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User-centered design in rural South Africa: How well does current best practice apply for this setting?

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Problem description.

Does best practice in user-centered design apply for systems to be used in developing countries?

The thesis project will analyze the development process of a help system integrated in a portable ultrasound machine for midwives in South Africa and Norway. The aim of the project is to identify usability-related challenges when designing for third world use.

Assignment given: 15. February 2012
Supervisor: Dag Svanæs

Abstract

Designing ICT systems in the developing world is perceived to be a challenge. But is this really a challenge if we use state-of-the-art development methods? Will the fact that most standards, guidelines and heuristics are made in the western world render them useless as tools of making modern computer software for the developing world?

In this thesis I will analyze the findings of a software development project I did for my employer, National Center for Fetal Medicine (NCFM) at St. Olav's Hospital in Trondheim, Norway. In this project I used a user centered development process as defined in ISO 9142-210 to develop and test the prototype of an ultrasound help system. I tested the prototype using two different user groups: midwives in KwaZulu-Natal participating in an ultrasound teaching and training program held by NCFM and midwives in Trondheim, Norway, receiving a post-qualification course in ultrasound diagnostics also held by NCFM at the Norwegian University of Science and Technology (NTNU) in Trondheim. I analyzed the test results and then did an evaluation of the methods used – both the user-centered design process and the usability methods to see how well the methods have worked in my project.

Oppsummering

Å designe IT-systemer for utviklingsland blir sett på som en utfordring. Men er det virkelig en utfordring, hvis vi bruker state-of-the-art utviklingsmetoder? Vil det at de fleste standarder, retningslinjer og heuristikker er lagd i vesten gjøre at de er ubrukelige i utviklingsland?

I denne oppgaven har jeg analysert funnene fra et programvare-utviklingsprosjekt som jeg utførte for min arbeidsgiver, Nasjonalt senter for fostermedisin (NSFM) ved St. Olavs hospital i Trondheim. I dette prosjektet bruke jeg en brukersentrert utviklingsprosess som definert i ISO 9142-210 for å utvikle og teste en prototype av et hjelpesystem for ultralydapparat. Vi testet prototypen på to grupper: jordmødre i KwaZulu-Natal som deltok på et videreutdanningskurs i ultralyd holdt av NSFM, og jordmødre som tar videreutdanning i ultralyddiagnostikk også holdt av NSFM ved NTNU i Trondheim. Jeg analyserte testresultatene og utførte en evaluering av metodene som ble brukt – både den brukersentrerte designprosessen og usability-metodene, for å se hvor bra metodene har fungert i mitt prosjekt.

Acknowledgement

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And last but not least – thank you to my wife Elisabeth for not only being patient while I have worked on this thesis but also for being a valuable conversation partner and an always available usability expert. ☺

Content

1 Introduction

1.1 Motivation

IT and high technology is not just for the western world anymore – in the underdeveloped part of the world high technology now is becoming an integrated part of people's lives. Will this change the way we make software? Are the users in the underdeveloped world any different than other users?

The ISO9241-210 standard – or in full "*Ergonomics of human-system interaction, Part 210: Human-centered design for interactive systems"* is a standard that describes a process for developing software with a strong focus on the user and the user's needs. The standard is derived from the old ISO 13407 standard *("Human-centered design processes for interactive systems")* and was finalized in 2010. Standards like these are based on the best practices in the area as described and analyzed by scientists and professionals from their context.

Will the standard be colored by the fact that their context-of-use is in a western, urban setting and thus covers the western "best practices"?
Will the method in the standard also work in rural South African areas?

Years of experimentation and practice in the usability field have given us several sets of design guidelines from people like Jacob Nielsen, Ben Shneiderman, Bruce Tognazzini and Don Norman among others. Are these design guidelines global? Will they survive the journey to rural South Africa?

1.2 Context

The case for my study is within the Umoja project at my work as a project manager at the National Center for Fetal Medicine (NCFM) at St. Olav's Hospital in Trondheim. The aim of the Umoja project is to develop an ultrasound machine for use in the rural areas in underdeveloped countries. This ultrasound machine will have a help system that will help the midwife operating the ultrasound machine to make decisions and a good diagnosis.

This thesis will use the process of making a prototype of the help system and testing it on midwives in KwaZulu-Natal in South Africa and Norway as a case to investigate the usage of the ISO9142-210 process.

The prototype system will merge with the clinical graphical user interface (GUI) and will be tested again on a new group of users – probably in early 2013.

1.3 Research questions

1.3.1 Research question 1:

The ISO9142-210 standard is made for a user-centered design and development process. As most standards of this kind, it is a de facto summary of best practices in the field.
The question is:

- *Will the process from the ISO9142-210 standard also work when working in rural South Africa?*
- *What adaptions are necessary – if any?*

1.3.2 Research question 2:

There are a number of design guidelines for usability available based on best practices and experiences made by people working in the usability field. These guidelines are both high-level principles and more hands-on, specific guidelines for specific situations.

- *To what extent do these guidelines comply in this SA context?*
- *What design guidelines can be derived from this process?*
- *Are they any different from the established guidelines in the usability field?*

1.4 Outline

This thesis is divided into eight chapters

- **Introduction**
  – describing the project.
- **Background**
  – background information relevant to this project – mainly usability related.
- **Umoja project**
  – an introduction to the Umoja project.
- **Research method**
  – a presentation of my research method.
- **The user-centered design process**
  – an overview over what was done including presentation of the usability methods.
- **Findings**
  – the results of the usability testing and data gathering.
- **Analysis and discussion**
  – analysis and discussion of the usability testing results and the process seen in light of the research questions.
- **Conclusions**
  – what did I learn from this?

2 Background

2.1 What is usability?

In simple terms, the usability describes how a product it is suited its purpose and how effective and easy to learn it is to use. Although there are many formal methods to try to measure the degree of usability, it is hard to generalize the usability of something since both the user and the usage context varies in large degree.

There are several good definitions on usability.

Shackel (Shackel 1991), for example, defined usability as

> *The capability in human functional terms to be used easily (to a specified level of subjective assessment) and effectively (to a specified level of performance) by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of environmental scenarios.*

Here, the notion of a user context is more vague – the "specified range of environmental scenarios" is in some kind related, but not the same.

Jacob Nielsen introduced his 5 quality components in 1993: *learnability, efficiency, memorability, errors and satisfaction* - and by doing that he introduced the subjective component "satisfaction" into the definition.

ISO/IEC 9126 has a different and more narrow take on usability by removing reliability and efficiency from the definition:

> *Usability is the capability of the software to be understood, learned, used and attractive to the user, when used under specified conditions*

I will, however, concentrate on the ISO 9241-11 definition, that states:

> *The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.*

2.2 User-centered design

User-centered design has been a developing method since the late 70's and the development of systems such as the Xerox Star, but has in recent years been summed up and formalized first in the ISO13407 standard and the modernized in the ISO9142-210 standard. I will present the user-centered design process in chapter 2.3.2 – ISO9142-210.

2.3 Relevant ISO standards for usability

2.3.1 ISO9241-11

The ISO9241-11 standard (ISO9241-11 1998) tries to define usability on "visual terminals" and proposes how to identify the information needed when specifying or evaluating usability.

The standard does so by defining usability as:
The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

Here I see that there are some specific measures – effectiveness, efficiency and satisfaction – where the first two are measurable by setting specific usage goals, while the last one is more subjective in its nature since it involves the user's subjective feeling of the system tested.

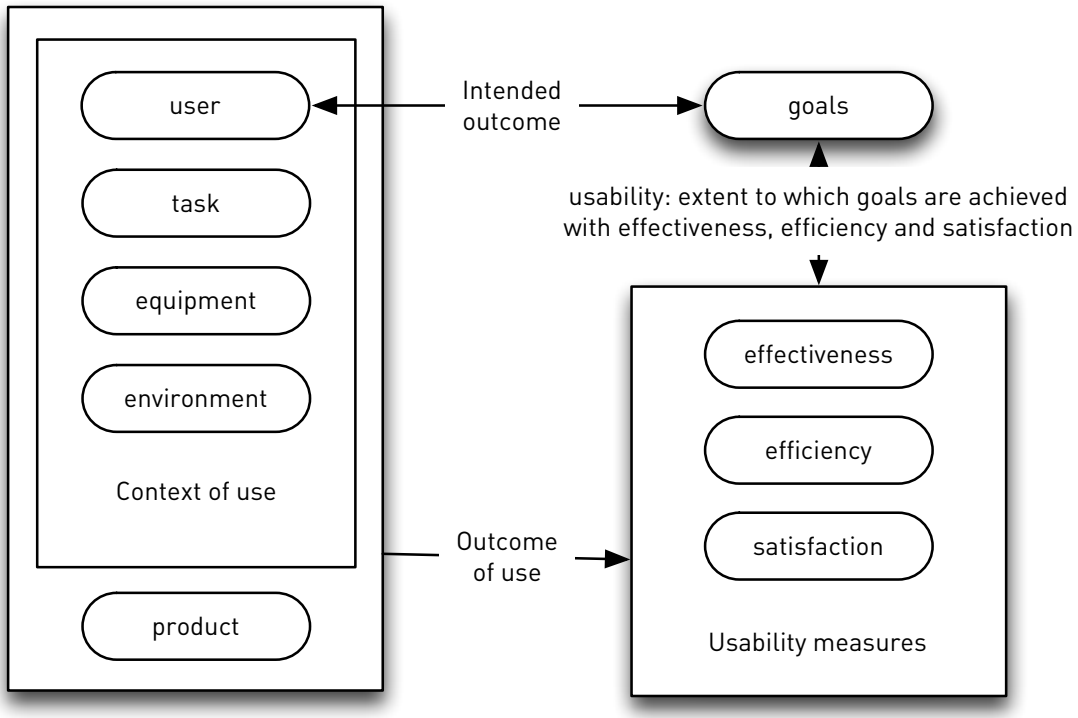

Figure 1 - ISO9241-11 Usability Framework

- ***Effectiveness*** is a measure of the degree of which a system fulfills defined goals or subgoals.
- ***Efficiency*** is a measure of how fast the user actually managed to fulfill the tasks at hand.
- ***Satisfaction*** is a measure on how secure and confident the user felt using the system.

These measures are evaluated against the goals of the system.

The Context of use is where the user and anything concerning the user and the usage of the system is described.

The User**.** To understand the user and the users needs, I need to find out as much as possible about the user. Factors such as knowledge, skills, experience, education, training, physical attributes and sensory capabilities are important to be able to describe the user and possibly see if there are several user groups that need to be taken into account when designing the system.

The Tasks**.** The tasks are the activities needed to be done to achieve the goals. The tasks and subtasks (if any) chosen should be chosen in a way that they all are related to the goals – then I can evaluate the effectiveness of the system by calculating the number of tasks achieved

The Equipment**.** Most equipment is designed for specific user or a specific context. For example – the hammer is a good tool for most people, but only for those of us with arms. We can say that equipment has both constraints and advantages. It is important for the usability of a product that we take the constraints and advantages in account when designing.

The Environment**.** The physical and social environment must be taken into account. Is it cold? Is it hot? Is it possible to use the touch screen with gloves? Can the user reach both the keyboard and the touch screen from the same position? How does the use of gel on the ultrasound probe affect the use of a mouse, clickpad or a touchscreen? Is it noisy? Is there a chance that the user will be interrupted?

2.3.2 ISO9241-210

ISO 9241- 210(ISO9241-210 2010) outlines a framework for Human-centered design for interactive systems. The standard focuses on the user, the user experience and the user's needs in the development process. This standard is a revised version of ISO 13407 standard.

Principles for human-centered design

According to ISO9241-210, a human-centered design approach is should follow these principles:

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*

Now how can we interpret these principles and put them to use?

a) The design is based upon en explicit understanding of users, tasks and environments

The "*explicit understanding*" in this point means that the design team should find out as much as possible about the users and the users "*context-of-use*" – including the information on the users, the environment in which the design is to be use, stakeholders that may have some influence or integration without actually being users of the system being designed. In other words – all information concerning the use of the system is relevant.

b) Users are involved throughout design and development

The purpose of this point is to involve the users in all phases of the design process. There are some quite obvious advantages to this: Users can easily spot out misconceptions and misunderstandings early in the process and they can – by their domain information of the product – even come up with process changes that can ease both the final result as well as making the design process shorter by being accessible to the design team when they have questions. One other aspect is often toned down – user participation and involvement can increase the user acceptance and commitment in an organization – it may even be a crucial factor when introducing the finished product to the users.

c) The design is driven and refined by user-centered evaluation

One might be tempted to think that this is a consequence of the previous principle, but it is more. The term "*user-centered*" puts emphasis on the need for the system to be evaluated from the users perspective. One way to do this is by performing a usability test that will test the project being developed against the real world and real world users. Usability tests should be done several times during a projects lifecycle to confirm that you are on the right track.

d) The process is iterative

Not only it is iterative, the standard says, *"The most appropriate design for an interactive system cannot typically be achieved without iteration".* The standard also state *"iterations implies that descriptions, specifications and prototypes are revised and refined when new information is obtained in order to minimize the risk of the system under development failing to meet user requirements".* The standard also clarifies that the human-centered activities should iterate both on the macro level (the complete system) and on the micro level (parts and components).

e) The design addresses the whole user experience

In short – the design addresses anything concerning the system – including even impact on organizations, interfaces and collaboration with other systems, documentation, support and maintenance. It also addresses the common misconception that usability is "making things easy". It is more about making complex situations/scenarios seem more simple than they actually are without actually losing the complexity. The standard emphasize this by stating: "*The concept of usability used in ISO 9241 is broader and, when interpreted from the perspective of the users' personal goals, can include the kind of perceptual and emotional aspects typically associated with user experience, as well as issues such as job satisfaction and the elimination of monotony".*

f) The design team includes multidisciplinary skills and perspectives

The design team should be "*sufficiently diverse*" to ensure that as many views and perspectives are covered to make the finished product as optimized for the task as possible. The standard supplies a list of professions and skills to emphasize that all groups that possibly can be a stakeholder in one way or another can be a valuable team member with experiences that can help the product get as good as possible.

Human-centered design process

The standard also presents a model for a human-centered design process. Complying with principle d, the model is iterative.
After planning the design process, the standard state that "*four linked human-centered design activities* shall take place *during the design of the interactive system":*

1. *Understanding and specifying the context of use*
2. *Specifying the user requirements*
3. *Producing design solutions*
4. *Evaluating the design*

Even though a flowchart-like model like this look very strict and linear, the standard emphasize that "*It (the figure) does not imply a strict linear process,*

rather it illustrates that each human-centered design activity uses output from other activities"

a) Understanding and specifying the context of use

The "*context of use*" is a central concept in the ISO9241-210 standard. By context of use, the standard means "*the characteristics of the users, tasks and organizational, technical and physical environment…in which the system is used"* - in other worlds – anything that can affect the use of the system is relevant.

In this activity the standard specifies a list of things that *must* be in the context-of-use description:

1) *The users and other stakeholder groups*. All user groups or users that affect the system or are affected by the system.
2) *The characteristics of the users or groups of users*. All relevant characteristics of the users and/or user groups shall be identified.
3) *The goals and tasks of the users*. All user goals and overall system goals "shall be identified". This includes the way the users actually do the tasks and even the possibility of error while performing the tasks.
4) *The environment of the system*. This includes "the technical environment … and the relevant characteristics of the physical, social and cultural environment.

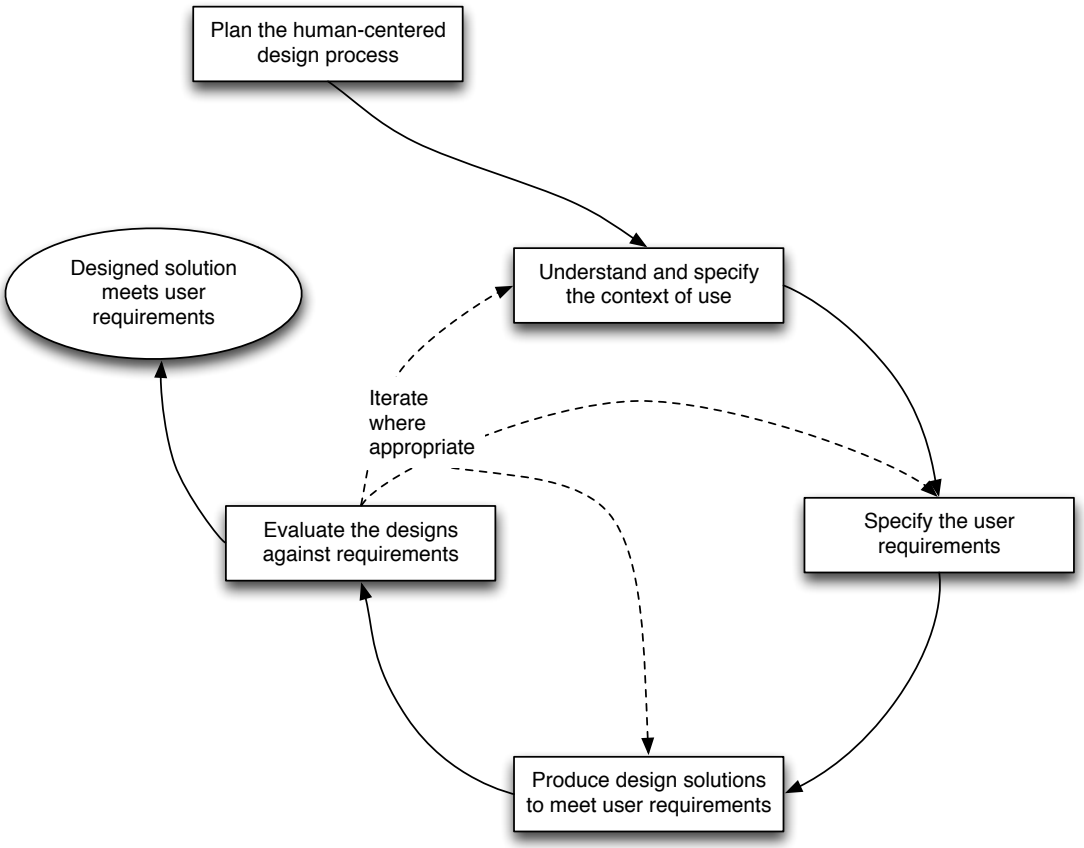

Figure 2 - Interdependence of human-centered design activities

b) Specifying the user requirements

The user requirements specify the criteria that should be in the finished product, and can be used to evaluate the design solutions. The scope of what is considered user requirements in the standard is very wide – it addresses the users and stakeholders needs as well as the requirements to the organization and any other implications the new system can have.

