Developing a User Interface and Integrated Workflow Data Collection for a Dental Implant Quality Register

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Abstract

Health quality registers are commonly used and contributes continuously to a significant increase in quality of treatment and care within various areas of the Norwegian health care system. The use of health quality registers improves both quality of the treatments and products that are being used. This comes with various other benefits such as reduction of costs, a more efficient health care, less variations in the treatments that are given, more and better data for research, and a raise in both skills and competence within the health work force. All health quality registers are based on data reported from instances in the field. The data is the foundation of the analyzes and research that is conducted to achieve the improvement of quality. To ensure that this data is sufficient, it is crucial to have an efficient process of collecting the required data for any such register. This includes, among other factors, clear forms for data collection, high coverage of registered data (among all known cases), accessibility and user friendliness both for collection and later for access to the data and services. Nevertheless, within dental care there are no quality registers yet, even though the need for such registries is equally important as in any other field of health care.

By the use of design science methodology, we designed and implemented an artifact in order to look into the data collection for a dental implant quality register. The aim of the design process was to gain an understanding of the domain, how data could be collected (interface, frontend), and how it could be represented (modelled, backend). This thesis has its focus on the development of the interface for the designed and implemented artifact. The evaluation of the artifact consisted of semi-structured interviews with experts within dental health care, dental implants and health quality registers. The interviews were both conducted with a focus group of experts, who participated through the entire development process, and with a final single interviewee, who conducted an evaluation towards the end of the project. Finally, the process of the development is discussed, contributions and problems problems are presented, and possible further work is discussed.

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Chapter 1

Introduction

1.1 Motivation

The number of health quality registers has increased significantly within the Norwegian health care system, much due to the improvement in technical advancements within the medical fields [1]. As of April 2022, there are now 53 Norwegian national health quality registers in total. The main goal of a health quality register is to ensure quality in treatment for specific groups of patients [2]. Furthermore, many aspects of medical research rely on the data gathered by health quality registers [3]. They ensure that best practises are being used which contributes to improvement of health outcomes by reducing costs, monitoring quality, providing feedback, reduce treatment variation and as a tool in research [4].

1.1.1 The Impact of Quality Registers

To explore the impact of quality registers, we have looked into existing research. In 2017, Hoque et al. conducted a systematic review of the impact of health quality registers [5]. This involved collecting data regarding the mortality rate, the outcome of health care and the costs across disciplines within health care before and after the implementation of a corresponding quality register. The data was then analyzed to reveal relations between the implementation of the quality register and potential improvements. Hoque sums up the results of the research as follows:

> *The measures of impact of registries were multifarious and included change in processes of care, quality of care, treatment outcomes, adherence to guidelines and survival. Sixteen of 17 studies demonstrated positive findings in their outcomes after implementation of*

the registry [5, p. 1].

Another study conducted by Martinsson et al. in 2012 examined the effect of quality registers in end-life care [6]. The main focus of these registers were to improve quality based on patient reported information. The results of the study presents benefits of the registers by improvements in correct medication, and decreases in the incidence of troublesome symptoms for the patients.

The results from Martinssons' and Hoques' research show some potential benefits of health quality registers. These studies concern health quality registers in general, and do not address dental implant registers specifically. However, as quality registers ensure better results and care for patients, reduce costs and are used as a source for learning in multiple medical fields, there are reasons not to believe that this could apply to dental health care as well, with the implementation of a quality register for dental implants.

1.1.2 Data Collection in Existing EDR Systems

Currently there are no standards given for EDR systems as goes for representation or communication of patient dental data. However, in 2019 Opus Dental had a market share of 95 percent in Norway [7], which could be described as being a marked standard. Opus dental also states on their website that it is "the most widespread practice management solution in the Nordic countries"[8]. The experts who have participated in the focus group involved in this study, states that "Opus Dental does not gather sufficient data about dental implants to perform research based on it. Nor is there any other available system for this purpose on the market".

In 2018, Klinge et al. published a paper arguing for implementing European dental implant registers, where they presented the following estimate of the market of dental implants:

> *The annual global dental implant market is estimated at around 12–18 million implants sold, representing more than 100 commercial brands. In Europe alone, the annual market has been estimated at 5.5–6 million implants* [9].

The exact number of used implants in Norway is not known, as implant insertions are not registered in any way. Yet one can estimate the number based on data from Helfo, who covers costs of implant treatment for Norwegian citizens [10]. The data from Helfo does not, however, give any information about the products and procedures used in an implant insertion. Also, only implant insertions granted refund are registered by Helfo. Following, implants which are not refunded by Helfo or inserted abroad do not get registered in a common

register. This lack of data gathering can lead to that insufficient quality in both products and clinical procedures used are not being detected.

To summarize, the exiting data collection in data patient records lacks sufficient data to contribute to quality improvement. We can to some extent, by using data from Helfo, estimate an approximation of inserted implants. The data collected by Helfo is, however, due to its lack of details about both the implants and the insertions as well as the low degree of coverage, is far from sufficient to lay the foundation for a quality register.

1.1.3 The Success Rate of Implants

Several factors affect the success or failure of a implant insertion. Klinge et al. explains that dental implants come with various characteristics and material compositions, which gives them different properties [9]. Today, knowing which implants are beneficial to use under various circumstances, relies on one's own experiences and promises from manufacturers. It is not only the dental implants that can vary from clinic to clinic, but also the surgical materials and clinical procedures are often chosen with little scientific support. Thus, there are numerous factors influencing the result of a dental implant insertion.

In a retrospective study performed by Raikar et al., 5200 patients with dental implants placed between 2008-2015 were included [11]. Among these patients, there were a total of 120 implants failing. Raikar et al. report that the significant factors affecting the success rate were the length of the implant, the diameter of the implant and the type of bone it was inserted into. Norwegian clinics and researchers do not have access to the data needed to perform similar research to this, and are therefore not able to identify other factors which may affect the result of an implant insertion. To summarize, without scientific evidence of the effect of a product, procedure or technique, Norwegian clinics cannot guarantee the quality of the treatments.

