired - D, Unnecessary - U

Change placement of “History” button (U)
Filter for protected orders (D)
Icon that marks Neutrophil or Diff (D)
Single click when opening slide from worklist (U)

Plus sign close to worklist to add slide (U)
Open as a hover function (U)
Better mapping of the filters (N)
Reset all button for search area (D)
Add first name in columns (D)
Drag and drop order to worklist (N)
Remove the pathology filter (N)
Re-design header columns (N)
Re-design pathology icon (N)
Make the column header with icon customizeable (N)
Add protected as a filter (D)
Link on patient ID to search/history (D)
Remove hover for open slide (N)
Enable: mark several slides and add into worklist (N)

H.4 Quantitative tests in the detail phase

TP = Test Persor	TP1	TP2	TP3	TP4	TP5	TP6
System first teste	New	Old	New	Old	New	Old
Test 1						
OLD TTC (s):	4,97	3,42	8,96	5,12	5,36	8,65
OLD Level of diff	1	3	2	1	2	1
NEW TTC (s):	24,33	9,74	10,86	4,25	4,58	3,95
NEW Level of dif	2	3	3	1	2	1
Test 2						
OLD TTC (s):	7,91	19,55	8,23	11,56	12,08	18,03
OLD Level of diff	1	4	2	2	2	2
NEW TTC (s):	13,53	12,57	11,5	6,86	14,88	16,19
NEW Level of dif	2	2	2	1	1	1
Test 3						
OLD TTC (s):	73,53	49,65	94,49	50,61	172,18	161,41
OLD Level of diff	4	4	4	4	5	4
NEW TTC (s):	22,05	11,51	24,55	14,3	25,86	42,88
NEW Level of dif	2	1	3	1	1	2
Test 4						
OLD TTC (s):	149,61	55,83	126,61	132,55	83,68	217,79
OLD Level of diff	5	5	5	5	4	5
NEW TTC (s):	21,32	3,08	43,52	2,1	70,51	28,87
NEW Level of dif	3	2	5	1	2	2
Test 5						
OLD TTC (s):	19,42	52,06	43,43	8,89	15,58	18,48
OLD Level of diff	2	5	4	2	2	1
NEW TTC (s):	8,03	13,79	31,34	6,37	6,86	23,32
NEW Level of dif	1	2	4	1	1	2
Test 6						
OLD TTC (s):	4,18	4,79	10,32	5,1	6,99	6,34
OLD Level of diff	1	1	2	2	1	1
NEW TTC (s):	9,55	6,35	22,72	5,86	5,87	10,52
NEW Level of dif	2	1	4	1	1	1

I Product Specification

The worklist should be dynamic in the meaning that it should be easy to use for the frequent users and for the user that do not frequently use it, the worklist should not be too central in the workspace.
Short and long
Bring forward and hide
Easy add and delete
Easy open
Right click for
- Open
- Delete
- Move up
- Move down

Possible to change the order in worklist
STAT should be put first all the time
Number that tells how many orders in worklist
Information:
- Order ID
- Slide NBR
- Ward
- Mark STAT

There should be only relevant filters. They should be visible and user should be able to switch between the filter without too much cognitive load. The filter and search options should be designed so that the user understand the difference between them and it should be made more clear how to select dates. There should be an option to reset the search area if wanted.
Search
- Be able to search for anything in the search field
- Easily empty search bar

Filter
- -Unsigned: default filter
- -Signed
- -All
- -STAT
- -Pathology or protected
- -BF
- - Reset All button

Calendar, choosing date with a full month calendar
The search area updates the result simultaneously

The main list should not be truncated and all the information visible should be relevant. Orders should be clearly separated from each other and it should be clear which information that belongs to each order.
All information and columns have to be visible at all times
Default setting: only the unsigned orders show

There should be enough space between orders in order to separate the orders.
The list can be sorted by different categories.
The amount of orders in order list should be indicated
A number should tell how many slides in order
Right click at order in list:

- Export
- Mark/unmark as protected
- Mark/unmark as STAT
- Edit order data
- Open
- Delete
- Add to worklist

Columns:

- Text:
    - Order ID
    - Patient ID
    - Date
    - Last Name
    - Ward
- Icons:
    - Signed/by who
    - STAT
    - Protected
    - LIS
    - Pathology
    - STOP
    - Comment
    - Transfer tool?

Independent of how many slides per order, the orders should be managed the same way.
Order Data and Slide Data should be dynamical and adapt depending on amount of slides
Order Data:

- Order ID
- Ordertype: diff/neutrophil
- LIS status
- Prel result
- Patient:
    - Name
    - Patient ID
    - Age
    - Ward
    - History
    - Gender

Slide Data:

- Slide Nbr
- Slide Date
- Preliminary result
- Signed by

- WBC count
- RBC count

Orders should be managed in the same way independent of the amount of slides.

- Open
- Delete
- View "Order data"/"slide data"
- Add to worklist

The system should provide sufficient information for the user. However, information that is not important at the moment should be able to make less central.

Information always visible:

Main top bar

- Who is logged in
- Which database
- Help
- Settings
- Order List
- LOGO

Search and filter bar

Order List with 20 orders visible (scroll to see more)

Number of slides in worklist

Indication of worklist if hidden

All columns

All orders and indication of how many slides it contain

Pending order

Information needed but not always:

Order data

Slides in order

Slide data

History slides of patient

Worklist

The most frequent operations in the system should be easier to perform Worklist

- Open
- Delete

Order List

- Open
- Add to worklist
- View history
- Sort