There is a strict index of what the user requirements must include:

- *The intended context of use.*
- *Requirements derived from user needs and the context of use.*
- *Requirements arising from relevant ergonomics and user interface knowledge, standards and guidelines.*
- *Usability requirements and objectives, including usability performance and satisfaction criteria in specific context of use.*
- *Requirements derived from organizational requirements that directly affect the user.*

c) Producing design solutions

This is the phase where we capitalize on the work done so far – if the context of use and the user requirements are specified as detailed and precise as possible, it will be a much easier task to make a design solution that will evaluate well against the user requirements.

The standard describes four non-mandatory sub-activities for the design process:

- *Designing user tasks, user-system interaction and user interface to meet user requirements*
- *Making the design solutions more concrete (by using visualization methods like scenarios, simulations, prototypes, mock-ups, etc.)*
- *Altering the design solutions in response to user-centered evaluation and feedback*
- *Communicating the design solutions to those responsible for their implementation.*

The standard also supplies a list of design principles taken from ISO9241-110 (ISO9241-110 1996)

d) Evaluating the design

The evaluation is the key action in this standard. Done right, it can collect new information, provide feedback based on the design, see if the user requirements are implemented or even provide information that lead to a rewrite of the user

requirements. Central in this action is the user-centered evaluation. There are two ways recommended by the standard:

1. User-based testing
This evaluation method involves testing components or visualization of concepts of a system on the user as well as analyzing any kind of logs or reports that can say anything about the use of a system. Visualization methods may include prototypes, models, written or acted scenarios and sketches. The testing can be done at any stage of the process but it is important to start as early as possible to get feedback from the users early in the process to correct any misunderstandings or misconceptions. Testing done later in the process can be used to evaluate the software being tested against the user requirements and even act as a tool for correcting the user requirements if the users find them wrong or inaccurate.

2. Inspection-based evaluation
Inspection-based evaluation is ideally conducted by usability experts that use their knowledge and experience as well as usability guidelines and heuristics, corporate guidelines, best practices and any other tools that can be used to evaluate the product. This method of evaluation might be cost-effective and effective for removing obvious mistakes from the implementers, but it cannot serve as a correction of the user requirements as the user-based testing will because the evaluator is (most often) not a user and only knows the context-of-use from observation and/or documentation. On the other hand – this method can see wider usage patterns than a user and may even see the whole picture better, so a combination of inspection-based and user-based evaluation is a very good idea.

2.4 Usability methods

In this section I will present relevant usability theory that designers should keep in mind when designing any system that has a user interface.

2.4.1 Affordances and constraints

Donald "Don" Norman in 1988 (Norman 1988) introduced the terms "*affordances*" and "*constraints*" to the field of interface design. The term "*affordances*" he had borrowed from psychologist J. J. Gibson who had a very broad definition on affordances – for Gibson affordances were everything and object has to offer a user – visible or hidden. Don Norman's take on affordances is more about the perceived affordance of objects – what the object offer when you see it. An example: The handle of a coffee mug offers you to grab the handle.

In addition to have affordances, objects may also have constraints. An example: A jigsaw puzzle can only be put together in a particular way. This is a physical constraint.

2.4.2 Usability testing

Usability testing is a way of testing the usability of a product by letting real users use the products while being observed. There are several ways to evaluate the tests. One way is to give the user tasks and then calculate the task completion score. Another way is to measure the time the user spends completing the tasks. It is also common the measure the users subjective satisfaction with a method like SUS – see 2.4.3.

Since the early 80's, usability testing has been used as a tool in the software industry and researchers, but seen as a method, traditional industry firms and social sciences have used it for decades for instance for making kitchen appliances or researching behavior in psychology.

The main method for usability testing is observation – and here we can use all possible methods such as taking notes, recording sound and/or video, acting out scenarios etc.

Usability testing as a method can uncover a wider range of usability issues than other methods like heuristic evaluation (book ref) – mainly because they user real users that will evaluate the product much better than a domain or usability expert.

Jakob Nielsen and Tom Landauer in a 1993 study (Nielsen and Landauer 1993) showed that you need very few users to uncover most of the usability issues in a system – Nielsen's example is that 5 users will uncover 85% of the usability issues in a system. Some studies have different results (Spool and Schroeder 2001; Woolrych and Cockton 2001) and think the number is too low. A 2012 study by the Nielsen Norman Group (Nielsen 2012) presented on Jakob Nielsen's website analyze a large number of usability tests concluding that the maximum number of errors were found when the numbers of testers was between 5 and 15.

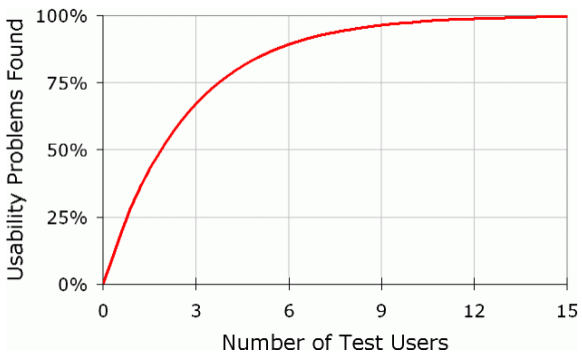

Figure 3 - The relationship between uncovered usability issues and number of users. From Nielsen and Landauer

2.4.3 SUS Evaluation

SUS, or the System Usability Scale, is a attempt to measure a group of users subjective satisfaction of a particular system (Brooke 1996). Based on 10 questions to be answered on a Likert scale, the method will return a score between 0 and 100. The standardized SUS form is at Appendix 5 – System Usability Scale.

In a recent study Jeff Sauro (Sauro 2011) analyzed 500 SUS studies and found that the average SUS score (in his material) is 68, and that the 90th percentile is at 80.3. In other words – if your system gets a score over 80.3, it is in the top 10% according to Sauro's data.

Lewis and Sauro (Lewis and Sauro 2009) describe how they found two factors, Usable and Learnable, when analyzing two separate SUS dataset. Learnable consists of two questions – question 4 and 10, and Usable the rest of the questionnaire.

2.4.4 Fidelity considerations

Fidelity says something about the degree of realism in a prototype. A low fidelity prototype can be rather abstract and is mainly used to test concepts and ideas – for example with paper prototypes or mock-up applications with very limited functionality. On the other hand - a high fidelity prototype has a look and feel that is very much like the real product and is often used to test how ideas and concepts actually are implemented in the finished product.

In (Dahl, Alsos et al. 2010) the authors break up the fidelity dimensions into two main dimensions and four sub-dimensions. Comparing this model, more specifically the four sub-dimensions, with Figure 1 - ISO9241-11 Usability Framework, shows us that the sub-dimensions are more or less identical to ISO9241-11's context of use characteristics – thus it is compatible with the ISO9241-11 standards model and can act as a tool for evaluating systems made with the methods described in the standard.

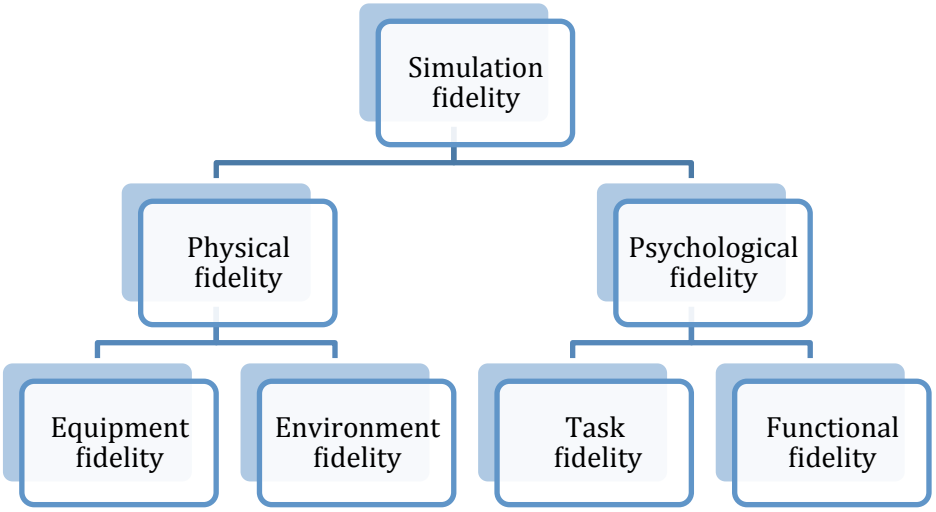

Figure 4 - Simulation fidelity dimensions (Dahl, Alsos et al. 2010)

Physical fidelity

Equipment fidelity
To ensure that the system is tested as realistically as possible, the equipment should be as realistic as possible. This affects all equipment used to achieve the goals of the system.

Environment fidelity
The environment – both the physical and social – will affect how a user uses a system. Examples: If is it to cold to work without the gloves, a touch screen might be a bad idea; if it is noisy, speech recognition is probably a bad idea, etc.

Psychological fidelity

Task fidelity
The tasks at hand should be as realistic as possible. Tasks that seem meaningless to the user may result in the user not taking the system seriously.

Functional fidelity
Functional fidelity deals with the degree of reality the system has. Example: when doing heart compression resuscitation to a dummy, a dummy with high functional fidelity would make sounds, open its eyes and gasp for air when you have done your "tasks" the right way the correct number of times.

2.4.5 Shneiderman's 8 golden rules

These guidelines were first published in Ben Shneiderman's book "*Designing the user interface"* in 1987 and have changed slightly from edition to edition. This set of guidelines is from the fourth edition (Shneiderman 2005):

- *Strive for consistency.* Be consistent in language, appearance and actions. Examples: terminology,

- *Cater to universal usability.* Recognize that the users will be diverse in experience, age, disabilities and technological background. Example: shortcuts for experienced users, explanations and walk-throughs for novices.
- *Offer informative feedback.* For every action there should be a system feedback. If there is an error, show a constructive error message and not just an error code. Example: instantly showing that that information like postal codes is validated and ok without having to post or save the form.
- *Design Dialogs to yield closure.* All sequences of actions should have a clear start, middle and end phase. Example: e-commerce shopping sequence: Shopping basket -> checkout -> pay.
- *Prevent errors.* Try to prevent errors as much as possible. Example: use instant input-validation on text fields, remove/gray out options that will result in errors.
- *Permit easy reversal of actions.* Easily available undo functionality will calm the user and potentially make the user less scared of making mistakes.
- *Support internal locus of control.* Make the user feel that he/she is in charge of the system and not the other way.
- *Reduce short-term memory load.* The limitations of human information processing in short-term memory (cognitive load) require that the display at all times is kept as simple and uncluttered as possible. The rule of thumb is seven plus/minus two "chunks of information" based on G. A. Miller's psychology experiments in the 50s and 60s.

2.4.6 Nielsen's 10 heuristics

Jakob Nielsen's 10 heuristics are widely acknowledged as one of the most influential usability tools. They are called heuristics and not guidelines because they are meant to be used more as "rules of thumb" than specific guidelines for specific situations. Originally published in 1990 and revised at least twice since then – this is current version from Jakob Nielsen's website (Nielsen 1994; Nielsen 2012)

t1 *Visibility of system status.* The user should at all time be informed about what is going on.

t2 *Match between the system and the real word.* In short: speak the users language – including visual language, concepts and real-world conventions.

t3 *User control and freedom.* Let the user be in control – don't leave the user trapped without exits. Support undo and redo.

t4 *Consistency and standards.* Follow platform standards to avoid user confusion.

t5 *Error prevention.* If possible, avoid setting the user in situations where there is a high risk for making errors.

t6 *Recognition rather than recall.* Make available actions visible, remove un-needed actions and information and provide instructions for user.
t7 *Flexibility and efficiency of use.* Provide a way to work both for novices and experts. The novice needs support – the expert needs efficiency. Help them both.
t8 *Aesthetic and minimalist design.* Keep things simple. Remove unnecessary or rarely used information.
t9 *Help users recognize, diagnose, and recover from errors.* Use error messages the user understands and that provide a solution.
t10 *Help and documentation.* Provide compact and task-oriented documentation.

2.4.7 Other guidelines

Norman's 7 Principles

Donald Normans 7 principles were published in 1988 in his book "*The psychology of everyday things*" (Norman 1988) and are fairly general and include his theories about "*the gulf of Execution*" and "*the gulf of evaluation*".

t1 Use both knowledge in the world and knowledge in the head
t2 Simplify the structure of tasks
t3 Make things visible: bridge the gulfs of Execution and Evaluation
t4 Get the mappings right
t5 Exploit the power of constraints, both natural and artificial
t6 Design for error
t7 When all else fails, standardize

Tognazzini's First Principles of Interaction Design

Bruce "Tog" Tognazzini also has a set of principles (Tognazzini 2003) to be used both as guidelines and for evaluation. It is quite large and according to Jacob Nielsen "too long to be used for heuristic evaluation"(Nielsen 2012).

2.5 Usability in the developing world

There is a growing interest in research on usability in and for the developing world. I have used some specific South African papers describing methods and heuristics used in the rural areas as well as some general papers describing doing usability testing in multi-cultural settings.

Adebesin, Kotzé and Gelderblom have written two papers (Adebesin, Kotzé et al. 2010; Adebesin, Kotzé et al. 2010b) where they describe the heuristic evaluation and usability testing done on the South African "*Digital Doorway*" project – a project made to bring computer training to people in "*rural and disadvantaged areas*". In the first paper they first heuristically tested the Digital Doorway and then user multiple usability methods to evaluate the system. Their conclusion

was that even if each of the methods has its limitations, the combination of the methods offset such limitations. In the second paper they presented the results from a field study conducted to evaluate the usability of the Digital Doorway in depth and described the problems encountered.

Maunder, Marsden et al in a 2007 paper(Maunder, Marsden et al.) described how they used ISO13407 User-Centered Design methodology in two case studies from different regions in South Africa and the experiences they have had. They find there are some methodical challenges with using Users Centered Design (UCD) and conclude with *"Currently, we are aware of no field-proven and replicable UCD4Dev methodologies and significant work is still required to define a candidate UCD4Dev methodology suitable for design purposes."*
Torkil Clemmensen and Shivam Goyal (Clemmensen and Goyal 2005) did a study where they tested if there is a difference if the tester and the user in an talk-aloud usability test are from the same or a different culture using Danish and Indian users and testers. The concluded that same-culture testers will tend to "*inspire the user to talk more aloud*", do the test faster, find more task-specific usability issues and generally be more assisting than using a different-culture tester.

9 representatives of the "*Mobile Midwives Ultrasound*" project at the University of Washington's Change project, in a 2012 paper (Anderson, Kolko et al. 2012) describe their process of building a mobile ultrasound machine for the rural, African midwife, building a help system, and then testing the system in usability tests both in Washington and Uganda as well as carrying out interviews with midwives in Uganda. This is a project quite like the Umoja project, but with a different approach to both the hardware and software design process. Unlike the Umoja project they rely on off-the-shelf ultrasound hardware and the software testing is base on a open-source ultrasound machine GUI made in the US before even talking to their target group – the rural, African midwife.

2.5.1 Hofstede's cultural dimensions

Geert Hofstede's cultural dimensions have been commonly used in usability research and practice since they were published. (Hofstede 1980). Hofstede's "*dimensions of culture*" are mainly based on questionnaires made out to IBM employees all around the world in the 1970s. From this research, Hofstede presented his 5 dimensions: Power Distance Index (PDI), Individualism (IDV), Masculinity (MAS), Uncertainty Avoidance Index (UAI) and the Long-Term Orientation (LTO). These dimensions are used as tools for understanding the differences in culture in many fields of research.

2.6 Mother and child healthcare in South Africa

South Africa has committed to the eight WHO Millennium Development Goals (MDG)(WHO 2000). They have, however, problems reaching the goals, as shown in the 2010 status for MDG 5, "*Reduce Child Mortality*"(SSA 2010). They have good vaccination programs against tuberculosis, diphtheria, whooping cough, tetanus, polio, measles, hepatitis B and hemophilic influenza, but they still struggle to reach their other goals. The life expectancy at birth has decreased 2.3 years for males and 4.4 years for females from 2001 to 2007; the under-five-year-old mortality rate has grown from 59 per 1000 in 1998 to 104 per 1000 in 2007; the pneumonia incidence under five years of age has increased from 21 per 1000 in 2003 to 102.1 per 1000 in 2009. This coincides with the growth of the HIV virus in the region and the situation is mostly the same all over sub-Saharan Africa.
MDG 6, "*Improve maternal healt*h" has the same trend as MDG 5 in South Africa. The maternal mortality ratio has risen from 369 per 1000 in 2001 to 625 per 1000.

Even though the maternal and child health care has been vastly improved, the strain on the South African health care system due to the HIV epidemic is obvious.

2.7 Technology usage in South Africa

South Africa is in many ways a segregated land even if the formal barriers were removed when apartheid ended in 1994. In the 2001 census only 2% of "*black households*" had a computer while 46% of "*white households*" had (SSA 2001). A 2007 Community Survey shows that the overall share of households with a computer has grown from 8,6 % in 2001 to 15.7% in 2007, so there is no reason to believe that the situation has changed dramatically since then (SSA 2007). According to the UN's 2009 Information Economy Report (Unctad 2009) the cell phone coverage in South Africa reached 97.54% of the adult population in 2008. The same report also states that over 50% of the broadband subscribers use a 3G connection as their broadband connection. A 2011 report from South African marked research firm World Wide Worx (World Wide Worx 2011) state that 27% of rural South Africans use their mobile phones for banking while 44% of urban users do the same.

2.8 Technology usage in Norway

According to Statistical Yearbook of Norway 2011 (Statistics Norway 2011) 97% of Norwegians aged 7 to 79 have a cell phone, 93% have access to Internet at home and 94% have access to a computer at home.