1.1.4 Creating a Digital Quality Register

Based on analyzes of the success rate of implant insertions, with the right data available, we can eliminate poor procedures and products. To accomplish this, we will need a database covering implant insertions with following data in detail, and ensure high coverage of implant insertions at a national level. Then, over time, we can ensure that only the best products and procedures reach the patients, and that products with problematic properties will not be inserted in dental clinics in Norway. This quality assurance is the main factor behind the initiative of a dental implant quality register.

Traditionally, health registers vary a lot in form and technical degree. Paper forms are widely used, which requires the gathered data to be read and analyzed manually. Over the past years, however, several registers have created technical services for both recording and processing data. Benefits of using digital registers include [12]:

- larger variety of electronic documents compared to paper documents.
- the possibility to include dynamic data.
- electronic documents are more efficient than paper documents in terms of being more open for change.
- electronic documents are more persistent and more difficult to destroy than paper documents.
- the redundancy in electronic documents is higher than in paper documents as minor errors in a document can be corrected by computer tools.
- electronic documents may be created by electronic means while paper documents are created by humans.

With these points taken into consideration, it is safe to say that creating a digital quality register is beneficial for the usability and accessibility of the register.

The appearance of digital quality registers varies a lot, but the general increasing focus on user experience in web development also applies for healthcare. To achieve a successful healthcare application, focus on user experience is key, as bad user experience can lead to crucial user errors [13]. The main component of a quality register from a users perspective, is the registration of relevant data. It is therefore highly important that the forms are well designed to ensure correctness and avoid confusion and impatience by the users [14]. Although many aspects of user experience has changed, forms remain as one of the core elements for interaction with the users [15].

1.2 Research Questions

The guiding research question of this thesis is based on the development, implementation and evaluation of an artifact for a proposal for the data registration module for a dental implant quality register. To explore this question, the following research questions was in focus:

RQ1 What needs could a Norwegian dental implant quality register serve?

RQ2 How can one conduct the development of a user interface to facilitate valuable data collection for a dental implant quality register?

RQ3 Can the development of a user interface for data collection to a quality register for dental implants contribute as a boundary object to facilitate an understanding of how do develop a data model for a dental implant quality register – and if so, which experiences were made from the development process?

RQ4 What are the benefits and disadvantages of an isolated application for data collection in a dental implant quality register compared to integrating the data collection in existing electronic dental record systems?

1.3 Research Methods

For this thesis the Design Science methodology was applied. The main concept in Design Science is to design an artifact to solve a real problem, which fits the description of this thesis well. The artifact to be developed in this case is the prototype of an interface for data gathering, and the purpose is for this prototype is to be a tool in the development of a quality register for dental implants. The Design Science research is divided into three processes which consists of six activities [16] [17]:

- Exploration, induction and deduction of the problem
    1. Identifying the research problem and justifying the value of a solution.
    2. Defining objectives for a solution
- Designing and testing the solutions
    3. Designing and developing artifacts
    4. Demonstration by using the artifact to solve the problem
- Validation of the research
    5. Evaluating the solution
    6. Communicating the problem, the artifact, its utility and effectiveness to other researches.

1.3.1 Exploration, Induction and Deduction of the Problem

The first part of the process is to identify the research problem and justify the value of a solution. To start the project a team was put together consisting of experts within dental health, software engineering, medical statistics and

health quality registers. We had several meetings to discuss what system to be built, how it can be done technically, and the requirements from the users. To gain insight in the systems and procedures the dentists use when working, similar systems, such as Opus Dental [8], were shown and reviewed. Also, an article was written to advocate the need of a register for dental implants [10]. In the beginning, the meetings were mainly oriented around exploration of the problem. We did, however, also discuss possible solutions the problem.

1.3.2 Validation of the Research

As a part of the validation of the artifact, potential users was used to give input regarding what to include in the prototype, and how to present it. By continuously presenting the artifact in development to the potential users, they can provide input to ensure that the artifact being implemented corresponds to their expectations. There are multiple techniques to use for evaluation of the artifact in human computer interaction (HCI). These include cognitive walk-through, heuristic evaluation, model based evaluation and more . Participants in the evaluation should be chosen to match the expected user populations as closely as possible, states Jinjakam in her lecture notes about HCI evaluation [18]. As several members in our research team have experience using applications for dental health, these fit the descriptions given by Jinjakam, and their competence was useful for evaluation of the artifact.

1.4 Thesis Structure

Following, the thesis is presented with the main topics of each chapter:

1. **Chapter one** addresses the problem identification and the motivation for the thesis. Also, the methods to be used to solve the problem are presented and discussed.

2. **Chapter two** presents theoretical background information and explores relevant literature on topics such as Health Quality registers, methods for data gathering, form field usability and usability testing. Finally, related work is presented with the main focus on NORCEs prototype for a dental implant quality register and the Norwegian quality register for breast cancer, which in many ways can be looked to for technical solutions.

3. **Chapter three** presents the process of designing an artifact and the final design for an artifact. Chapter three also explains why the design is chosen and which considerations has lead to the final design.

4. **Chapter four** presents the implementation of the final artifact and describes the process of the implementation, hence technical solutions, tools and the architecture of the system.

5. **Chapter five** addresses the evaluation of the artifact. A description of the conduct of demonstration and evaluation is presented, along with the results of the evaluation.

6. **Chapter six** discusses the findings of this master thesis project. The research questions presented in chapter one is answered, and a discussion of the tools used for implementation is presented.

7. **Chapter seven** contains the conclusion of the thesis and suggests related further work.

Chapter 2

Background

2.1 Health Quality Registers

A health quality register is a collection of data about patients within a defined group. The data may contain information about the patient from the first assessment, during treatment and to follow-up. The main purpose of a health quality register is to ensure and improve quality of treatment and products given to the patients [4][2]. In addition to this, quality registers can also contribute to the improvement of health outcomes by reducing the costs, monitoring quality, providing feedback, reducing treatment variation and in providing data for research [5]. The variation in aim determines which data to register and from whom to gather data. A register may only gather data gathered by clinicians, as this may be enough to evaluate the techniques or products the register concerns. Other registers need input from patients to ensure a thorough evaluation [2].

Health quality registers contribute to improvement by offering a platform for data sharing and analysis across organisations, regions and countries. By having large amounts of data, researchers have a better foundation for their research and are more likely to discover potentials for improvement within their field. By sharing data through a register, hospitals can cooperate to gather enough information to perform good research that will benefit future patients [4]. Some hospitals may have limited experience with specific groups of patients, as well as limited knowledge about which methods and products that are suitable in different situations. Registers permit anyone to use research-based knowledge about currently used methods, rather than basing decisions on assumptions [2].

In the article "The role of cardiac registers in evidence-based medicine" Gitt et al. present the following attributes to identify an effective clinical register [19]:

1. Standardized data collection with definitions and reporting
2. Integrated tools for rapid feedback to participating institutions
3. Appointment of a single principal investigator or a small steering committee
4. Proper ethical review procedures
5. Electronic data capture with clear, simple explanations of definitions and instructions for participants, and plausibility controls to highlight incorrectly entered data
6. Randomized selection of centres (ideally, 100% participation)
7. Consecutive enrolment of patients for representativity
8. Audit of at least a small group of randomly selected centres
9. Centralized data compilation and statistical analysis, performed by professional statisticians
10. Reporting of all collected data, with conclusions appropriate to study the design
11. Transparent reporting of investigators and funding sources in all publications

These attributes should be taken into consideration in the development process of a quality register. In this project, we will not develop a complete quality register, but the data collection module for such a register. Consequently, all the attributes presented by Gitt et al. are not directly relevant for the development process in this project. They are, however, important to take into consideration for further work. The first attribute regarding data collection will be the most important during this project. This involves providing standardized input fields for the data collection, and providing a clear description of what data to include.

2.1.1 History of Health Quality Registers

The first notable register of patient data was the Framingham Heart Study, which started in 1948 [20]. The main goal of the study was to identify common factors that contribute to cardiovascular disease, and started out with recording relevant information about 5209 patients. Data from the study are still being used in research today, and the data has been a source to identify several risk factors [20]. The data registration conducted by Framingam et al. can be seen

as the "beginning" of health quality registers, even though it would take decades before registers became the standard within health care.

The modern history of health quality registers as important research tools started in the late 1990s. The technological and statistical advances developed during these years made it possible to gather data efficiently, and as the technology has grown, so has the registers, in both the amount of available data and the available services around the registers [21]. In the old traditional form of a quality register, paper forms with written data had to be sent physically to the register, and then manually entered to the database by employees. The use of digital solutions within health care started in the early 2000s, when among other things, Kaiser Permanente created digital patient portals where patients could view parts of their electronic health records [22]. Also, many registers have moved over to use digital solutions, which automates administrative work, and ensures safety for the patients.

2.1.2 Data Gathering in Health Quality Registers

Data gathering is one of the fundamentals in a health quality register. This can be done in many different ways. "Nasjonalt servicemiljø for medisinske kvalitetsregistre" through the following steps [2] , lists the general requirements of the data collection module:

- Clear and interactive registration forms that show / hide fields based on a logical connection between these for an efficient manual registration of data.
- Validation / control at registration to ensure the best possible data quality.
- Retrieve data from other systems to avoid double registration.
- Updated and good documentation of registry variables.

These requirements should be met when implementing a data collection module for a dental quality register. What differs our data collection module from others, is that the data is directly registered for each patient. This has not been done in any of the existing Norwegian quality registers. The requirements are, however just as relevant for our data collection as for the data collection in any other health quality register.

2.2 Designing for Usability

The basics of HCI is very simple. If a person wants to perform any type of action using computer systems, a human-computer interaction is necessary to

complete the task. This can be anything from buying a product online to pilot an airplane [23]. What makes human-computer interaction more complex is the need for good usability. This means that the design needs to provide a simple and understandable way for the user to complete their goal, reduce the complexity of the system and make the environment enjoyable to work with [24] [25]. Usability is one of the core aspects of interaction design, as it is a crucial factor in whether the system is successful. There are multiple characteristics which must be met for a systems usability to be classified as favorable. These are effectiveness, efficiency, engagement, learnability and error tolerance [26]. With all these characteristics covered in a system, we can expect an acceptable usability for the system.

2.2.1 Factor of Effectiveness

By *effectiveness*, means the completeness and accuracy the system provides for the users to complete a task [26]. In a quality register, this can be concerns such as gathering the correct data, or performing the correct analyses of the data. As one of the main characteristics of a quality register is to collect and analyse data, the factor of effectiveness is certainly important. Errors of effectiveness can lead to failure in the assessment of products and procedures, and reveal false findings about them. To avoid this and to ensure effectiveness, it is important that tasks are clear for the users, so that wrong information is not gathered, and that algorithms within the system works correctly.

2.2.2 Factor of Efficiency

Efficiency is the measurement of the time and accuracy it takes for a user to complete a task in the system. A good measure of this can be the number of clicks required to complete the task, or the time it takes. A quality register contains a number of different components to present information and collect data. These could for instance be text, sound, videos, animations and other graphics. The choice of components will highly influence the efficiency of the system [27]. Based on input from experts within the field of dental health, text and graphic maps have been chosen as the main components of this system. Text is in many ways the most informational and precise component, and is therefore efficient to use to provide important information. Using graphics provides creative possibilities for the system, and increases the opportunity of memorability for the users. Graphics can be different types of components. For this system, graphic mappings have been chosen. This includes interactive teeth diagrams presenting the state of the chosen patient.