3 The Umoja project

The Umoja project is a direct outcome of my employer National Center for Fetal Medicine's (NCFM) status as a "*WHO Teaching and Training Center for Ultrasound in Obstetrics and Gynecology*". NCFM has had this status since 1997, and since 2001 the main focus has been in South Africa. A teaching and training program in the use of ultrasound in obstetrics and gynecology in cooperation with the Nelson Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa was started in 2004. This program revealed that ultrasound equipment in the rural areas where the midwives work was scarce and not always suited to the needs of an African rural midwife. This teaching and training program also has provided us with South African test users for the Umoja ultrasound machine. In addition, demographics on the class of 2004 have been collected by the teaching staff of the course.

3.1 Umoja motivation

The Umoja project is motivated by a belief that modern and appropriate adapted ultrasound equipment can ease some of the strain on the mother and child's health situation and save lives when put to systematically and correct practical use. Precise dating of the pregnancy, early detection of twins and other fetal and maternal conditions that may affect the outcome of the mother and child, are some of the goals of introducing the Umoja ultrasound machine to rural Africa.

3.2 The Umoja ultrasound machine

Two prototypes of the Umoja ultrasound machine have been made, and both have been tested in the field in South Africa. The third prototype is being planned. The two first prototypes were made by the Trondheim/Selbu based firm Aurotech Ultrasound AS.

The Umoja II is modular. The main ultrasound unit ("Manus") is a closed box that has an ultrasound probe, gigabit ethernet and a power chord attached.

Figure 5 - The Umoja II ultrasound machine

Attached to the Ethernet cable is a standard laptop PC. This could also be some kind of miniature mother-board-based PC or even a Tablet, but the prototypes used a standard Dell laptop. All “hardcore” ultrasound image enhancements are done in the Manus. The raw data is transferred to the virtual EPS signal processor in the PC, which converts the raw image stream to viewable data in the US GUI. The GUI contains the image output and some controls to operate the EPS and the Manus.

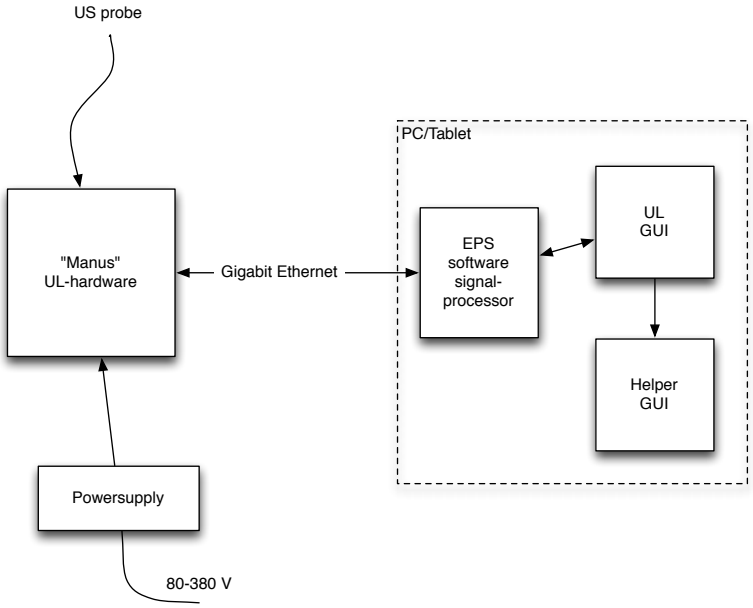

Figure 6 - Umoja I/II prototype overview

The Umoja II GUI is a simplified version of Aurotech’s “proof-of-concept”-GUI – a cluttered, overcrowded GUI that tries to show all functionality of the Manus and EPS at once. The GUI has not been tested on users and will be redesigned.

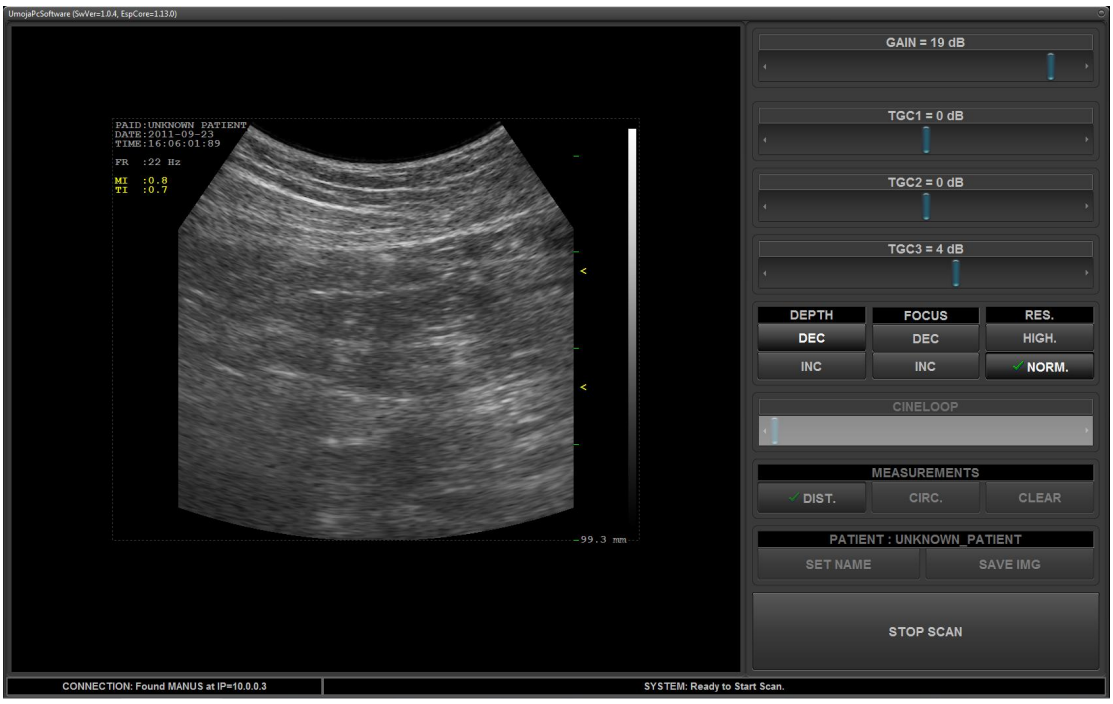

Figure 7 - Aurotech Umoja II GUI

3.3 Technical demands

The Umoja ultrasound machine specifications (Appendix 1) specify that the machine should tolerate the voltage fluctuations that may occur in rural Africa. The Umoja II prototype is designed to run on 12/24 V DC and 80-380 V AC – both sinus and non-sinus-formed AC. It also has external surge protection to protect against voltage spikes in the power distribution network. Thunderstorms are quite frequent in South Africa and should be considered when building equipment to be used there. The machine should be contained in a tough dust and water-protected transport unit.

Figure 8 - The Umoja I prototype tested on a car battery

3.4 The Umoja midwife assistant

The focus of my project is to implement and test a prototype of the help system – named "*The Umoja midwife assistant*".

The functions of the Umoja midwife assistant are defined in paragraphs n, o and q in Appendix 1.

> n) The system should contain lectures in fetal medicine accessible for the user.
> o) The system should contain an image database accessible to the user. The database should contain images of the most common diagnoses as well as reference images of normal fetuses.
> q) The system should contain a list of procedures for the most common diagnoses.

4 Research method

To see how the ISO 9241-210-standards method fit the underdeveloped world, I chose to develop a prototype of the help system and then test the it first on the intended target group – the African rural midwife, and then test it on Norwegian midwives as a comparative study.

The users are two groups of midwives – one in KwaZulu-Natal in South Africa and one in Trondheim, Norway. They have in common that they all are attending a post-qualification course in ultrasound diagnostics held by NCFM.

To see how my development and testing method fits the ISO standards method, I then analyzed the method used and compared it to the method in the standard.

It is important to differentiate between the methods used to answer my research question and the methods used in my work in the field. This chapter will deal with the methods I chose to analyze and answer my research question; methods used in the field are described in the next chapter, "The user-centered design process".

Quantitative methods
Quantitative methods are methods that lead to countable, calculable and objectively comparable results.

Qualitative methods
Qualitative methods are methods that depend on interpretation to lead to a result. This usually means trying to understand what the research subject is doing and maybe even why. It is in the nature of the qualitative methods that they are not easily comparable, unless you try to quantify the results in some way.

4.1 Chosen methods

I chose to do a combination of quantitative and qualitative methods. I used the qualitative methods to get information on the background of the user group in advance of the finalization of the prototype. I also used a quantitative method in the background study. I used existing statistics from the midwife class of 2004 as well as statistics from the 2011 users both in South Africa and Norway who filled out two demographics forms and a SUS evaluation form.

The usability test itself can be interpreted both quantitatively and qualitatively – I chose to focus mostly on the quantitative data to better compare the two user groups. The usability test is divided into tasks and subtasks that provide a

percentage score. I then tested the software on the users – both in South Africa and in Norway and completed both tests with a modified SUS form.

The SUS analysis can be viewed as a quantitative measure on the users subjective, quantitative experiences with the software and can say something about how well the users perceive the prototype.

RQ1: To answer research question 1, I chose the following methods:

- t1 Map the methods I've used onto the ISO 9241-210 standard's method
- t2 Evaluate the methods used – are there any special considerations not covered by the ISO standards methods?

This will show how the work done fits with the ISO 9241-210 method and evaluate the methods used in this process.

RQ2: To answer research question 2, I had to see what lessons I had learned while working in South Africa and then see if and how they differed from the "best practice" guidelines in the field. To test this, I first went through the usability issues found in South Africa and Norway, and then tried to see if they are covered by the guidelines given in Ben Shneiderman's Eight Golden Rules of Design.

4.2 Alternative methods

There are several ways to test if the ISO 9241-210 method applies in a non-western context. One possibility is to use a larger test group with randomly picked midwives from the region. I could have used South African and Norwegian programmers in parallel to see what difference that makes – to test the findings of Clemmensen/Goyal in "*Cross cultural usability testing – the relationship between evaluator and test user*" (Clemmensen and Goyal 2005) and Molich/Ede in "*Comparative Usability Evaluation*" (Molich, Ede et al. 2004) to see if this makes any difference. Both papers conclude that using a local tester improves the quality of the usability test.

I also could have used Hofstede's theories as a tool to understand how the users differ. There is however a few problems with Hofstede's work – both in general and specifically in South Africa. In the recent years it has been pointed out that Hofstede's dimensions have some shortcomings(McSweeney 2002; Ailon 2008). I have chosen not to use Hofstede's theories while developing the help system for a simple reason: Hofstede's original investigations were based on interviews with IBM employees some time around 1980. I suspect that the findings from Hofstede's questionnaires to white, apartheid-area, middle/upper class IBM employees in South Africa will not be representative for the post-apartheid Zulu/Xhosa midwives included in my study – especially regarding dimensions such as the Power Distance Index (PDI) and the Uncertainty Avoidance Index

(UAI). I have strong doubts about the validity of the numbers for my user group; I thus chose not to use Hofstede at all.

4.3 Comparative studies

There are many ways to do a comparative study – you can compare testers, compare methods and compare users. I will here present some studies and relevant results.

In the CUE-2 study, Molich, Ede et al. (Molich, Ede et al. 2004) compared how 9 different teams in different organizations preformed a usability evaluation of Microsoft Hotmail with each organization using the method of their choice. A simple method was used: the teams were told to identify usability issues by following a scenario using their favorite methodology. The scenarios included a different set of tasks for each team. The results and usability findings were then analyzed.
The results were striking: Out of 310 identified usability issues, 232 (75%) were identified by one team only. Only 6 issues were identified by 5 or more teams. The authors conclude that the result of a usability test is dependent on the task chosen, the testers and the methodology. They also recommend that one should "Use an appropriate mix of methods." and remember to also address the usability issues only detected by one tester.

In his master thesis, Lars Flem (Flem 2009), compared two usability methods – cultural probes and focus groups using the use of Apples iPhone as a theme. He did so by setting up a set of categories he wanted to know more about and then analyzing the data from each method using the categories. In addition, he used a secondary empirical method – users from both groups were interviewed and participated in a UTAUT study. By comparing the results from all methods, Flem concluded that the different methods had different characteristics and came up with a recommendation of combined methods.

In a 2010 study, Marco Pretorius, Judy van Biljon and Estelle de Kock (Pretorius, van Biljon et al. 2010) tested if using an eye tracker device would give an added value to the understanding of the usability issues in a system. He did so by comparing two user groups of South African students – one group identifying themselves as "*expert internet users*", the other "*non-expert internet users*". The users tested a Learning Management System with a set of tasks and the data was collected with an eye tracker. In addition a questionnaire was handed out. They concluded that the experts used shorter time, non-experts scanned the display for information more than the experts, that the non-experts did not understand even the most basic error messages, and that eye tracking really helped them understand that.

5 The user-centered design process

This part describes how the work was done.

I divided the work into four phases:

- t1 **Preparations in Norway** to find out as much as possible about the midwives in KwaZulu-Natal, South Africa, from the information already available.
- t2 **Work in KwaZulu-Natal** where I delved further into the midwives background before completing the prototype and doing a usability test together with the midwives.
- t3 **Work in Norway** where I repeated the usability test to see if the product made for midwives in KwaZulu-Natal is suited to Norwegian midwives.
- t4 **Analysis** where I analyzed the findings to see what the main differences between the user groups are – if there are any.

The prototype tested will not result in a finished product in this project – the project will continue and merge into the GUI project of the Umoja III machine in the second half of 2012 and will probably undergo a new usability test in KwaZulu-Natal in 2013 with a new set of midwives.

5.1 Target group

The target group for this system is the African, rural midwife working in small hospitals or community health centers in South Africa.

5.2 The mobile test lab

The mobile test lab consisted of a Dell Latitude E6420 running Windows 7, a Microsoft LifeCam Cinema HD, a camera stand and a Livescribe Pulse electronic pen. The internal display, the camera and sound from both the laptops and the LifeCams internal microphone were recorded with Camtasia Studio.

Figure 9 - The mobile usability test lab set up in South Africa

5.3 Phase 1: Preparations in Norway

5.3.1 Motivation

The motivation of this phase was to find out as much as possible about the targeted users of the system before actually going into the field and working with them. The NCFM team has vast experience from teaching and working with the targeted groups and has both experience and statistics that are interesting for this study.

Goals of phase 1:

t1 To find out as much as possible about the target group before actually talking to them
t2 To build personas based on information gathered
t3 To write a draft of the scenario for the usability test
t4 To make a navigational map of the system
t5 To make the first version of the prototype.

What was available before going in the field?

e1. Functional specification
e2. NCFM staff that had already worked with the target group
e3. Demographics gathered on earlier visits to South Africa.

5.3.2 Method

t1 ***Unstructured interview.*** I chose to do an unstructured interview with one of the teaching staff involved. The unstructured interview with people who have worked with the users is a good way to get a first impression of a user group without actually having direct access to the users.
t2 ***Statistics***. The statistics provided can say something about the user group and possibly reveal if there are any demographical subgroups.
t3 ***Personas.*** Persona(s) are an incarnations of one or more virtual persons in the target user group. The personas are derived from the specification and all information that can be gathered about the user. Persons provide a good tool for ensuring that both the product and the testing of the product will be as valid and precise as possible. The personas in my case were based on the interview and the statistics.
t4 ***Scenario***. With the information gathered, a scenario was written to set the tasks for the user in a context known to the user.
t5 ***Navigational map.*** The navigational map is a graphical representation of the system that shows the main navigational choices available to the user.

5.3.3 Outcome Phase 1

The outcome of phase 1 was:

t1 Demographics
t2 Personas
t3 Navigational map of system
t4 Draft scenario
t5 First prototype.

5.3.4 Functional Specification

The functional specification (Appendix 1 – Umoja system requirements) of the Umoja ultrasound machine was written by Sturla Eik-Nes and Eva Tegnander from the National Center for Fetal Medicine based on their experiences with work in South Africa since 2002. The specification covers both the diagnostic/clinical goal of using the machine, practical specifications, clinical specifications and specifications that describe the software supporting the diagnostic process. In this thesis, I focused on the requirements for the supportive software for the ultrasound machine – "*the midwife assistant*", but the rest of the specification is also a valuable document since it describes some of the technical challenges an ultrasound in rural Africa will have. Eik-Nes and Tegnander have worked in rural areas in South Africa for more than 10 years and the functional specification in many ways sums up their experiences regarding hardware and software.

5.3.5 Target Group Demographics

We already had some statistics available from the previous students that took part in the teaching and training program in ultrasound in 2004. The forms were filled in at the start of the midwives' training and were kindly made available to me by midwife dr. philos Eva Tegnander. Eva Tegnander works at NCFM, and participated in the 2004 course as an instructor and has subsequently visited many of the midwives at their local hospitals/clinics several times.

5.3.6 Interview

An interview with Eva Tegnander was conducted.

5.3.7 Personas

Using the information gathered from the interview and the demographics, two personas were constructed.

5.3.8 Scenario

A basic scenario was created.

5.3.9 Navigational Map

Based on the personas, scenario and information gathered, a navigational map was created. This map was made partly to concretize the user's options at any time and partly to assist the implementation of the system.

5.3.10First prototype

The first prototype was implemented based on the navigational map, the personas, the demographics, the functional specification and the interviews.

5.4 Phase 2: Work in KwaZulu-Natal

5.4.1 Motivation

The goal of Phase 2 was to learn as much as possible about the South African testers of the prototype, i.e. the midwives attending the 2011 teaching and training program, before finishing the work on the prototype and carrying out the usability test.

5.4.2 Methods

- ***Statistics*.** More demographics to find out more about the users background.
- ***Interviews***. Informal interviews with the local users to supplement my previous knowledge.
- ***Field studies***. Field studies to see the physical context where the system is to be used .
- ***Scenario***. Updating the scenario based on the information gathered.
- ***Prototype***. Updating the prototype based on the information gathered.
- ***SUS Evaluation***. Doing a SUS evaluation to measure the users subjective satisfaction with the system.

Of these methods, the demographics and the SUS evaluation are quantitative methods, the rest are qualitative. As opposed to the demographic statistics that are measurements of objective data, the SUS evaluation can be seen as a quantitative measurement of the users subjective, qualitative feelings about the usability test and the prototype.

5.4.3 User demographics

The "*first day survey*" is a form developed with the NCFM teaching staff with the purpose of discovering demographics, practical and clinical factors for the training the users are to be given. I have removed the clinical factors from the form, as they are not of interest for my research. The form is in Appendix 3 – First day .