2.2.3 Factor of Engagement

If the system is pleasant and enjoyable to use, it is also *engaging*. The design and frontend development is the essential element in creating an engaging system. Multiple elements can affect the engagement [26]:

- visual presentation, such as choice of colors and placement of object.
- the use of interactive elements such as input fields, check boxes, drop down menus, buttons and graphic maps.
- the flow in the system needs to be intuitive and pleasant.

A lot of time and resources have been put into creating an engaging system, and with the help of experts in dental health, design choices have been made to ensure that correct elements are chosen, and that the system is visually pleasing and functional.

2.2.4 Factor of Learnability

The concepts of *learnability* are in many ways similar to engagement. Providing a simple design makes the system easy to learn, which leads to it being engaging. An important aspect of learnability is that the users should be able to build on their prior knowledge of computer systems, and in this case, dental health systems [26]. This can be done by using icons known to the user, and find inspiration for placements of menus, buttons, etc. in other systems used in dental health. Specifically, Opus Dental [8] has been an inspiration for visually designing this system, as it is used by the same group of users on a daily basis. By doing similar design choices as done in Opus Dental, the amount of concepts to learn decreases, which is pleasant for the users. Also, Dentrix Ascend [28] and Dentimax [29] has been looked into, and we have found that they have a lot of similar design as Opus Dental.

2.2.5 Factor of Error Tolerance

One of the main challenges of data gathering and designing user interfaces is the risk of users making mistakes [30]. In a data gathering form, the user is prompted with multiple choices, selections and interactions to complete a task. This could be filling in an input field, navigating to, through or submitting a form, or recording data in a tooth diagram. When performing these actions, there will always be a possibility of the user making mistakes. Consequently, it is crucial that the system account for user errors, and is designed with the capability to avoid and handle them in proper ways. In the article "Preventing

User Errors: Avoiding Conscious Mistakes", Laubheimer [31] explains that when users are exposed to an interface, they create a mental model of how the system behaves, and how they need to interact with the system to perform a certain task. If the users mental model does not match the developers mental model, the system will be prone to user errors. These can be avoided by practicing usability testing to minimize the difference between the users and developers mental model [31].

To do so, experts have taken part in the development process and had several walk-throughs of the system. These have been done both individually and in groups to provide the opportunity to discuss possible pain points, and to find them unaccompanied. The process have been done in iterations to ensure that changes done in one iteration does not negatively affect the system, and that elements with potential for improvement do not get neglected. Measures to prevent user errors have been applied to the system based on feedback from the experts. Afterwards, during the next iteration, the redesigned interface have been presented to them again for feedback.

2.3 Design Guidelines for Data Registration Forms

In 2014 Seckler et al. conducted a study which aimed at testing guidelines for designing web forms, presented in Bargas-Avila et al. [32] [33]. These guidelines included form content, layout, input types, error handling and submission. The study was carried out by improving three existing web forms according to these guidelines, with users filling out the original forms and the improved forms. As stated in the report the users performed better with the improved versions of the form. In all three forms they needed fewer trials to successfully submit the form.

Also, improvements in initial and consecutive errors and task completion time were found. The report concludes that:

> *"all three web forms showed improvements in regard to user performance and subjective ratings. Eye tracking data revealed further more that the original forms needed more fixations, longer total fixation duration and longer total saccade duration than the improved forms"* [33, p. 1282].

Bargas-Avila et al. presented a total of twenty guidelines. Below we present the guidelines out of these that we consider to be the most relevant for the implementation of a prototype at the current stage:

- Form content

1. Let people provide answers in a format that they are familiar with from common situations and keep questions in an intuitive sequence.
2. Keep the form as short and simple as possible and do not ask for unnecessary input.
3. (a) If possible and reasonable, separate required from optional fields and (b) use color and asterisks to mark required fields.

- Form layout

4. To enable people to fill in a form as quickly as possible, place the labels above the corresponding input fields.
5. Do not separate a form into more than one column and only ask one question per row.
6. Match the size of the input fields to the expected length of the answer.

- Input types

7. Use check boxes, radio buttons or drop-down menus to restrict the number of options and for entries that can easily be mistyped. Also use them if it is not clear to users in advance what kind of answer is expected from them.
8. Use check boxes instead of list boxes for multiple selection items.
9. For up to four options, use radio buttons; when more than four options are required, use a drop-down menu to save screen real estate.
10. Order options in an intuitive sequence (e.g., weekdays in the sequence Monday, Tuesday, etc.). If no meaningful sequence is possible, order them alphabetically.
11. (a) For date entries use a drop-down menu when it is crucial to avoid format errors. Use only one input field and place (b) the format requirements with symbols (MM, YYYY) left or inside the text box to achieve faster completion time.

As presented, the guidelines has been scientifically documented to have a positive impact on the performance of digital forms. Consequently, the forms to be developed will be based on the given guidelines to ensure good user experience and effectiveness, as well as to prevent errors. To understand how to do so, the focus group of experts will contribute with their expertise. Some of the guidelines are straight forward, but knowledge of the dentists experiences is crucial to achieve an optimal data collection. The dentists experience is for instance needed to fulfill guideline number two, as they know what input that is valuable to collect. The experts will be the main source to this type of information.

2.4 Boundary Objects

One of the research questions presented in Chapter 1 refers to boundary objects, and how a prototype can be used as one. The definition of a boundary object is an artifact or a concept with enough structure to support activities within separate social worlds, and with enough elasticity as well to cut across multiple social worlds [34]. This means that for the prototype to be a boundary object, it has to have value for several different groups involved in the development of the dental implant quality register. These groups could for instance be patients, clinicians, developers, designers or marketing teams. The use of boundary object in design has been studied by among others, Bødker [35], who views design representations as containers. These contain multiple ideas and present their limitations to communicate between stakeholders. Through this project we will look into using the prototype as a boundary object. By doing so, we can explore if it can be used as a tool to present the ideas from different groups involved in the project, and communicate the ideas to other groups.