The second demographics form was handed out some days later and the questions loosely based on statistics from the previous Community Census 2007 (SSA 2007), the then ongoing national Census 2011(SSA 2011) as well as other data considered useful. The form is in Appendix 4 – Demographics survey.

5.4.4 Informal interviews

I conducted several informal interviews while observing the teaching at the Lower Umfolozi War Memorial Provincial Hospital. The interview had no specific themes, and I took random notes – often summarized in the evening.

5.4.5 Field studies

I visited two rural clinics and one squatter settlement with a mobile clinic in addition to our base at the Lower Umfolozi War Memorial Provincial Hospital in Empangeni. Some of the visits were conducted together with the representatives from the Faculty of Medicine at NTNU and two NTNU medical students doing their thesis in the area. At the sites I took notes, photographed and filmed – there are approx. 80 photographs and one hour of video from these field studies.

5.4.6 Scenario

After getting more information on the users and studying how they work, the scenario was written out as a manuscript for the usability test – see Appendix 2 – Usability test manuscript.

5.4.7 Prototype

The prototype was updated to comply with the changes in scenario and some usability recommendations from a paper by Adebesin and Kotzé (Adebesin, Kotzé et al. 2010) (see 0 Prototype)

5.4.8 Usability test

A usability test was conducted using the mobile usability test lab. The test was based on the written scenario and the finished prototype.

5.4.9 SUS evaluation

The SUS form was slightly modified in accordance with advice from Lewis and Sauro (Lewis and Sauro 2009) that “non native English speakers”, in their experience, do not understand the word “cumbersome” in question 8. They recommend using “awkward” instead.

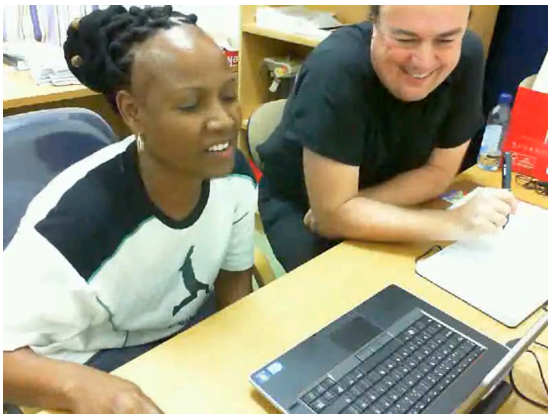

Figure 10 - Usability test in South Africa

5.5 Phase 3: Work in Norway

5.5.1 User demographics

The Norwegian midwifes were given the same forms as the South-African users.

5.5.2 Usability test

The Norwegian users were given the same usability test as the South African users and the test results were analyzed using the same criteria.

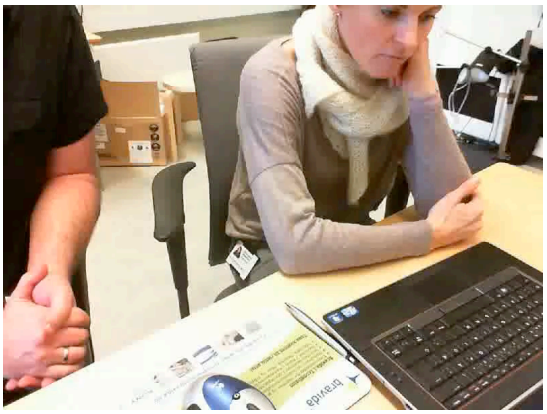

Figure 11 - Usability test in Norway

5.6 Phase 4: Analysis

The material gathered from the two groups were compared and the lessons learned summarized.

5.7 My process

Summing up, my process looks like this:

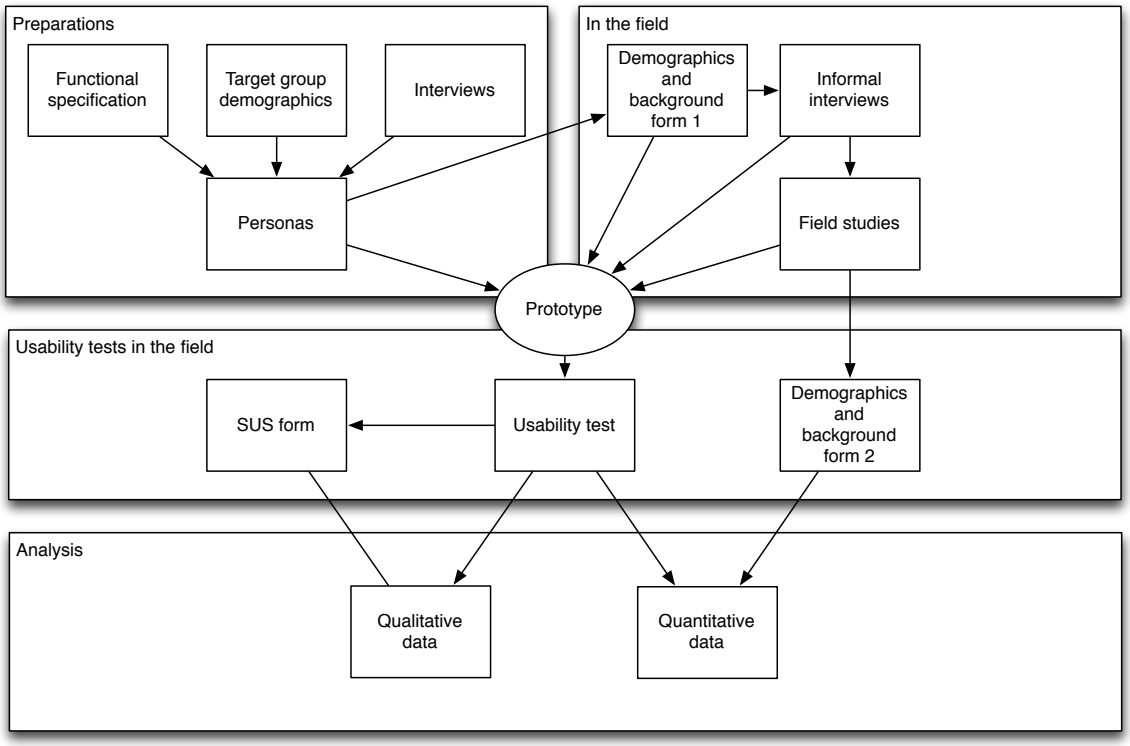

Figure 12 - My process

Seen as a list, the process looks like this:

Step	Actions
1	Receive functional specification
2	Identify need for user-centered design
3	Process statistics from former students
4	Interview with informants
5	Make personas
6	Make scenarios
7	Specify user requirements
8	Implement the first prototype
9	Evaluate prototype against requirements
10	Form 1 with demographics and background
11	Informal interview
12	Field studies
13	Form 2 – more demographics
14	Modify personas
15	Modify scenario
16	Re-specify user demands
17	Implement second prototype
18	Test second prototype with real users
	Iterate until satisfied

Table 1 - My process

6 Findings

This chapter contains the results of the demographics studies, fieldwork and other experiences working with the Umoja project.

6.1 Phase 1 – Preparations in Norway

6.1.1 Demographics

The South African midwife class of 2004 filled out a simple form when starting a training course in ultrasound.

Students name	Date of birth	Place of work	Ultrasound machine	Telephone number	E-mail address
P1	xx.xx.60	Hospital	Yes	Work, Cell	Private
P2	xx.xx.53	Hospital	Yes	Work, Cell	Work
P3	xx.xx.53	Hospital	Yes	Work, Cell	Work
P4	xx.xx.56	Hospital	Yes	Work	Work
P5	xx.xx.63	Hospital	Yes	Work, Cell	Private – same as P6
P6	xx.xx.70	Hospital	Yes	Work, Cell	Private – same as P5
P7	xx.xx.56	Clinic	Yes	Work, Cell	Work
P8	xx.xx.66	Hospital	Yes	Work, Cell	Work
P9	xx.xx.52	Hospital	Yes	Work, Cell	Private
P10	xx.xx.57	Hospital	Yes	Work, Cell	Private
P11	xx.xx.64	Clinic	Yes	Work, Cell	Private
P12	xx.xx.58	Clinic	Yes	Work	Work
P13	xx.xx.53	Hospital	Yes	Work, Cell, Home	Work

Table 2 – South African midwife class of 2004 demographics

Their average age was 44.5 years ranging from 34 to 52 years, they all had some kind of ultrasound machine at their clinic/hospital, 9/12 provided their cell phone number when asked for a telephone number, and they all provided a contact email address – although two supplied the same address.

6.1.2 Interview

The interview was informal and had the following main areas:

- Age
- Family
- Education
- Relationship to technology
- Stamina/self driven
- Do they stay?

Main findings:

- The midwives are between 30 and 55 years old.
- Most of them have children. Typically the youngest midwives haven't married yet.

- All midwives have had a two-year education to become a midwife. Most of them also have an extra year to become an “advanced midwife”. Some of them have use ultrasound before the participating in the NCFM training course, but most of them have not.
- Their relationship with technology seems age dependent. Most of them have a cellular phone. The main use of the phone is speech – they do not use them for messages or Internet. There are very few PCs at the smaller hospitals/clinics – and they are typically in the administration. Only a few have a computer at home.
- The midwives are very autonomous, and they are very positive toward learning to use technology that will assist them in their work. When asked, they say that they now use ultrasound every day.
- It is all in a days work for the rural midwife to assist in any situation that demands the intervention of a healthcare worker.
- As far as the respondent knows, all midwives that have participated in the education program still work as midwives. One has moved to another region, but she still uses ultrasound.

6.1.3 Personas

Midwife 1:
Midwife 1 – Thabisa – is 35 years old, is not married and has no children. She lives close to the hospital where she works, and also close to her parents and some of her siblings. She had a sister who died in labor. She is an advanced midwife and has worked 6 years at the hospital. She sometimes borrows a relatives computer and has a relatively new cellular phone that she uses for speech, messaging and bank services. She is curious about new technology – especially if it can help her do her job better.

Midwife 2:
Midwife 2 – Nobantu – is 50 years old, married and has 4 children in the range of 15 to 30 years. She lives not far from the hospital where she works, and lives with her husband and their two youngest children. The oldest child and her first grandchild live nearby. Her second oldest child – a boy – is seldom home because he is working in Durban – many hours away. She is an advanced midwife and has practiced her midwifery skills for over 20 years. As a senior advanced midwife she also has some administrative responsibilities at work. She has a cellp hone but does not use it at work – she mainly uses it to stay in contact with her child who works away. She is a little reserved when it comes to using new technology, but when she is convinced that something can help her do her job better and more effectively, she embraces it and makes great efforts to learn how to use it.

6.1.4 Draft scenario

A draft scenario was created bearing the gathered information in mind.

Setting:
The midwife is sitting in an examination room and is examining a pregnant woman. The midwife sees something on the screen when doing a cross section of the head. The midwife sees something unfamiliar in the head of the fetus, but is not sure what it is or even if it is a normal variant. The midwife enters the help system and flips through a few images before she finds the correct one.

Tasks:

1) Enter help system
2) Find a reference image with the same condition.
3) See if there are any relevant lectures

6.1.5 Navigational map

The navigational map shows the main navigational choices available to the user. The functional specification is the basis for the map. There was main consideration: should it be possible to enter the treatment guidelines directly from the "Enter help-mode" state or should a diagnosis of a real patient be provided first?
I chose to have the user choose a diagnosis first to see the guidelines – it seemed much more logical to be given this option in a patient context.

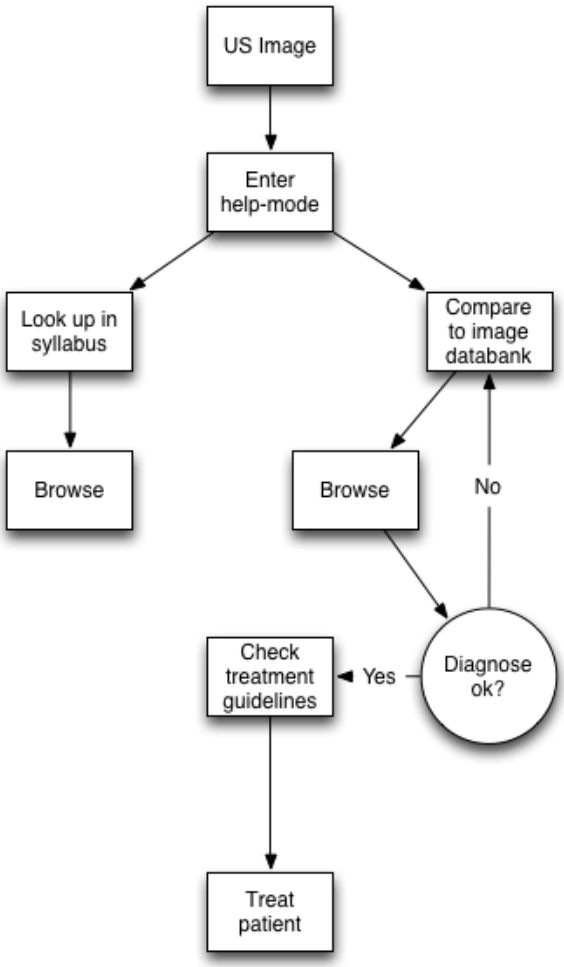

Figure 13 - The navigational map of the system

6.2 Phase 2: Work in KwaZulu-Natal

6.2.1 The users

The users chosen to participate in the test were 10 midwives working in the KwaZulu-Natal (KZN) health region. These were selected by the KZN health authorities to receive a training program in ultrasound given by my employer NCFM. The participants were selected in accordance with several criteria – the main criterion in addition to being interested in getting trained in ultrasound, was that the participants should be geographically distributed evenly in the region and that there should be one from each hospital.

6.2.2 Demographics

The first day, a simple demographics and user expectance form was handed out and filled in and the result matrix is in Appendix 6 – First day survey South Africa. As a general note for all the forms and paperwork it appears that the users are very accustomed to filling out forms and doing paperwork. I also observed this in other situations – there were forms about entering the apartment area where I lived when I arrived in a taxi, security forms that had to be filled in every time I entered and left the hospital with computers and so on.

The complete result matrix for the first day survey is in Appendix 6 – First day survey South Africa.

The second demographics survey is in Appendix 7 - Demographics survey South Africa.

Demographics summary

User	Extra training?	Has cellphone (years)	Own a computer (years)	Familiar with computer use
1	Yes	10	2	Yes -
2	No	12	No	No
3	Yes	15	No	No
4	No	± 12	No	No
5	No	No	No	No
6	Yes	20	1	Yes -
7	No	10	No	No
8	Yes	5	No	No
9	No	15	No	No
10	Yes	± 14	± 4	Yes
	50%	**12.5**	**30%**	**30%**

Table 3 - KZN user characteristics 1

User	Age (years)	Experience as midwife (years)	Use internet?	Main source for internet
1	33	6	Yes	Cell phone
2	41	6	Yes	Cell phone
3	55	29	No	-
4	34	1	Yes	Cell phone
5	56	26	Yes	Cell phone
6	49	24	Yes	Cell phone
7	44	3	Yes	Cell phone
8	41	8	No	-
9	47	6	Yes	Cell phone
10	38	12	Yes	Cell phone
	43.8 years	**12.1 years**	**80%**	

Table 4 - KZN user characteristics 2

Demographic findings:

t1 Average experience as midwife is 12.1 years grouped in two separate groups: 3 midwives had over 24 years of experience while the others had 12 years or less.

t2 The average age is 43.8 and the average age of the users then is only 0.5 years lower than the class of 2004 midwives.

t3 9 out of 10 have cellular phones and have had them for a while – on average 12.5 years.

t4 3 out of 10 have a computer.

t5 4 out of 10 have used an ultrasound machine before. All the computer-owners are in this group.

t6 5 out of 10 do not have a computer, say that they cannot use a computer, and have not used ultrasound before. The midwife that does not have a cell phone is in thus group.

t7 The distribution does not strictly follow age and experience, even though two of the most experienced midwives from pt. 1 are in the non-tech group in pt. 5, the third experienced midwife with 24 years of experience has her own computer, think that she can use it and uses an ultrasound machine on a regular basis.

6.2.3 Informal interviews and observations

These are the summarized results of several informal interviews. Many of them took place during breaks and in other informal situations.

Findings:

- The midwives work long hours – often their shifts are 12 hours up to 6 days a week

- Even if they have ultrasound equipment available at the hospital, they do not have access to it because it is primarily used by someone that outranks them or because of internal hospital politics.
- If there is an emergency, the midwives also treat other non-pregnant patients.
- Whatever you do, do not try to skip the tea break.
- When looking for a room to use for the usability test, I stumbled upon a midwife training class. It was interesting to see how the focus of the learning was to learn all symptom and procedures by heart by repeating them like something that for me sounded like rhythmic verses. For me it is a unusual way to learn and I associate this way of learning with books and movies from British boarding schools. South Africa in many ways seems very British, and this may be an expression of that.
- Most of the midwives had quite modern cellphones – some even had smartphones with touch screen. I was told that there was a big upgrade in both the mobile and 3G data coverage and in the models offered in the months before the 2010 Soccer World Cup in South Africa. The mobile operators upgraded their networks to sell video transmissions of the matches to the phone subscribers.

6.2.4 Field study 1 - The Ntuze Clinic

First I visited the Ntuze Clinic – a small clinic about one hours drive from our base in Empangeni. Map: http://bit.ly/ntuzeclinic. The clinic has the oldest buildings in use and is, according to our hosts, a typical clinic. As I was in a delegation from the Medical Faculty at NTNU, there was always the risk that they showed us an above average standard clinic, but three separate sources, Outreach midwife S, Dr. U and Dr. C all confirmed that this was a typical clinic where the buildings were a little outdated. Only 3-4 patients a month give birth at the Ntuze clinic; most of the patients go to the Lower Umfolozi War Memorial Provincial Hospital in Empangeni – mainly because the food is better there according to the head nurse at Ntuze.

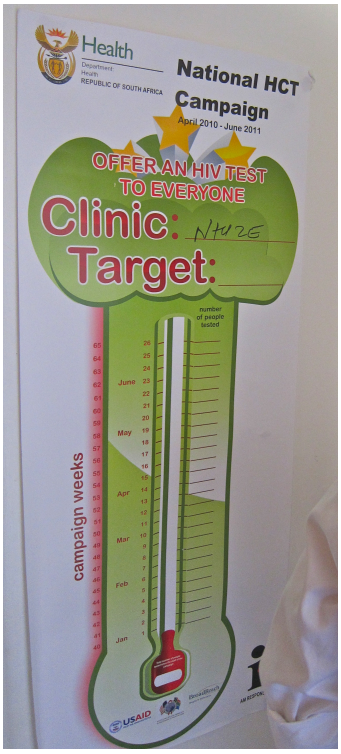

Figure 14 - National campaign for HIV testing

The clinic was a little hard to find – what was marked as the main road on the map was only accessible with a four wheel drive car, but since we had the head nurse from KZN Health Authorities with us, we soon were directed to the new main road that hadn't made it to the maps yet.

Who works here?

This kind of clinic employs several kinds of nurses and midwives. A nurse here usually is a specialized nurse, but not always. The other nurses have their specialties as well – such as children's health, surgery and HIV/AIDS. Normally there are no doctors at clinics like this one, but doctors regularly travel to the clinics to teach and discuss hot topics.

What are their tasks?

Those working in the clinics are the primary health providers for their region. They deal with all emergencies and do all the vaccination, pregnancy care, treatment and follow-ups in the area. They also do simple surgery. Much time is spent treating HIV positive patients – some of these areas have a very high incidence of HIV. About one in three pregnant women coming in for a examination have HIV and there seems to be an increase of the percentage of pregnant women with HIV, but it is hard to say since only a few years ago, only 10% of the women actually wanted a HIV test. After years of national campaigns the percentage of women getting tested now is over 90%.

How do the midwives work?

The pregnant women come in when it suits them – typically much later than in northern Europe – sometimes as late as third trimester (= week 27). Some clinics have ultrasound machines, but most of the pregnancy care is done by listening to the abdomen and examining the fetus by trying to feel the position the fetus is in from the stomach.

The Ntuze Clinic has separate rooms for examinations and our informants emphasized that this is the norm. The only place we saw rooms with multiple examinations were in our base at Empangeni – there the rooms were divided with fabric partition walls to provide for multiple examinations in the same room. This is not normal and was caused by the construction work going on – they were doubling the size of the hospital and during the building process there were some compromises – this was one of them.

What takes place in a regular consultation?

The midwife fetches the patient from the waiting room. The midwife confirms a living fetus by listening for the fetus heartbeat from the abdomen of the pregnant woman. The midwife measures the patient's blood pressure and asks if it is ok to take a blood sample. For most of the pregnant women that is ok, and they check their HIV status and do other tests. The clinics that have ultrasound use it only when there are indications that something is wrong. They do not date the pregnancy and set a term date with ultrasound – they ask the woman for the date of their last menstrual cycle.

General impressions

The Ntuze Clinic is a nice and well kept clinic. In comparison it was in a better shape and more suited for its use than parts of the old, recently demolished hospital here in Trondheim. Everything was well organized and this was not because they knew that we were coming – they were not notified of our visit in advance.

6.2.5 Field study 2 - The Tongaat Clinic

Next I visited the Tongaat Clinic. Map: http://g.co/maps/q2kwv. Tongaat is a clinic that accepts patients from 8-9 other clinics in the area. The hospital director S met us and guided us through the clinic with great enthusiasm. Tongaat has 105 births a month – normal, vaginal births only; all caesarian and other complications are referred to Lower Umfolozi District War Memorial Hospital in Empangeni. Tongaat Clinic has about 28000 patients a month. They have a mobile clinic that travels the local villages and do checkups and other non-invasive procedures.

Who works there?

The Tongaat Clinic receives patients from a handful of nearby clinics. It is a fully equipped hospital that can do simple surgery as well as X-ray examinations in their Radiology department. The staff is much more diversified in Tongaat than in Ntuze. There are several midwives working here and they do pregnancy care and are responsible for about 3-4 births a day. They have an ultrasound machine, but they do not have any qualified users, so the machine has been redeployed. One of the midwives is a member of the NCFM ultrasound-training program.

How do the midwives work?

Pretty much like in the Ntuze Clinic, but since they get referred patients from other clinics, they have more patients with complications.

General impressions

The Tongaat Clinic is a quite large and well-run clinic. The spirit among the staff is very high and they have a popular boss in hospital director S. The premises were large and lucid and – most of the waiting rooms were outside under a fabric roof. The waiting rooms were quite crowded.

6.2.6 Field study 3 - Magwaveni

Our last field trip was with a mobile clinic to the squatter camp Magwaveni outside Tongaat. Map: http://g.co/maps/6td53. Hospital director S and his head nurse took us to the squatter camp Magwaveni. Magwaveni is a squatter village with an unknown number of inhabitants. The village is built with leftover or reused materials from the nearby area, but it is still has some kind of organized

infrastructure like a kindergarten and a village community hall. All houses, even the shabbiest ones, had numbers and all the inhabitants had been counted in the big census mid November 2011. People were quite curious about who we were, but only a few came up and talked with us. People had a great deal of respect for the nurses with their uniforms. Crime used to be a big problem here some years ago, but the hospital director stressed that is no longer was a big problem – and as long as we stayed close to the nurses nothing would happen to us.

Who works there?

Nurses and midwives usually staff the mobile clinics which are covered pickup trucks furnished with a few basic instruments, a narrow cot, medicine and vaccination supplies.

What are their tasks?

The mobile clinics usually do follow-ups on from the patients that have come to the hospital as well as treating those who can't or won't go the to hospital. The pregnancy care is pretty simple – the midwife measure the blood pressure and listen to the abdomen with a Pinard stethoscope. The mobile clinics also do vaccination.

What takes place in a regular consultation?

For pregnant women pretty much the same as in Ntuze and Tongaat.

How do the midwives work?

The patients are received in the community hall, in the back of the mobile clinic or by a desk outside.

General impressions

The area itself has the standard of a village built temporarily on "borrowed" ground – quite shabby. But the quality of the health services they receive seems quite ok. People are friendly and they have a great deal of respect for the uniforms of the health workers.

6.2.7 Field studies - main findings

- Clean and well-kept modern buildings – the old hospital at St. Olav's Hospital was far worse.
- Almost all examinations in hospitals are done in a separate examination room
- In the mobile clinics, all use of technical medical equipment is done in or next to the mobile clinic (=the pickup).

6.2.8 Prototype

The prototype was slightly modified to suit the new scenario.

Figure 15 - Prototype – help system first screen

Several modifications were done based on information with local informants – the most important one is that the "Exit help" button always must be available. The midwife can at all stages of an examination be interrupted by someone with a more critical condition, and thus must be able to exit the help system fast to start an examination of the new patient.

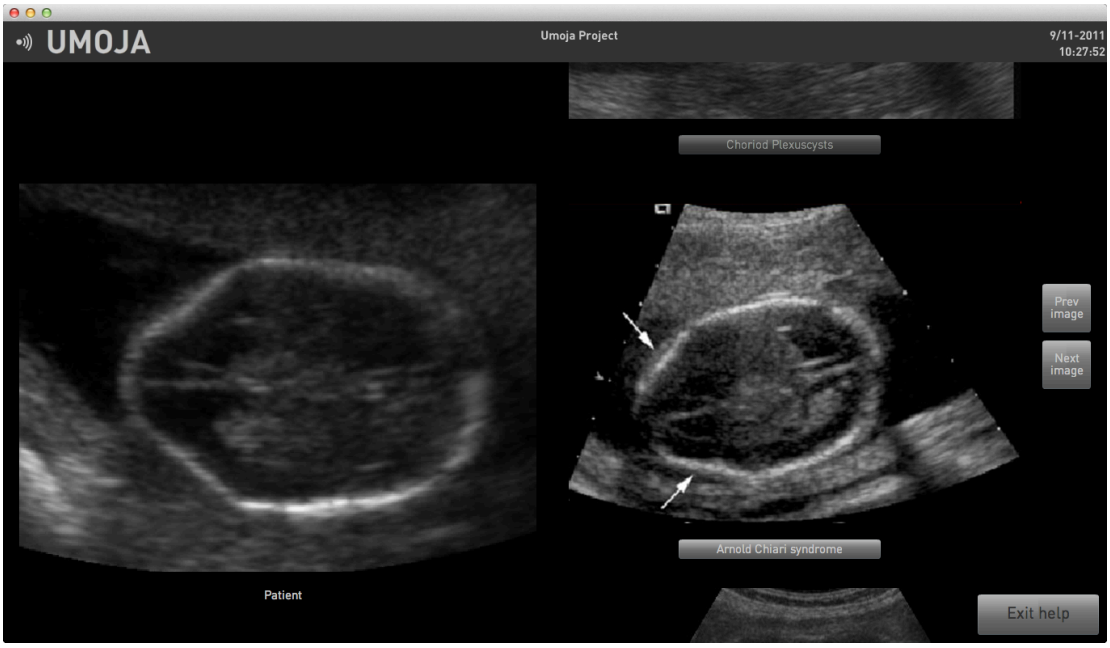

Figure 16 - Prototype - compare mode

6.2.9 Usability test

This part describe the results of the usability test. The setup of this part and the results are heavily inspired the reporting templates by ISO25062 (ISO/IEC 25062 2006).

Fidelity concerns

The fidelity concerns of the usability test were analyzed according to (Dahl, Alsos et al. 2010) fidelity dimensions.

Equipment fidelity
The equipment fidelity was well taken care of. I used the same kind of laptop computer as in the Umoja II prototype and a computer mouse as the pointing device. Ideally I should have used the Umoja II prototype, but since Aurotech could not provide us with the programming environment for machine, I had to use a similar Dell laptop instead.

Environmental fidelity
The environmental fidelity was not that well taken care of. The usability test was conducted in a room where others worked, and even if this is a busy hospital, this is not how it normally is, according to the users – most ultrasound examination rooms are separate and only one examination take place at the time. This was not how it was reported from the 2004 midwife class, but things change and new hospital buildings are being built all over South Africa.

One of the users was distracted by what happened in the rest of the room, and background noise was a problem in 3 of the tests. Attempts to get a quieter room failed – there was a temporary shortage of rooms due to construction work on the site.

Task Fidelity
The task fidelity was well taken care of. The tasks were based on a realistic workflow – using information from both the Norwegian staff and local doctors.

Functional fidelity
The functional fidelity was well taken care of. The system is not an ultrasound machine, and the scenario starts just after the user presses “freeze”, but if the user accepts the scenario, all other functionality is realistic.

Usability test tasks

There were four tasks in the usability test:

t1. The user finds the help mode
t2. The user opens the image database and finds something that he/she thinks looks like the image from the examination (before the start of the scenario). The image chosen is a relatively simple one – a scull with at distinct lemonshape, which can be identified as an Arnold Chiari malformation.
t3. The user opens a lecture
t4. The user finds to the description of the Arnold Chiari malformation.

Usability test evaluation criteria

e1. The user finds the help mode and opens it.
e2. The user opens "investigate" mode and finds a picture in the image database that he/she thinks is the correct one. Any picture is ok – this is not a clinical test. The user will be notified of the diagnosis description if he/she does not find it.
e3. The user opens any lecture.
e4. The user finds his/her way back to the diagnosis description.

Usability test results

As seen in the table below, only 10% of the users completed t1, 60% completed t2, 80% completed t3 and 60% completed t4.

Task id		Share
t1	User enters help mode	**10%**
t2	User opens investigate, finds an image	**60%**
t3	User opens lecture	**80%**
t4	User finds way back to diagnosis	**60%**

Table 5 - Usability test task results KZN

After performing the usability test, I realized that to see the full picture, I had to analyze the recordings of the usability test further. I the identified 16 subtasks – some of them identical to the main tasks and some of them more basic items like "user knows what a button is" and "user finds next slide". These results are presented in Table 6 – Subtasks South Africa

Task id		User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8	User 9	User 10	n	%
st1	User finds help button		x						helped	helped	helped	1	**10%**
st2	**User knows what a button is**	**x**			**x**					**x**	**x**	**4**	**40%**
st3	**User can move mouse**	**x**	**x**		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**9**	**90%**
st4	**User clicks with the wrong mouse button**		**x**	**x**	**x**	**x**			**x**		**x**	**6**	**60%**
st5	User opens investigate mode	x	x		x	x	x	x		x	x	8	**80%**
st6	User finds an image	x	x		x			x	x	x	x	7	**70%**
st7	User opens diagnosis info	x			x	x		x		x	x	6	**60%**
st8	User closes diagnosis window	x	x		x			x	x	x	x	7	**70%**
st9	User exits help mode	x	x	x	x	x	x	x	x	x	x	10	**100%**
st10	User finds lectures	x	x		x	x	x	x		x	x	8	**80%**
st11	User opens lecture	x	x	x	x	x	x	x	x	x	x	10	**100%**
st12	User finds next slide	x	x		x			x	x	x	x	7	**70%**
st13	User closes lecture with close button	x	x	x	x				x	x	x	7	**70%**
st14	User closes lecture with Exit help					x	x					2	**20%**
st15	User finds way back to diagnosis	x	x	x				x		x	x	6	**60%**
st16	**Used a computer before?**	**x**			**x**	**x**	**x**				**x**	**5**	**50%**
	n	14	13	6	14	10	8	10	9	13	15		
	Percentage	82.4%	76.5%	35.3%	82.4%	58.8%	47.1%	58.8%	52.9%	76.5%	88.2%		
	Time used (min:sec)	9:10	10:23	10:38	5:22	6:10	8:57	7:04	10:19	8:01	5:06		

Table 6 – Subtasks South Africa

Please note that st13 and st14 are two different ways to close the same window, so when calculating the percentage, I compensate by calculating with 15 tasks and not 16 tasks.

From this table we can read a number of interesting things.

st2 – 60% of the users did not know what a button was.
st3 – 10% of the users did not know how to use a computer mouse.
st4 – 60% of the users once or more clicked with the wrong mouse button.
st16 - 50% of the users had never used a computer before.

These four findings are user characteristics that say something about the user's technological background and are marked with bold font in the table.

60% of the users did not know what a button was at the start of the test (st2). However, we see that 83% of these users managed to close the lectures with the close bottom or the Exit Help button without help (st13/st14) so one can say that it seems like they learned the concept of a button quickly.

Usability test observations

- Two users tried to click on the screen with their index finger
- One user had a great deal of trouble using a computer mouse while two users had moderate problems.
- One user did not understand the concept of a computer window.
- Having to exit the help system to re-enter the help systems startup screen seemed to confuse some of the users.
- Some users were confused and overlooked the "Next Image"-button.
- Some uses were confused over "vertical images carousel"-metaphor.
- One user had forgotten her glasses, and had great difficulty seeing the text on the screen.
- All the users were talkative and in a cheerful mood.
- The users seemed very eager to learn.

6.2.10 SUS evaluation

The SUS form was slightly modified according to the advice from (Lewis and Sauro 2009) that "*non native English speakers*", in their experience, have a problem with the word "*cumbersome*" in question 8. Since 9 of our users have isiZulu as their native language and 1 had isiXhosa as her native language. I first changed the word from "*cumbersome*" to "awkward", which is Lewis/Sauro's recommendation. However, when I asked other non-participating midwives about these two words, they were not comfortable with either of the words. After some consideration, we changed the word to "*difficult*" in the survey – it is not a 100% overlap of the meaning of the word "*cumbersome*" but it was the closest I could find there and then.

SUS Results South Africa

The SUS results are calculated both with Brooks "classic" SUS-score (Brooke 1996) and with Lewis and Sauro (Lewis and Sauro 2009) Usability and Learnability dimensions. Note that the SUS-score is on a 100 point scale, while the L&S Usability score is on an 80 point scale and the L&S Learnability is on a 20 point scale.

User	SUS score	L&S Usability	L&S Learnability
1	80	67.5	12.5
2	70	70	0
3	80	70	10
4	82.5	72.5	10
5	82.5	72.5	10
6	87.5	80	7.5
7	82.5	80	2.5
8	82.5	80	2.5
9	95	80	15
10	97.5	80	17.5
Average:	**84/100**	**75.25/80**	**8.75/20**

Table 7 - SUS summary South Africa

6.3 Phase 3: Work in Norway

6.3.1 User demographics results.

The users in this phase are Norwegian midwives participating in NCFM/NTNU's ultrasound midwife course – just like the South African midwives. Of the 12 Norwegian midwives participating, only 11 took part in the testing – one had to leave due to illness.

User	Extra training?	Has cell phone (years)	Own a computer (years)	Familiar with computer use?
N1	n/a	14	12	Yes
N2	n/a	15	27	Yes
N3	n/a	16	9	Yes
N4	n/a	10	14	Yes
N5	n/a	17	12	Yes
N6	n/a	12	3	Yes
N7	n/a	14	10	Yes
N8	n/a	14	24	Yes
N9	n/a	15	15	Yes
N10	n/a	15	18	Yes
N11	n/a	11	15	Yes
	n/a	13.9 years	14.5 years	100%

Table 8 - Norwegian user characteristics 1

User	Age (years)	Experience as midwife (years)	Use internet?	Main source for internet?
N1	51	20	Yes	From home
N2	53	19	Yes	From home
N3	42	15	Yes	From home
N4	43	11	Yes	From home
N5	37	6	Yes	From home
N6	38	10	Yes	From home
N7	50	13	Yes	From home
N8	45	13	Yes	From home
N9	36	8	Yes	From home
N10	50	11	Yes	From home
N11	45	15	Yes	From home
	44.5 years	12.8 years	100%	All from home

Table 9 - Norwegian user characteristics 2

For full statistics see Appendix 8 – First day survey Norway and Appendix 9 – Demographics survey Norway.

6.3.2 Usability test

The same prototype using the same scenario as in South Africa was tested in Norway. The fidelity dimensions were very similar to those in South Africa. Two of the tests were disturbed by people walking into the room – otherwise everything was similar to the situation in South Africa.