2.5 Related Work

We found no other open data collection modules for health quality registers in general, which gathered clinical patient data directly from the clinicians. Neither have they managed to find any dentistry related quality register anywhere in the world, yet. It has, however been developed a prototype of a dental implant register by Norwegian Research Centre AS (NORCE)[36].

2.5.1 Prototype by NORCE

A prototype for a dental implant quality register was developed by NORCE in 2019 for testing purposes [36]. This prototype was implemented in Open Clinica [37]. Open Clinica is a tool for empowering data managers, clinical researchers, and study participants by enabling more efficient clinical research through smart clinical data management and automation. The prototype was evaluated by the users and a report was written to present the evaluations [36]. The first step was to point out the pain points in the Open Clinica prototype based on the evaluations from the users. From the evaluation report one could identify the following pain points [36]:

- The prototype gathers more information than needed which is inconvenient and time consuming.
- The prototype has poor form structure, regarding poor order and duplicated fields.

- The prototype could have been more visually aesthetic and user friendly.
- The prototype is not very flexible
- The prototype has poor functionality when it comes to retrieving data and creating reports.

If any of the listed pain points are improved in the new prototype, the improvement will bring value to the prototype. It will therefore be crucial to have these in mind when developing a new prototype.

Chapter 3

Method and Design

This chapter presents the applied research method, design science. The design process, from literature reviews to user testing is described. The term "the system" is introduced in this chapter. By "the system" we mean the prototype to be built.

3.1 Design Process

Because agile development has been used, the process of designing, implementing and evaluating the artifact has been conducted simultaneously. The agile manifesto states that states the value "Responding to change over following a plan" [38]. This is solved by not planning the entire process from start, but rather plan short sprints. Every sprint includes both planning the design, implementing it and evaluating the work in progress. In this project, every sprint had a duration of approximately two to four weeks. During the sprint the prototype was improved based on requirements defined in the previous sprint meeting. At the end of every sprint we had a meeting with the focus group. In this meeting, we evaluated the work that had been done during the current sprint, and planned the next one. By following the agile development manifesto, taking change of requirements into account was less of a challenge compared to if we had a plan from start to end.

Another value stated in the agile manifesto is "Individuals and interactions over processes and tools". By including the focus group of experts from the start of the development, we ensured that they, who represented the users, could influence the process and the final artifact. The various sprints are presented in more detail in section 5.1.1. As mentioned, the implementation and evaluation was done simultaneously, and are therefore presented the same way.

3.2 Literature Review

An important first step in any research is the literature review, where relevant literature is explored. By evaluating the sources found during this process, we can identify important debates and gaps in the conducted research, which can lay the foundation for the research to be conducted [39]. The literature reviewed for this thesis concerns quality registers and design of data gathering tools within health care. Results of the literature review is presented in chapter 2.

3.3 Methods for Design and Implementation

This section describes the methods that were used during the design and implementation of the artifact. Figure 3.1 summarizes the function of the different methods that has been used. These are explained in detail in following sections.

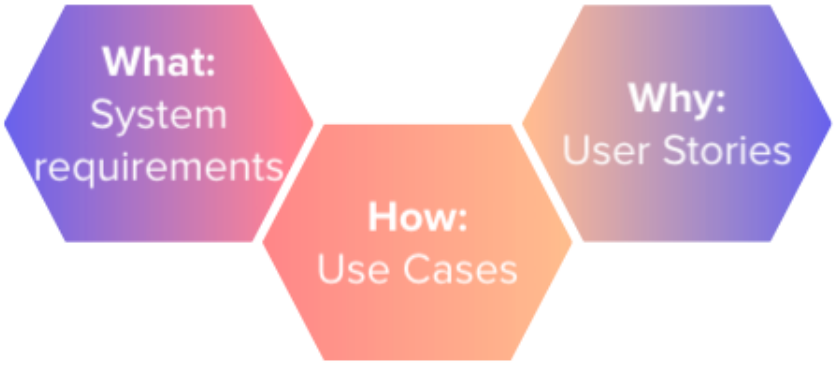

Figure 3.1: Different tools to define the artifact during the design process

3.3.1 User Stories and Minimal Viable Product

Based on the findings from the literature review, functionality to be implemented in the system can be defined. There are many ways to do this, but in this project defining user stories was one of the procedures chosen. A user story is usually a single sentence which describes *who* the users are, *what* they want to do, and *why* they want to do it. This helps the developer clarify what functionality which is important to the users. One of the reasons why user stories are made to identify features, is that the developers get a better understanding of the user context by implementing the user stories, and seeing the product from a users perspective [40]. This supports the user centered design process

that has been chosen for the artifact. It also provides a reason for implementing every feature, which helps the developer and the experts to see the value of the implemented features.

The following figures, 3.2 and 3.3, presents the user stories defined for the dental implant quality register. Here, we can see the *who* marked in green, the *what* in yellow and *why* in purple. The users have been split into four different groups, which will have different access rights and different goals using the system.