Task id		Share
t1	User enters help mode	**82%**
t2	User opens investigate, finds an image	**64%**
t3	User opens lecture	**100%**
t4	User finds way back to diagnosis	**91%**

Table 10 - Usability test task results Norway

As with the South African data, I broke this down into subtasks when analyzing the video – see Table 11 - Subtasks Norway

Task id		User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8	User 9	User 10	User 11	n	%
st1	User finds help button	x	x	x	x	x	helped	helped	x	x		x	9	**82%**
st2	**User knows what a button is**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**11**	**100%**
st3	**User can move mouse**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**11**	**100%**
st4	**User clicks with the wrong button**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**11**	**100%**
st5	User opens investigate mode	helped	x	helped	helped	helped	x	x	x	x	x	x	7	**64%**
st6	User finds an image	x	x	x	x	x	x	x	x	x	x	x	11	**100%**
st7	User opens diagnosis info	x	x	x	x	x	helped	x	x	x	x	x	10	**91%**
st8	User closes diagnosis window	x	x	x	x			x	x	x	x	x	11	**100%**
st9	User exits help mode	x	x	x	x	x	x	x	x	x	x	x	11	**100%**
st10	User finds lectures	x	x	x	x	x	x	x	x	x	x	x	11	**100%**
st11	User opens lecture	x	x	x	x	x	x	x	x	x	x	x	11	**100%**
st12	User finds next slide	x	x	x	x	x	x	x	x	x	x	x	11	**100%**
st13	User closes lecture with close button		x	x	x	x	x	x		x	x		8	**73%**
st14	User closes lecture with Exit help	x							x			x	3	**27%**
st15	User finds way back to diagnosis	x	x	x	x	x	x	x	x	helped	x	x	10	**91%**
st16	**Used a computer before?**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**11**	**100%**
	n	14	13	6	14	10	8	10	9	13	15			
	Percentage	93.8%	100%	93.8%	93.8%	93.8%	87.5%	93.8%	100%	100%	93.8%	100%		
	Time used (min:sec)	3:10	3:47	4:16	4:40	5:40	5:10	5:47	2:40	2:15	3:50	3:24		

Table 11 - Subtasks Norway

Please note that st13 and st14 are two ways to close the same window, so when calculating the percentage, I compensate by calculating with 15 tasks and not 16 tasks.

6.3.3 Usability test observations

- The term "*investigate*" sounded like "*something out of a crime novel*".
- All users were fairly quick.
- One of the users made a "*mental path*" back to the diagnosis description and clicked "*next*" even though she already was on the right diagnosis.
- One of the users thought the next slide-button entitled "*next*" was to get the next lecture.

6.3.4 SUS results Norway

The Norwegian users were given the same SUS-evaluation form as the South African users.

User	SUS-score	L&S Usability	L&S Learnability
N1	95	67.5	12.5
N2	100	70	0
N3	85	70	10
N4	100	72.5	10
N5	95	72.5	10
N6	92.5	80	7.5
N7	100	80	2.5
N8	97.5	80	2.5
N9	100	80	15
N10	97.5	80	17.5
N11	95	80	15
Average:	**84/100**	**75.25/80**	**8.75/20**

Table 12 - SUS summary Norway

6.4 Phase 4: Usability analysis

6.4.1 Demographics compared

When looking at the demographic statistics, the similarities are more striking than the differences. For full data see Appendix 6 – First day survey South Africa, Appendix 7 - Demographics survey South Africa, Appendix 8 – First day survey Norway and Appendix 9 – Demographics survey Norway.

Question	South African users average	Norwegian users average
Age	43.8	44.5
Children	2.8	2.7
Married	60%	72.73%
What year did you complete your midwifery education?	1998	1999
For how many years have you practiced midwifery?	12.1	12.8
Do you have your own mobile telephone?	90%	100%
How long have you had a mobile telephone?	11.3	13.9
Do you have a computer?	30%	100%
How long have you had a computer?	0.7	14.5
Are you familiar with the use of a computer?	30%	100%
Higher education	70%	100%
Connected to electricity mains?	80%	100%
Main source of internet?	80% mobile	100% home
Household owns a computer	60%	100%

Table 13 - Demographics compared

As we see, the only main difference here is the fact that 30% of the South African users have a computer while 100% of the Norwegian users have a computer – which actually is above the national average both for South Africa and Norway. Otherwise, they are the same age, have the same number of children, have practiced midwifery for approx. the same number of years and have even had cell phones for approx. the same number of years.

6.4.2 Usability tests compared

Task id		South African users	Norwegian users
t1	User enters help mode	**10%**	**82%**
t2	User opens investigate, finds an image	**60%**	**64%**
t3	User opens lecture	**80%**	**100%**
t4	User finds way back to diagnosis	**60%**	**91%**

Table 14 - Task completion compared

I analyzed this further by analyzing the recordings of the usability test to see what the users failed at, and I ended up with a set of sub-tasks – see Table 15 - Subtask completion compared.

Task ID	Subtask	South African subtask completion	Norwegian subtask completion
st1	User finds help button	10 %	82 %
st2	**User knows what a button is**	**40 %**	**100 %**
st3	**User can move mouse**	**90 %**	**100 %**
st4	**User clicks with the wrong mouse button**	**60 %**	**100 %**
st5	User opens investigate mode	80 %	64 %
st6	User finds next image	70 %	100 %
st7	User opens diagnosis info	60 %	91 %
st8	User closes diagnosis window	70 %	100 %
st9	User exits help mode	100 %	100 %
st10	User finds lectures	80 %	100 %
st11	User opens lecture	100 %	100 %
st12	User finds next slide	70 %	100 %
st13	User closes lecture with close button	70 %	73 %
st14	User closes lecture with Exit help	20 %	27 %
st13 OR st14	User closes lecture in some way	90 %	100 %
st15	User finds the way back to diagnosis	60 %	91 %
st16	**Used a computer before?**	**50 %**	**100 %**

Table 15 - Subtask completion compared

For full tables see Table 6 – Subtasks South Africa and Table 11 - Subtasks Norway.

As we see from Table 14, only 10% of the South African users managed to open the help mode. When we now look at Table 15, we see the reason why – only 40% knew what a button was and one tester had never used or seen someone use a computer mouse before. It was no wonder the scores are lower than the Norwegian user's scores. But, as we see from the numbers, they learn quickly, and they also have 100% subtask completion at some tasks.

It is also interesting that two of the users tried to touch the button on the display instead of using the mouse. One might speculate that this is because the South African rural user has used and seen relatively new mobile telephones – including touch-screen models. With cell phone coverage that is the same - 97.54% vs. 97% - in the two regions, and the fact that the mobile phones sold and used for most people are quite new due to the growing usage of smartphones in South Africa, this theory is plausible.

6.4.3 The SUS evaluation scores

The SUS evaluation for both the usability test had quite good scores. The "classic" SUS score for the South African test was 84 and the same score for the Norwegian test was 91. Both scores were over the 90-percentile of tested systems according to Sauro (Sauro 2011; Sauro 2011b).

6.5 The usability issues

Summing up – these are the usability issues identified and in which location they occurred.

Id	Description	SA	N
P1	User can't find help button	90 %	18%
P2	User uses wrong mouse button and gets confused by dialog	40 %	0 %
P3	User did not find the "next image"-button	30 %	0 %
P4	User cant find diagnosis info button	40 %	9 %
P5	User confused over the image stacking system	10 %	0 %
P6	User expects the "Next" button under the slide to open the next lecture, not the next slide	0 %	10 %
P7	User exits the help system instead of exiting lectures.	20 %	27 %
P8	User has problems reading the text on buttons	10 %	0 %
P9	User has problems opening investigate mode	20 %	36 %

Table 16 - Identified usability issues with detection rate

7 Analysis and discussion

In light of the research questions – what are the results?

7.1 RQ1: Will the ISO9142-210 design model also work in rural Africa?

The ISO9153-210 standard emphasize that the process is not a linear process, and that it is just an illustration of the fact that each action build on the output of other processes, it is in a way quite strict anyway. For instance – going the other way round does not make sense at all. There *is* a certain sequence of actions and there is a right way and a wrong way to work. Evaluating the design (E) before making the design (D) or produce the design (D) before specifying the user requirements (C) make no sense at all.

In this part I will see how my method and my actions fits into the ISO9142-210 process.

7.1.1 The human-centered process

I have described the standard's actions in chapter 2.3.2.

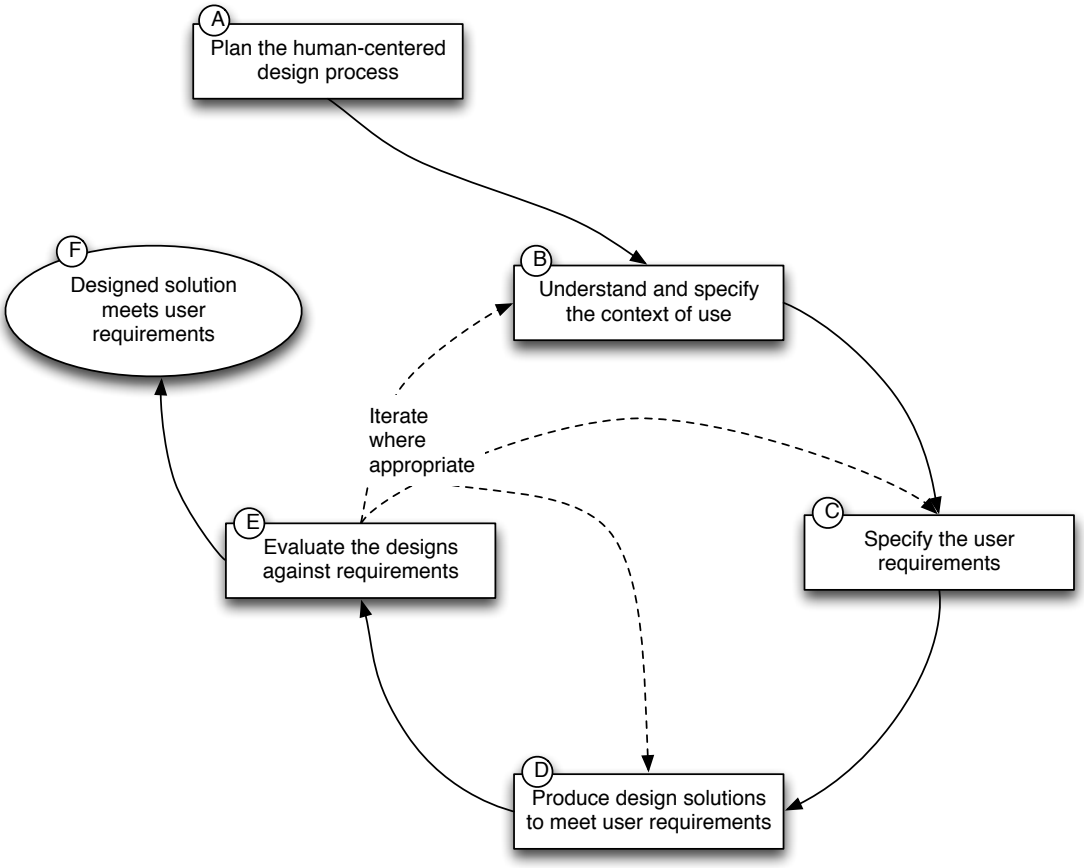

Figure 17 - Interdependence of human-centered design activities

If I now take my list of actions from
Table 1 - My process and try to map it onto the ISO "Interdependence of human-centered design activities", it will look like this:

Step	My actions	Action in model
1	Receive functional specification	
2	Identify need for user-centered design	A
3	Process statistics from former students	B
4	Interview with informants	B
5	Make personas	B
6	Make scenarios	B
7	Specify user requirements	C
8	Implement the first prototype	D
9	Evaluate prototype against requirements	E
10	Form 1 with demographics and background	B
11	Informal interview	B
12	Field studies	B
13	Form 2 – more demographics	B
14	Modify personas	B
15	Modify scenario	B
16	Re-specify user demands	C
17	Implement second prototype	D
18	Test second prototype with real users	E
	Iterate until satisfied	

Table 17 - My process compared to ISO9142-210 model

If you try to visualize the process, it will look like this:

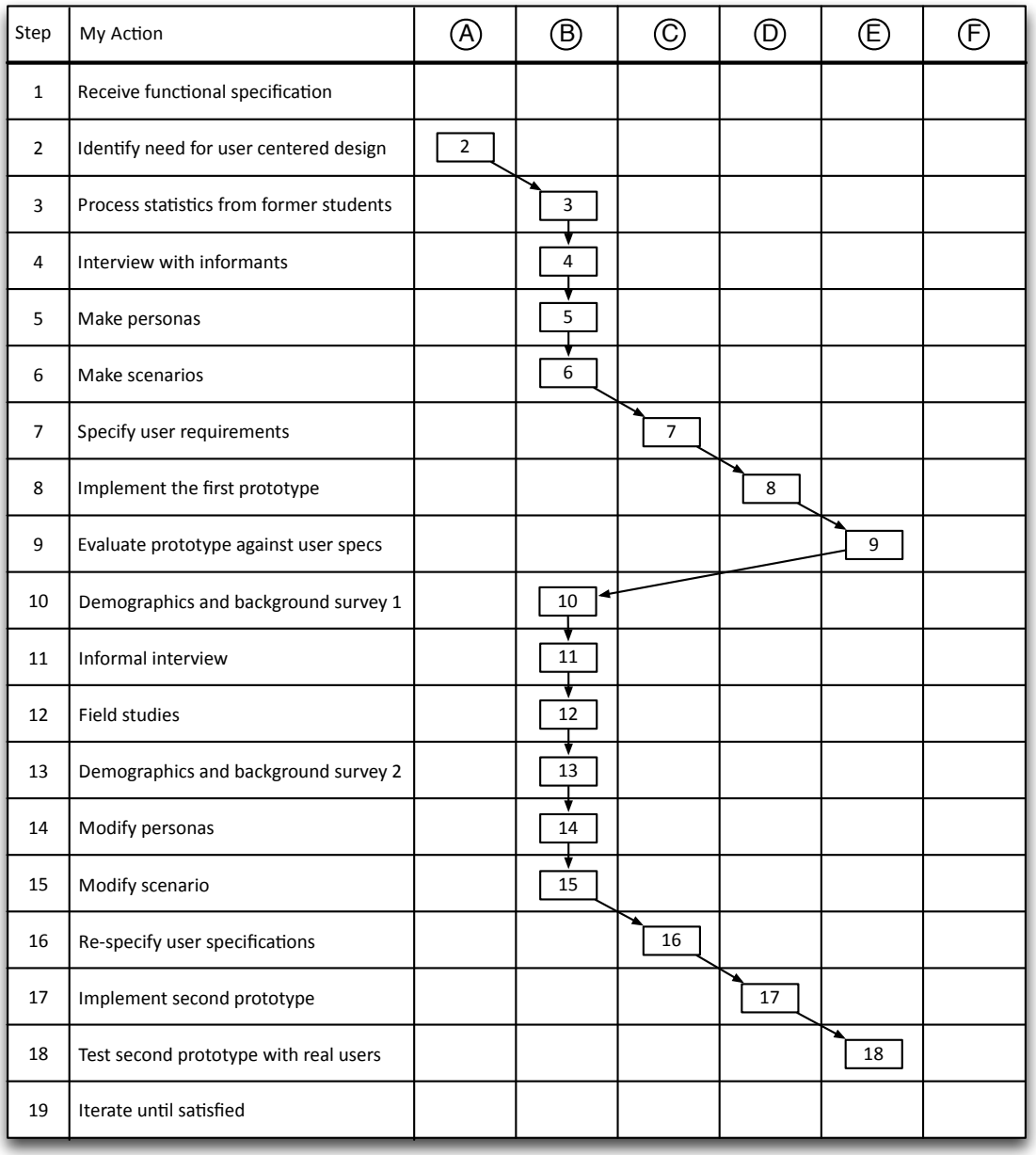

Figure 18 - My process as ISO 9142-210 actions

I had some challenges fitting this part of my process to the ISO model. The main challenge here is not the fact that the users are in rural South Africa, but the physical distance between the developer to the users. It seems rational to prepare as much as possible before going to a remote location, and I did that – I used all the sources of information available at the time and by doing so found a set of user requirements which I used to build the prototype draft. After evaluating the prototype using Inspection-based evaluation in step 9, I might reach action F – which in this model is a finite state – fully knowing that the background data and knowledge of the users context-of-use probably would change in the next phase in South Africa. On the other hand – if I instead go from

action E to action B again when entering Phase 2 and meeting the users in person, the model with fit perfectly to my process.

After meeting with the users and both seeing and talking to them about their context-of-use, it did indeed change. And since the product is not finished, there probably will be another prototype built followed by another trip to meet 10 new users, interview them, gather more data and then (probably) adjust the prototype and test it again with help from the users.

Being a one-man team, I did not have the strict user specification documentation that the standard describe: My user specification consisted of the functional specification, the demographics, the personas and the scenario – in other words all my data. I had a good overview of my data and my sources and since all meetings and interviews were recorded, I could always go back to the sources and see what was said and how. Since I did it that way, the divisions between actions B ("Understand and specify the context-of-use") and C ("Specify the user requirements") were a little blurred – I actually feel like I went back and forth between B and C a number of times.

In hindsight one might see the lack of a formal user specification as a minus. If I for some reason was prevented from finishing the work myself – or even wanted others to finish the design and implement the prototype, a good formal user specification would have been a good tool for those then involved and the quality of the project.

7.1.2 Method experiences

Interviews

There were no problems getting to talk to the users. The only real formal interview was in Norway; in South Africa I conducted only informal interviews in breaks, while having dinner etc. Everyone seemed eager to talk about their work, and after getting used to their English dialect, there were no difficulties communicating with the users. It is, however, important to remember that less than 10 % of South Africans have English as a primary language. 9 of our users had isiZulu as their primary language, and one had isiXhosa, and even if their English skills probably are better than mine, some of them were stopping mid sentence looking for words many times.

Demographics

Gathering demographics was easier than expected. South Africans are used to filling out forms all the time, so when asked if it was ok to fill out a form, they gladly did so. In many ways, South Africa is a very well organized country, and gathering good statistics to use as background material when making decisions

seems to be the norm. All the clinics and hospitals keep good statistics of their work, which they report to the health region. In addition to the health statistics, Statistics South Africa has a community survey from 2007 and conducted a full census at the time of out stay (October 2011) in addition to the 2001census, so there are good statistics and demographics available.

Field Studies

I visited several sites in addition to our base in Empangeni, and I was always greeted with sincere interest and an accommodation attitude. All staff and patients were asked if it was ok if I observed and they all agreed to that. The fact that both my employer NCFM and the NCFM midwife school have a good local and central political support could be a reason for this – I was accompanied by officials both from the hospital and health region on most of the trips.

Personas and Scenario

The personas and the process of writing a scenario in the preparations were good tools to understand the users. This, however, depends on the quality of the information you are given and the amount of work done in the research phase.

The quality of the gathered information was very good – especially having access to people that have worked with the target group for many years was very valuable. In fact, the quality of the information was so good that the personas mainly remained unchanged while some minor modifications was needed in the scenario.

Prototype

The framework of the prototype and a draft prototype was made based on the preparations and research in Norway. This turned out to be a good idea. Working in the field is more time consuming than one can expect, and even though I worked 10-12 hour days, there was always a time shortage because *my* context had changed from the context I was used to. Some small alterations to the prototype were needed – most important here is the removal of "close boxes" in windows – which was replaced by buttons with the word "close" on them. This insight actually came to me after reading a local usability article describing some heuristics used to evaluate a robust computer made to be placed outdoors in rural South-Africa (Adebesin, Kotzé et al. 2010). Those of us that have lived with computers for 20+ years instinctively know that a small box in the upper corner probably is a close box – especially if it has an X in it like in Windows, swing/java or OSX. This is implicit knowledge that we have because we have been exposed to this on a regular basis for years.

Figure 19 - Windows, java/swing and OSX close buttons

Don Norman calls this cultural affordance – you have the knowledge on how to use it if you are in a group that has been exposed to cultural conventions – for us in the western world being in a society where it has been usual to use computers for two decades.

However – a user that hasn't used a computer at all will not understand this symbol. So I tried to clean up the whole user interface and removed/changed all symbols that did not speak for them themselves.

Usability test

The execution of the usability test in itself was good. The users were enthusiastic and also were also quite curious about what we were going to make – there was already a rumor of a portable ultrasound unit going among the midwives.

However – after seeing the problems some of the South African users had with things like the computer mouse, the mouse button, where to click on the screen and so on – should we have done a technology introduction lecture before testing? Or would it be more realistic if we didn't and designed the whole system so users without previous knowledge of computers could use it? Undoubtedly there will be such users for the product when comes into use.

The main challenge to the usability testing was more of a practical nature: getting somewhere to actually perform the testing. The hospital was under reconstruction, but I managed to find a room that was reasonably undisturbed after talking to head of radiology department Dr. L. However – the room was occupied the morning I was going to start testing – there was a midwife course the next three days occupying all available rooms. It was all solved later that day – intern B generously lent me his office for the rest of the week.

7.2 RQ2: Will industry standard design guidelines work with rural South African users?

There were 9 usability issues uncovered in the process. In this part I will go through the issues in depth and try to map them to Shneiderman's guidelines and then see if there are any differences in the errors in the two groups.

Shneiderman's guidelines

Id	Guideline
G1	Strive for consistency.
G2	Cater to universal usability.
G3	Offer informative feedback.
G4	Design dialogs to yield closure.
G5	Prevent errors.
G6	Permit easy reversal of actions
G7	Support internal locus of control.
G8	Reduce short-term memory load.

Table 18 - Shneiderman's guidelines numbered

The usability issues

Id	Description	SA	N
P1	User can't find help button	90 %	18%
P2	User uses wrong mouse button and gets confused by dialog	40 %	0 %
P3	User did not find the "next image"-button	30 %	0 %
P4	User can't find diagnosis info button	40 %	9 %
P5	User confused over the image stacking system	10 %	0 %
P6	User expects the "Next" button under the slide to open the next lecture, not the next slide	0 %	10 %
P7	User exits the help system instead of exiting lectures.	20 %	27 %
P8	User has problems reading the text on buttons	10 %	0 %
P9	User has problems opening investigate mode	20 %	36 %

Table 19 - Usability issues numbered

7.2.1 P1 – user can't find help button

P1 is probably closely related to subtask 2 (st2) in Table 15 - "User does not know what a button is".

Figure 20 - Prototype - first screen

In Table 14, we see that 10% of the South African users and 82% of the Norwegian users found the help button. This is not so strange when we look at st2 in Table 15 – where we see 40% of the South African users know what a button is while the number for the Norwegian users is 100%. Comparing this to the demographics in
Table 3 that show that only 30% of the South African users have a personal computer and feel experienced using it, there is a big chance that the South African users low completion score on this task is simply because that they haven't used a computer before – at least not to the extent of the Norwegian users. The only main difference in demographics is that of the South African users, only 30% own a personal computer and that they have had the computer for an average of 2.3 years while all Norwegian users have a personal computer and have had so for an average of 13.9 years (
Table 3 and Table 8). Based on this, I ask myself - is the low score for South African users in Task 1 (t1) in Table 14 due to the difference in technological background? And then might one ask – is this a big problem for the product? Not if we look at the numbers in Table 14 – the rest of the numbers for the two groups become more even after learning the concepts in Task 1. It looks like most of the users learned the necessary user interface concepts during the on average 8 minutes and 7 seconds the test took.

Is P1 a breach of one of Shneiderman's guidelines? No, I don't think so, because the guidelines take for granted that the users know the fundamentals of computer usage.

This does not, however, exclude the possibility of there being a usability issue with the help button – 18% of the Norwegian users had a problem finding it as well, so the button should probably be more visible in some way. No mapping suggestion.

7.2.2 P2 – User uses wrong mouse button and gets confused by dialog

This is a weakness of the programming environment that I used. When using Flash, you will always get a contextual menu with flash preferences when using the right mouse button. It locks the screen and confuses the user. Result: the user gets a feeling of loosing control. A simple system like this does not require contextual menus and thus it probably does not require multiple mouse buttons either. This maps to G7.

7.2.3 P3 - User did not find the "Next image"-button.

70% of the South African users did not find the button for "Next image" shown in Figure 21. This usability issue is rather early in the test and my guess is that the users were not that familiar with buttons at this early stage. No mapping suggestion.

7.2.4 P4 - User can't find diagnosis info button.

In this screen the user gets confused and it is not apparent enough that the diagnosis button (here: Arnold Chiari Syndrome) is clickable. 40% of the South African users and 9% of the Norwegian users do not perceive the diagnosis button as clickable. This is a confusing – the button should be marked better or be marked with the action it provides, not the name of the condition. This maps to G7.

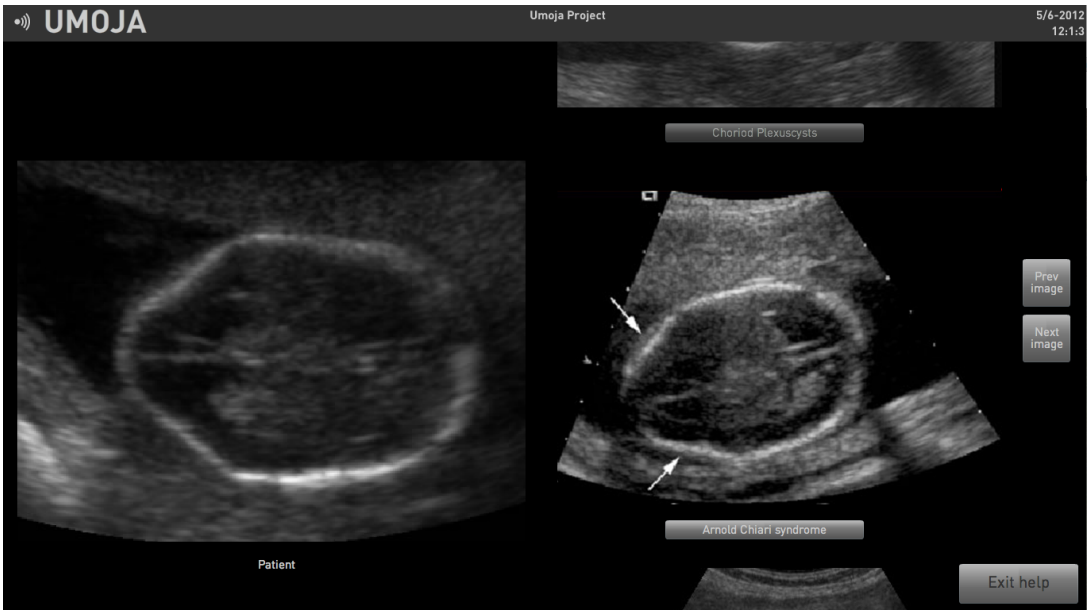

Figure 21 - Prototype showing a possible diagnosis

7.2.5 P5 – User confused over the image stacking system.

10% of the South African users were confused over the image stacking system. If we look at Figure 21, the patient image to the left and the diagnosis database images in a vertical image carousel to the right with the current image and diagnosis button highlighted. This issue maps to G7.

7.2.6 P6 – User expects the "Next" button under the slides to open the next lecture, not the next slide.

This problem occurred with 19% of the Norwegian users, and for me adresses that it would be smart to have a "back to lectures" button instead of a "close" button. This isseue maps to G7.

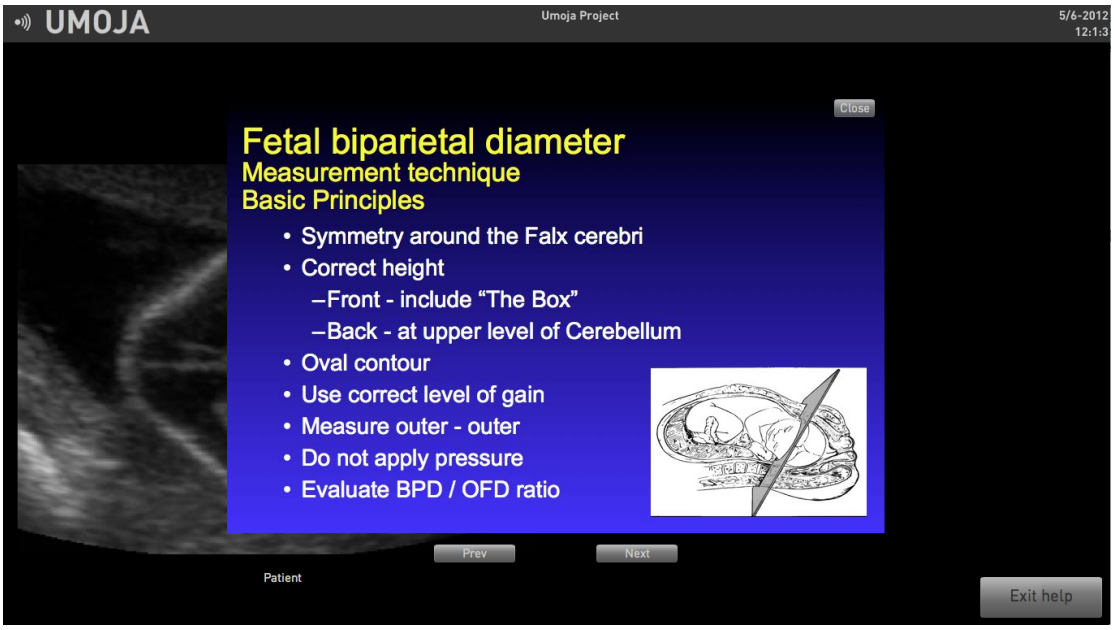

Figure 22 - Prototype showing a lecture slide

7.2.7 P7 - User exits the help system instead of exiting lectures.

The users were asked to close the lecture, and 20% of the South African and 27% of the Norwegian users used the "Exit help"-button instead of the smaller "Close"-button top right in the blue slide in Figure 22.

There is however a clinical rationale to having the "Exit help" button available. One of the informants at the Lower Umfolozi War Memorial Hospital said that in case of emergency, there should always be a one-click way to return to the diagnostic user interface without having to go through a number of sub menus before exiting the help system.

That being said – the navigation issues inside the help system are not good enough – there probably should be a simpler way to navigate inside the help system without having to exit it. This issue probably maps to both G7 and G6.

7.2.8 P8 – User has problems reading the text on buttons.

One of the South African users had forgotten her reading glasses and had problems reading the buttons. This uncovered a far to common error when making user interfaces: – not thinking about things like contrast and font and symbol sizes. No mapping suggestion.

7.2.9 P9 – User has problems opening investigate mode.

20% of the South African users and 36% of the Norwegian users had problems perceiving the "Investigate" button as the main source for finding out more about a diagnosis in the main dialogue. This means that the word "Investigate" probably is not the right word for this action. Does this issue map to G7?

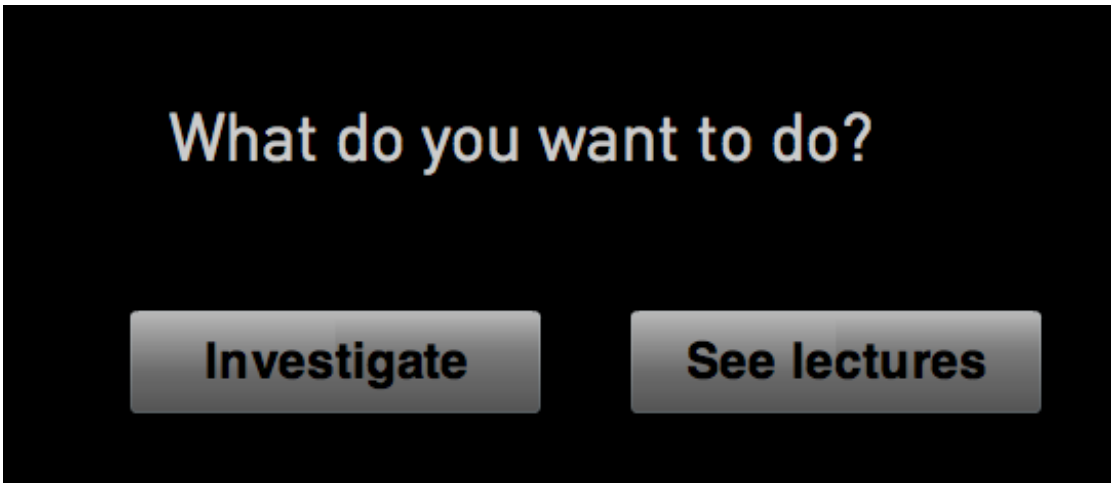

Figure 23 - Prototype help dialogue

7.2.10The usability issues and guidelines

As we see in the table, most usability issues are mapped to G7 – "Support internal locus of control" and is partly mapped top G6 –" Permit easy reversal of actions".

Issue	Guideline
P1	-
P2	G7
P3	-
P4	G7
P5	G7
P6	G7
P7	G6/G7
P8	-
P9	G7?

Table 20 - The usability issues mapped to guidelines

7.2.11The Norwegian usability issues

There two observations of possible usability issues that either occurred only with the Norwegian users or where there were significantly more issues identified by the Norwegian users.

Id	Description	SA	N
P6	User expects the "Next" button under the slide to open the next lecture, not the next slide	0 %	10 %
P9	User has problems opening investigate mode	20 %	36 %

Table 21 - Usability issues identified by Norwegian users

This problems address the lack of a good navigation inside the help system. The system lacks a clear understanding of where in the system you are. These

problems summed up might be a breach of G4 – they probably should have been more like sequences.

7.2.12The South African usability issues

There six observations of possible usability issues that either occurred only with the South African users or where there were significantly more issues identified by the South African users.

Id	Description	SA	N
P1	User can't find help button	90 %	18%
P2	User uses wrong mouse button and gets confused by dialog	40 %	0 %
P3	User did not find the "next image"-button	30 %	0 %
P4	User cant find diagnosis info button	40 %	9 %
P5	User confused over the image stacking system	10 %	0 %
P8	User has problems reading the text on buttons	10 %	0 %

Table 22 - Usability issues identified by South African users

Looking at these issues, we can see that there is a decreasing problem of identifying buttons in P1, P2, P3 and P4. In fact – if we now look at Table 15 again, we see that all these problems occur in the start of the usability test and that all later use of buttons in the test (st9 to st14) has an average completion score of 88%, which is lower than the Norwegian average of 100%, but is much better than at the start. Is this because the midwives now have learned the concept of a button? It looks like this in the data.

P5 might have something to do with experience with graphical user interfaces as well, but it also is a valid usability issue. The image carousel can be implemented better – for instance there is no reason why the stacked images' diagnosis button is visible.

P8 uncovered that the system was not designed well enough for the visually impaired.

Summing up it looks to me like the findings mainly uncover two things:

1) The users are not used to using computers
2) During the tests the users that had no or little knowledge of how to user computers picked up the concepts and quickly learned what was necessary to complete the task in the last part of the test.

It is also important to emphasize that the South African users that were used to computers had a task completion score that was as good as the Norwegian users. This strengthens my theory that this is not an "Africa versus the western world"

problem – it is a “those who know how to use a computers versus those who don’t” problem.

8 Conclusions

8.1 Research question 1 – User-centered design process

What can be learned from trying to fit my development process to the ISO 9241-210 process?

Working in a multi-location project like this where I have to visit the users learn about them, their context-of-use, develop and test the software does not automatically fit the ISO9241-210 actions model. Since the work is divided in distinct phases – some without access to the users – the user specifications will continue to be refined and hopefully more accurate. When doing an expert evaluation the outcome of design process against the user specifications, we can end up with a design that meets the demands of the user specifications before even meeting with the users. In the model this might lead us to the F stage – "Designed solution meets user requirements" already after the expert evaluation in Phase 1, but since this is a finite state in the model, the process then would stop. However if we instead go from the E stage (evaluation) back to the B stage when we enter Phase 2, it the ISO model will fit.

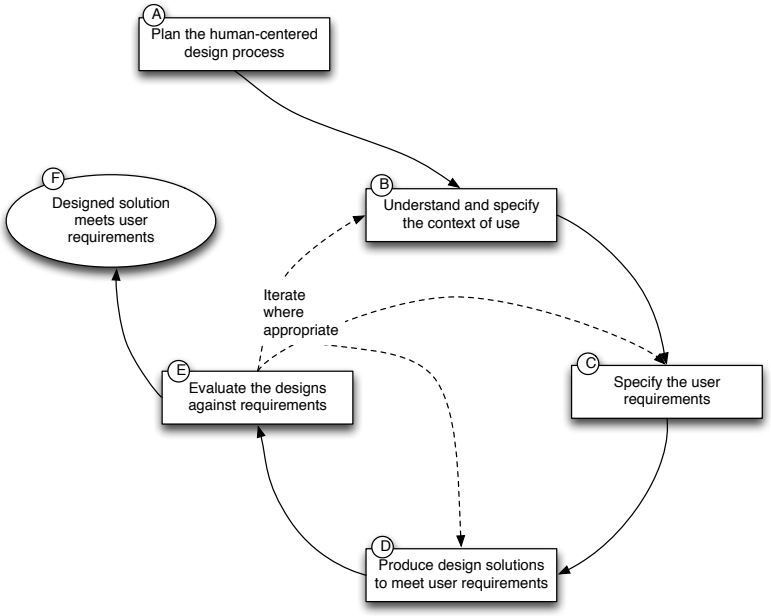

Figure 24 - Interdependence of human-centered design activities

Regarding the methods, I did not experience anything that I can put my finger on and say that this is because we are in rural South Africa.