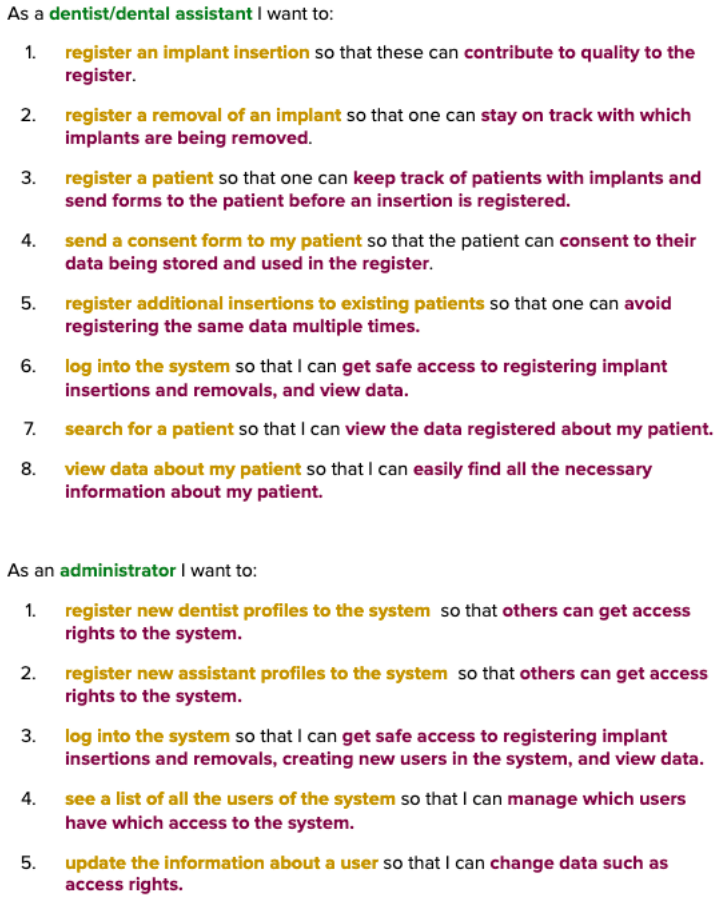

Figure 3.2: User stories for dentists and administrators

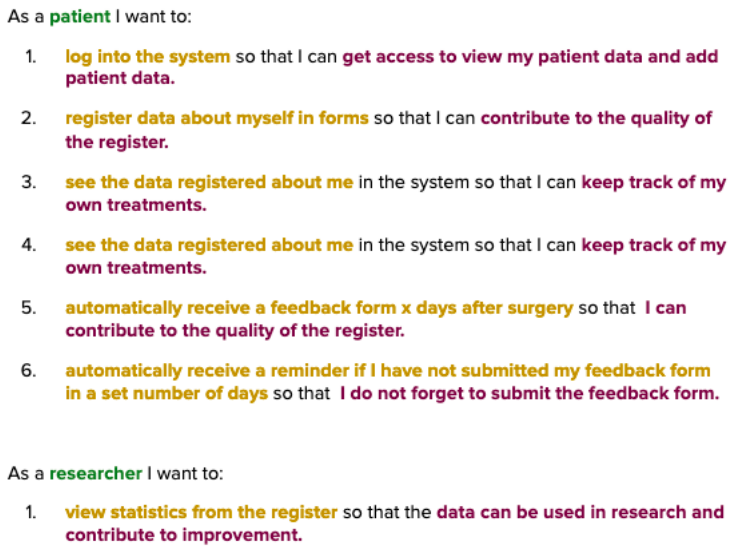

Figure 3.3: User stories for patients and researchers

The experts involved in the project helped defining these user stories and picking the ones with highest priority in the first prototype. As can be seen, the user stories presents many features, and several of them are not a part of the minimum viable product (MVP). MVP can be defined as a minimum version of the prototype that has any value to the users. When creating a MVP it can be asked *"Will the system still be valuable without this feature?"*. If the answer is yes, the feature can be left out of the MVP. The following user stories were picked as a part of the MVP:

1. As a dentist/dental assistant I want to register an implant insertion so that it can contribute to quality to the register.
2. As a dentist/dental assistant I want to register a removal of an implant so that one can stay on track with which implants are being removed.
3. As a dentist/dental assistant I want to register a patient so that one can keep track of patients with implants and send forms to the patient before an insertion is registered.
4. As a dentist/dental assistant I want to view data about my patient so that I can easily find all the necessary information about my patient.
   (a) As a dentist/dental assistant I want to register multiple insertions to existing patients and operations so that one can avoid registering the same data multiple times.

In total, these user stories addresses the need for the system to gather data. This, as discussed previously, is the most important feature of a quality register. The user stories are also helpful when identifying system requirements, which are presented in section 3.3.3.

3.3.2 Use Case Diagrams

In section 3.3.1 the user stories were presented, which describes what to include in the system. User stories do not describe how to include these features. A use case diagram visualizes the interaction between the user, or another external role, and the system. In addition to a user, this could also be other systems or external hardware. These roles are described as the actors in a use case diagram. Use case diagrams represent the interaction needed for an actor to accomplish a goal. This helps the developer define the interaction flow and see clearer how a feature can be implemented.

Figure 3.4 shows an example of a use case diagram for registering an implant insertion. The diagram contains a description of the actor, in which the groups of actors from the user stories have been used. The two boxes to the right shows the action that the user wants to perform, and the preconditions for the use case to be feasible. The middle part shows the flow if interaction. There is one main interaction path, with alternative paths if needed. Also, actions performed by the system which are crucial to the flow of interaction are presented in boxes with dotted borders.

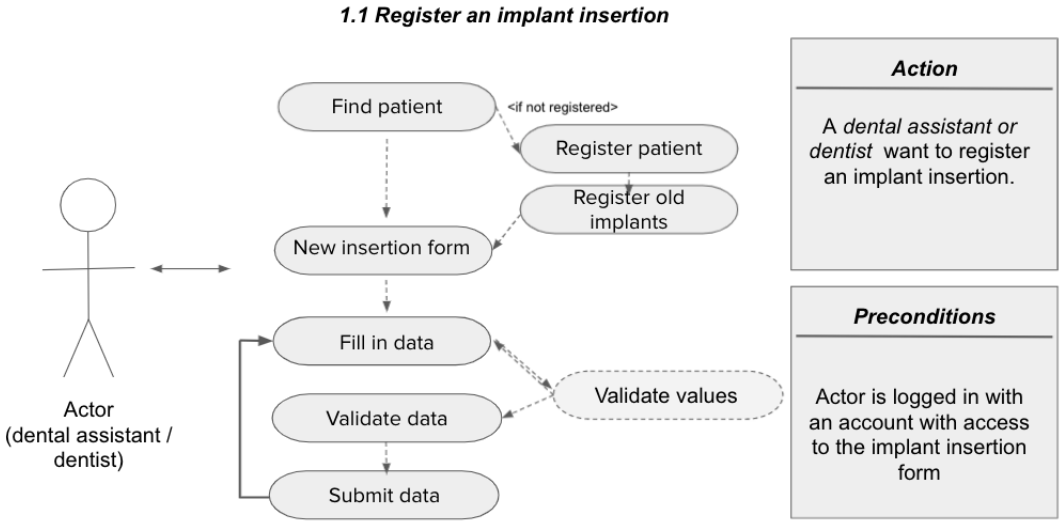

Figure 3.4: A use case diagram for adding an insertion.