- From all the data collected, it seems like this model is a good tool for working with usability issues and GUI design in rural areas in South Africa.
- The methods used worked well in rural South Africa as well as in Norway.
- The main findings seem more associated with working with users that are far away and not easily accessible rather than being in rural South Africa. The users might as well have been in rural Hungary or California – the same challenges with working remotely would probably occur.

8.2 Research question 2 – Design Guidelines

One of the main findings from the usability test was that a majority of the issues experienced with the South African users were related to the users lack of experience with the graphical user interface of the computers. Shneiderman's guidelines do not take into account the possible usability issues of people that have not used computes much. The guidelines describe usability issues of experienced computer users and it is difficult to fit the issues revealed by inexperienced users into the guidelines, but I still managed to do so with most of the usability issues.

It probably would have been easier to fit P1, P2, P3 and P4 into Nielsen's 10 heuristics, but they would probably all end up in heuristic 2: "Match between the system and the real world", where it is stated that you should speak the users language – including visual language, concepts and real-world conventions. This to me sounds a lot like getting to know the context-of-use and then it might be better to use the ISO9142-210 process instead of the heuristics?

- Usability issues found both in South Africa and Norway fit well with Shneiderman's guidelines.
- Shneiderman's guidelines do not cover the found usability issues in a good way as it seems they take for granted that the users have certain knowledge about how to operate computers.
- Nielsen's heuristics cover the usability issues not covered by Shneiderman, but since they all fit heuristic 2, it looks to me like we are better off using the ISO9142-210 methodology than heuristics

8.3 Limitations of the study

This study is based on one case only and should, because of that, be looked upon as a hypothesis and not conclusions. The results need to be validated with more cases.

The researcher and the programmer are one and the same person – me. This gives some challenges – I am very close the material and the users and this may color the conclusions.

The physical distance to the users has given some challenges. A good usability method can reduce the risk of getting incorrect data from both the data collection and the usability test but the best way is to be close to the user as long as possible.

Even though number of participants in the usability-testing fall well into what Jakob Nielsen thinks is enough to uncover most of the usability errors, the

methods in the “understanding context-of-use” phase normally require more users to be statistically trustable. All the participants were hand-picked to receive ultrasound training by the health region and the ministry of health and may not represent the average rural midwife.

8.4 Further work

This work has uncovered some questions that would be interesting to take a look at:

- What would the results be if we compared the South African midwives to Norwegian users that had not been exposed to computers?
- How would the results differ if we provided a short computer introduction course with the South African midwives?
- How would the results differ if we tested the system on random midwives in the bush instead of the ones receiving special training?
- If we reverse the process – how would a South African scientist conclude to the same research questions if he/she had to make a similar user interface for Norwegian users?

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10 Figures

11 Tables

12 Appendices

12.1Appendix 1 – Umoja system requirements

Uses:
• Fetal examination in first, second and third trimester of the pregnancy. This is to determine the number of fetuses, do fetal measurements, locate the placenta, evaluate amount of amniotic fluid. Examine the anatomy of the fetus in order to reveal anomalies in the central nervous system such as acrania, anencephaly, hydrocephaly; to discover abdominal wall defects, sacrococcygeal teratoma (that represent a hindrance to delivery). • Doppler ultrasound of arteria uterina and arteria umbilicalis (color- and pulsed Doppler). • Trans abdominal gynecological examinations.
The equipment should meet the following requirements:
a) The product shall comprise an ultrasound machine that can carry out the ultrasound examinations mentioned under “areas of use”, and have a PC-card with the functions mentioned under “Software”.
b) The following transducer should be included: 2D curved array (multihertz) transducer for obstetrical and gynecological examinations.
c) It should be possible to store personal data and results of measurements (BPD, HC, MAD, AC, FL), as well as ultrasound images.
d) Should include eSnurra – values for biparietaldiameter (BPD), mean abdominal diameter (MAD), femur length (FL) and growth to be registered in the machine.
e) Should have a printer connection.
f) Should support USB Mass Storage.
g) All text that is communicated in and out of the machine should be managed in accordance with Unicode/UTF-8.
Hardware:
h) All in one enclosure. It should not be visible that it actually contains a PC
i) The equipment should be robust and be as dust, damp- and shock-proof as possible.
j) The whole ultrasound machine should be in a hard shell box containing

everything necessary for using the machine, including probe, cables and gel.
k) The machine should tolerate fluctuations in voltage from 80 to 380 volts AC.
l) The machine should have a surge protector.
Software
m) The system should store patient data such as name, date of birth, date of examination and measurements from the examination.
n) The system should contain lectures in fetal medicine that are accessible for the user.
o) The system should contain an image database accessible to the user. The database should contain images of the most common diagnoses as well as reference images of normal fetuses.
p) The system should contain literature about the various subjects that are taught in the course on the use of ultrasound.
q) The system should contain a list of procedures for the most common diagnoses
r) The system should make it possible to retrieve statistics about treatments and patients.
s) It should be possible to connect the system to the internet.

Trondheim, 15. April 2011

Sturla H. Eik-Nes Eva Tegnander

12.2Appendix 2 – Usability test manuscript

Usability test manuscript

Part 1: Presentation:
Hi – my name is Morten and together we are going to test a part of a new ultrasound machine.
I am interested in knowing what you think of this program. We are not testing you, but we are testing the program. There are no right or wrong answers – all your feedback is interesting for us to improve the computer program.
It is important that you reason out loud and say what you are thinking when you are trying the program. We will not be insulted if you do not like aspects of the machine, but we will take your input with us and use it to make a even better machine.
All the information provided by you will be depersonalized and cannot be traced back to you at a later stage.

Lets start a little about you – how long have you been a midwife?
Have you done anything else before becoming a midwife?
And have you used ultrasound before?
At work – will there be a separate room for conducting the examination, or will the exams take place in a room with other activity?

Part 2: Background
As you may know, we are participating in a research program with the goal of making a good and affordable ultrasound machine made specific for the African rural midwife – called the Umoja Ultrasound machine. You may have seen it on a picture with Dr. Eddie Mhlanga in the opening lecture. What makes this machine special is that it is quite small and robust. It also contains a computer program that offers help in identifying malformations and also provides the lectures from this course. My role in this is to gather your experiences and opinions to improve the ultrasound machine.

Before we try the program I want to emphasise that this is not a real ultrasound machine, but we have to pretend that it is.

Are you familiar with the use of a computer mouse? If not let me show you.

Now, lets try the program.

Part 3: Scenario 1.
// Starting the program and the recorder.
Lets say you while measuring the BPD just saw a head shape that you think looks strange and you want to find you more about it. You hit the "freeze"-button and see this:
// Start screen
What do you do to enter the help-mode and try to determine if there is something wrong with the shape of the head?
// Guide the user if necessary and answer all questions.
// when the user enters the correct image:
Now what would you do to read more about the malformation you have chosen?
// When the user is finished reading:
Now lets exit the help system

Part 4: Scenario 2
This system also contains a couple of lectures. The final system will of course have all the lectures installed. Where would you go to read a lecture about Fetal Biometry?
// Assist if necessary

Part 5: Scenario 3
In the diagnosis description earlier on, there was a procedure for the Arnold Chiari malformation. Are you able to find your way back to it?

Part 6: Thank you!
Thank you very much – we are nearly finished now. I just need you to complete this form before we are done. Remember – all the forms will be depersonalized and we will not be able to track to see who said what. Take your time and please ask if anything is unclear.

Once again – thank you very much!

12.3Appendix 3 – First day survey

Name:

What year did you complete your midwifery education?

Are you an advanced midwife?

For how many years have you practiced midwifery? (Years)

What is your position today?

Do you have your own mobile telephone?

How long have you had a mobile telephone? (years)

Do you have a computer?

How long have you had a computer?

Are you familiar with the use of a computer?

Have you ever made use of an ultrasound machine?

If yes, how often do you use ultrasound?

How was your training in the use of ultrasound?

What kind of information can an ultrasound exam give in the second trimester of the pregnancy?

What kind of information can an ultrasound exam give in the third trimester of the pregnancy?

Complete name?

District hospital or clinic?

Number of deliveries/month

Ultrasound machine?

Doppler ultrasound?

12.4Appendix 4 – Demographics survey

Id:
Age:
Number of children:
Married:
Number of people in household:

What is your level of education?
□ Higher
□ Grade 12/Std 10
□ Some secondary
□ Completed primary
□ Some primary
□ No schooling

Is your household connected to the mains electricity supply?
□ Yes
□ No

How do you mainly connect to the internet?
□ From home
□ From cell phone
□ From work
□ From elsewhere
□ No access to internet

Do you or someone in your household own a computer?
□ Yes
□ No

How often do you use a computer at home?
□ Once a day or more
□ Once a week or more
□ Once a month or more
□ Once a year or more
□ Hardly ever
□ Never

How often do you use a computer at work?
□ Once a day or more
□ Once a week or more
□ Once a month or more
□ Once a year or more
□ Hardly ever
□ Never

12.5Appendix 5 – System Usability Scale

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very ~~cumbersome~~ difficult to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

12.6Appendix 6 – First day survey South Africa

ID	What year did you complete your midwifery education?	Are you an advanced midwife?	For how many years have you practiced midwifery? (Years)	What is your position today?	Do you have your own mobile telephone?	How long have you had a mobile telephone? (years)	Do you have a computer?	How long have you had a computer?	Are you familiar with the use of a computer?	Have you ever made use of an ultrasound machine?	District hospital or clinic	Number of deliveries/month	Do you have a ultrasound machine?
10	1999	Yes	12	Operational manager	Yes	± 14	Yes	± 4	Yes (basic skills)	Yes	District hospital	400	Yes
6	1987	Yes	24	Operational manager	Yes	20	Yes	1	Still need practice	Yes	District hospital	350	
8	2004	Yes (2009)	8	Clinical nurse practitioner	Yes	5	No	N/A	No	Yes	Clinic	15	Yes
1	2006	Yes (2009)	6	Clinical nurse practitioner	Yes	10	Yes	2	Not very much	No	Clinic	90	Yes, used by sonographer during the week
2	2005	No	6	Midwife	Yes	12	No	N/A	No	Yes	District hospital	4-500	Yes
9	2005	No	6	Clinical nurse practitioner	Yes	15	No	N/A	No	No	Clinic	60	No
7	2009	No	3	General midwife, clinical nurse practitioner	Yes	10	No	N/A	No	No	CNC	30	No
5	1981	No	26	Midwife	No	N/A	No	N/A	No	No	Clinic	35	No
3	1982	Yes	29	Clinical nurse practitioner	Yes	15	No	N/A	No	No	Clinic	80	No
4	2002	No	1	Clinical nurse practitioner	Yes	± 12	No	N/A	N/A	No	Clinic	50	No

12.7Appendix 7 - Demographics survey South Africa

Question			1	2	3	4	5	6	7	8	9	10	Average	Sum	
Q1	Age		33	41	55	34	56	49	44	41	47	38	43.8		
Q2	Children		2	1	4	2	4	4	2	2	4	3	2.8		
Q3	Married		x		x	x	x			x		x		6	60%
Q4	Persons in household		4	5	8	4	8	6	4	6	5	5	5.5		
Q5	Education	Higher	x		x	x		x		x	x	x		7	70%
		Grade12		x			x		x					3	30%
		Some secondary												0	0%
		Completed primary												0	0%
		Some primary												0	0%
		No schooling												0	0%
Q6	Electricity at home			x	x	x	x		x	x	x	x		8	80%
Q7	How do you mainly connect	From home												0	0%
	to the internet?	From cell phone	x	x		x	x	x	x		x	x		8	80%
		From work												0	0%
		From elsewhere												0	0%
		No access			x					x				2	20%
Q8	Household own computer?		x			x	x	x			x	x		6	60%
Q9	How often do you use a	Daily	x								x			2	20%
	computer at home?	Weekly				x						x		2	20%
		Monthly						x						1	10%
		Yearly												0	0%
		Hardly ever					x		x					2	20%
		Never		x	x					x				3	30%
Q10	How often do you use a	Daily	x						x			x		3	30%
	computer at work?	Weekly												0	0%
		Monthly						x						1	10%
		Yearly												0	0%
		Hardly ever												0	0%
		Never		x	x	x	x			x	x			6	60%

12.8Appendix 8 – First day survey Norway

ID	What year did you complete your midwifery education?	For how many years have you practiced midwifery? (Years)	What is your position today?	Do you have your own mobile telephone?	How long have you had a mobile telephone? (years)	Do you have a computer?	How long have you had a computer?	Are you familiar with the use of a computer?
n1	1991	20	Midwife	Yes	14	Yes	12	Yes
n2	1993	19	Midwife	Yes	15	Yes	27	Yes
n3	1997	15	Midwife	Yes	16	Yes	9	Yes
n4	2000	11	Midwife	Yes	10	Yes	14	Yes
n5	2006	6	Midwife	Yes	17	Yes	12	Yes
n6	2002	10	Midwife	Yes	12	Yes	3	Yes
n7	1999	13	Midwife	Yes	14	Yes	10	Yes
n8	1995	13	Midwife	Yes	14	Yes	24	Yes
n9	2004	8	Midwife	Yes	15	Yes	15	Yes
n10	2001	11	Midwife	Yes	15	Yes	18	Yes
n11	1996	15	Midwife	Yes	11	Yes	15	Yes

12.9Appendix 9 – Demographics survey Norway

Question			n1	n2	n3	n4	n5	n6	n7	n8	n9	n10	n11	Average	Sum	
Q1	Age		51	53	42	43	37	38	50	45	36	50	45	44.5		
Q2	Children		2	2	2	3	3	4	3	3	2	3	3	2.7		
Q3	Married				x		x	x	x	x	x	X	x		7	72%
Q4	Persons in household		4	1	4	2	5	6	4	5	4	2	5	3.81		
Q5	Education	Higher	x	x	x	x	x	x	x	x	x	x	x		11	100%
		Grade12													0	0%
		Some secondary													0	0%
		Completed primary													0	0%
		Some primary													0	0%
		No schooling													0	0%
Q6	Electricity at home		x	x	x	x	x	x	x	x	x	x	x		11	100%
Q7	How do you mainly connect	From home	x	x	x	x	x	x	x	x	x	x	x		11	100%
	to the internet?	From cell phone					x						x		2	18%
		From work				x						x	x		3	27%
		From elsewhere													0	0%
		No access													0	0%
Q8	Household own computer?		x	x	x	x	x	x	x	x	x	x	x		11	100%
Q9	How often do you use a	Daily	x	x	x	x	x	x	x	x	x	x	x		11	100%
	computer at home?	Weekly													0	0%
		Monthly													0	0%
		Yearly													0	0%
		Hardly ever													0	0%
		Never													0	0%
Q10	How often do you use a	Daily	x	x	x	x	x	x	x	x	x	x	x		11	100%
	computer at work?	Weekly													0	0%
		Monthly													0	0%
		Yearly													0	0%
		Hardly ever													0	0%
		Never													0	0%

12.10 Appendix 10 – SUS statistics South Africa

User	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS	L&S Usability	In %	L&S Learnability	In %
1	5	1	5	2	5	1	2	3	5	3	80	67.5	84.4	12.5	62.5
2	5	1	5	5	5	1	5	5	5	5	70	70	87.5	0	0
3	5	1	5	5	5	1	5	5	5	1	80	70	87.5	10	50
4	5	1	4	3	5	2	5	1	4	3	82.5	72.5	90.6	10	50
5	5	1	2	5	5	1	5	1	5	1	82.5	72.5	90.6	10	50
6	5	1	5	3	5	1	5	1	5	4	87.5	80	100	7.5	37.5
7	5	1	5	5	5	1	5	1	5	4	82.5	80	100	2.5	12.5
8	5	1	5	4	5	1	5	1	5	5	82.5	80	100	2.5	12.5
9	5	1	5	1	5	1	5	1	5	3	95	80	100	15	75
10	5	1	5	2	5	1	5	1	5	1	97.5	80	100	17.5	87.5
Average	**5**	**1**	**4.6**	**3.5**	**5**	**1.1**	**4.7**	**2**	**4.9**	**3**	**84**	**75.25**	**94.06**	**8.8**	**43.8**

Calculated with both classic Brooks SUS analysis and Lewis & S Usability and Learnability dimensions.

12.11 Appendix 11 – SUS statistics Norway

User	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS	L&S Usability	In %	L&S Learnability	In %
1	5	1	5	1	4	2	5	1	5	3	95	75	93.8	20	100
2	5	1	5	1	5	1	5	1	5	5	100	80	100	20	100
3	5	1	4	1	4	1	5	1	5	1	85	72.5	90.6	12.5	62.5
4	5	1	5	1	5	1	5	1	4	3	100	80	100	10	100
5	4	1	4	1	5	1	5	1	5	1	95	75	93.8	20	100
6	4	1	4	1	5	1	5	1	5	4	92.5	72.5	90.6	20	100
7	5	1	5	1	5	1	5	1	5	4	100	80	100	20	100
8	5	1	5	1	5	1	4	1	5	5	97.5	77.5	96.9	20	100
9	5	1	5	1	5	1	5	1	5	3	100	80	100	20	100
10	5	1	5	1	4	2	4	1	5	1	77.5	72.5	90.6	5	25
11	5	1	5	1	5	1	5	1	5	3	100	80	100	20	100
Average	**4.8**	**1**	**4.7**	**1.3**	**5**	**1.2**	**4.8**	**1**	**4.8**	**1.5**	**91**	**72.5**	**94.1**	**18.5**	**92.7**

Calculated with both classic Brooks SUS analysis and Lewis & S Usability and Learnability dimensions.