3.3.3 System Requirements

To create work tasks, and make sure the needed functionality is covered, system requirements has been defined. These can be based on the user stories and the use cases that have been defined. In every iteration, and after discussions with the experts, the system requirements were reconsidered and updated. The system requirements can be split into two parts, functional- and nonfunctional requirements [41].

The **functional** requirements considers the features provided by the system. These can be based on the *"what"* part of the user stories described in section 3.3.1. An example of this could be that the system should provide functionality to register patient information.

The **nonfunctional** requirements deals with how the system provides a feature. These are not necessarily visible to the user, but are just as important as the functional requirements. Nonfunctional requirements can be based on the use cases as described in section 3.4. An example of this could be that the system needs to store sensitive data such as patient information securely.

3.3.4 Prototype

The initial procedures described in section 3.3.1 to 3.3.3 are a part of the first iteration. When these are completed we will have an idea of what to develop, and we can start building a prototype based on the gathered information. As mentioned, the requirements of the system will probably change during the development process, as the prototype may reveal benefits and disadvantages of the planned solutions. This is one of the main goals of the prototype, and the reason for creating prototypes before implementing the system.

Prototyping is an experimental process where one can test different solutions mainly considering the features of the system, and how the system will communicate with the user [42]. There are multiple ways to create prototypes, but they should be less time consuming to create than the actual product to be built.

Prototypes can be ranked from low to high fidelity [42]. The fidelity describes how close the prototype is to the system or product to be implemented. The higher the fidelity, the closer to the system, and the more time consuming. Because high fidelity prototypes are more time consuming to develop, it is a good practice to start by making low fidelity prototypes. These can be used to get an idea of which solutions to include in the system. Once the idea of the system is clearer, higher fidelity prototypes can be created. Examples of low fidelity prototypes could be simple sketches or paper figures, while high fidelity prototypes can be interactive views designed using tools such as Marvel, which

is described in section 4.1.1.

3.3.5 System Development Methods

Following a development methodology is like using a tool to organize the work during the development process. There are multiple methodologies to chose from, but as described by Ilyés [43], agile methodology is recommended in software development, but should be adapted to the project. Agile methods involves continuous planning, development, and deliveries. This is beneficial as it encourages flexible responses to change, which will occur in most development processes. There are multiple ways to perform agile development, and the methodology chosen for this project is Kanban. When applying Kanban, all work tasks are set up in a "Kanban board". The board sections the tasks based on their priority, and provides an overview of which tasks are left to be done, which are work in progress, and which are finished. This also helps the developer to focus only on a set of tasks at once, and to make sure the tasks are followed up. The Kanban board used in this project was made using the online tool Trello, and is presented in section 4.1.2.

3.4 Evaluation Methods

This section presents the methods that were used to evaluate the artifact. An continuous evaluation was conducted throughout the project with the help of a focus group consisting of experts in dental health. In addition to this, a final evaluation was conducted in the form of a semi-structured interview with an expert dental implants [44].

3.4.1 Expert Evaluations

From the focus group, experts within dental health, and experts within health quality registers participated in the evaluation of the artifact. Together with the developers and supervisors, the experts accounted for the development team. At the end of every iteration the team gathered to discuss and evaluate the work that had been done, and plan for the next iteration. The experts were a key to success regarding selection of data to register, and how the flow of the registration should be.

Dental Health Experts

The dental health experts participated continuously throughout the development process. Their expertise helped the developers to think like the user, as

the main user group will be very similar to these experts. As presented in section 2.2.4 the factor of learnability is crucial to create a pleasant interface. One of the presented methods to ensure learnability is to create an interface similar to existing systems. These experts knew which systems that are commonly used among dental health professionals, and how we could reuse and take inspiration from components from these systems.

Also, the experts had knowledge of what data to collect. One should only collect data relevant to the quality of the products or procedures used. Sizes, materials and shapes of the implant, or the examination of the jaw structure and health of the gums of the patient are examples of valuable data. This lays the foundation of the data collection, and is a critical step in providing data for quality assurance and further research.

In addition to the experts participating in the continuous evaluation, another expert participated in a final semi-structured interview. The interviewee is specifically an expert in dental implants, and has worked with insertions for twenty years. The final evaluation will give important feedback from a new perspective, which will be central for further work.

Quality Register Experts

The quality register experts also participated throughout the process with their knowledge of building and maintaining a quality register. There are many aspects of building such a system, and these experts especially contributed regarding features, considerations to constraints and data storage.

3.4.2 Interviews

A semi-structured interview [44] was selected as the main method for evaluations. Interviews are generally a qualitative evaluation method, as it provides the opportunity to go in depth of the evaluation with every interviewee. Interviews can be categorized into three categories: structured, semi-structured and unstructured interviews [45]. A benefit of structured interviews is that the interviewer can make a plan ahead, to ensure that the needed information will be gathered. However, in structured interviews there is no room for following up questions and going into details of topics that were not planned ahead. A unstructured interview is at the other side of the scale, where the questions are not planned ahead. This provides the opportunity to shape the ongoing interview based on the interviewees responses. Unlike a structured interview, in an unstructured interview, there is no room for planning the interview. This can lead to important questions being forgotten and not enough information being gathered.

A semi-structured interview combines these two approaches. This means that questions are planned ahead, but the interviewee can deviate from the planned question if there is a need to. This could for instance be if the interviewer wants the interviewee to elaborate more on their answers, or if some of the answers lead the conversation in another direction of interest than planned. Both benefits of structured and unstructured interviews can be applied to semi-structured interviews if done correctly.

A disadvantage of interviews is that they are time consuming compared to questionnaires and focus groups. To make the evaluation more efficient a focus group consisting of experts was therefore put together to participate in the agile development process. By gathering a focus group several experts could raise their opinion during the same meetings and have discussions with each other, which one misses the opportunity for in an interview with a single interviewee.

Chapter 4

Implementation

In this chapter, the technical aspects of the development is presented. This includes tools used to develop the artifact and description of the architecture of the system. Following, the scalability of the artifact and possibilities for further expansion and optimization is discussed.

4.1 Tools and Technologies

This section presents the main tools and technologies used to develop the artifact. Throughout the process, numerous tools have been used, but those with less influence of the final artifact, such as IDE and smaller libraries are not presented. There is also a backend supporting the system with a database and an API to communicate between the layers of the system [46]. These are not presented here as this thesis only focuses on the frontend development. In addition to the tools presented in this section, some tools are presented in section 4.2 regarding the architecture of the application.

4.1.1 Marvel

To create and present design suggestions for the artifact, from low to high fidelity, Marvel was used [47]. This is an online platform for designing prototypes for data systems, focusing on interaction design. Marvel contains several features, such as prototyping and user testing, and also provides design specifications for developers and integration with multiple other tools. For developing this artifact, the features used are the prototyping and design specifications.

The prototyping tool is simple to learn, and provides both functionality to sketch design ideas, and to make them interactive by adding navigation and simple functionality. Even though Marvel is great for prototyping, it lacks es-

sential functionality needed in the artifact such as the possibility to collect, store, change and delete data. The prototypes made here are static, and small changes in the design can require a lot of manual work. Because of these restrictions, Marvel is not suitable for creating the final artifact. It has, however, been an important tool in the process.

As mentioned, Marvel also provides design specifications for developers, more specifically CSS code generated from the views created in the prototypes. Some of these were helpful, such as colors and fonts. Other factors such as sizes and positions were less helpful, as they are only presented in pixels, which is not ideal to use in development of a scalable system.

4.1.2 Trello

To organize the work, from early stages of the design process to completing the system, Trello was used [48]. Trello is a virtual board, where one can add cards describing chores, and categorize them as one wishes. A screenshot of the Trello board can be seen in figure 4.1. This screenshot was taken during the design process, and multiple tasks had already been done. The Trello board used during this design process was inspired by the Kanban-methodology and therefore contained the cards in the following lists: to do, prioritized, ongoing and done. Each card is marked with a color to categorize the tasks. Purple represents design tasks, green represents prototyping tasks and orange represents implementation tasks. Each task can also have a list of sub-tasks. This was beneficial in order to understand the size of the implementation of a feature, and for thinking through every element within a feature.

The initial board contained work tasks based on the user stories, use case diagrams and system requirements as described in chapter 3. After every meeting with supervisors or expert the board would be updated so no input would be forgotten. Also tasks that occurred during the development process were added along the way.

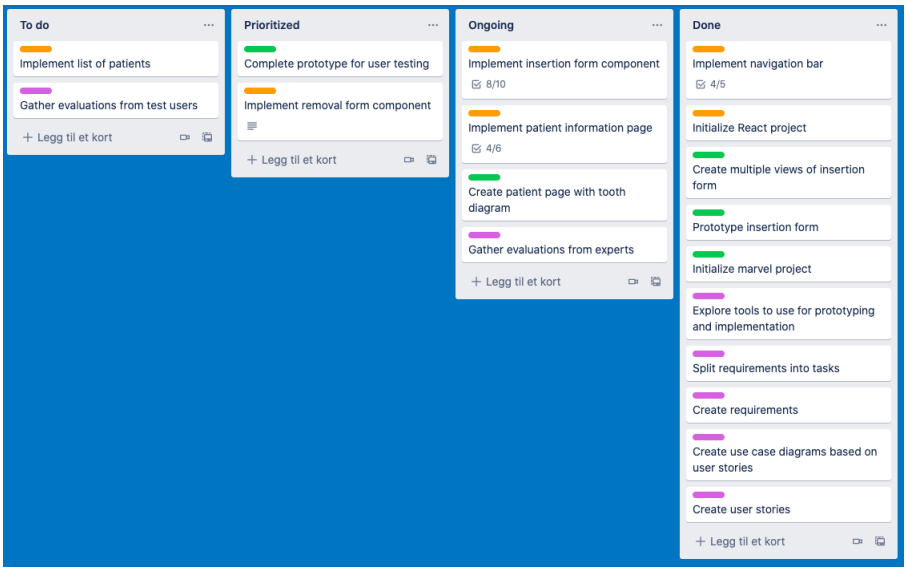

Figure 4.1: The Trello board

4.1.3 React

When finishing the designs in Marvel, parts of the design were developed using JavaScript with the React library [49]. React creates declarative views, which makes the code predictable and easy to debug. It is also component-based, with a separate state for each component. This is suitable for the developed artifact as it contains numerous components which differ based on for instance the role of the user of the system. React also contains numerous component libraries, which can be imported to the project to simply create a variation of components. The artifact has been built using multiple libraries, with React Bootstrap and React Router being the main ones.

React Bootstrap

React Bootstrap is a CSS framework that contains numerous classes with CSS styling [50]. The use of React Bootstrap is time-saving as the developer does not have to create all styling classes manually. In the artifact bootstrap has been used to style elements such as tables, alert boxes and buttons.

React Router

React Router is a library containing components providing navigation for any system built with React [51]. It is a efficient way to set up navigation in the artifact.

4.1.4 Typescript

Typescript is a language that compiles to JavaScript. It adds static type definitions to variables, functions and components, and is compatible with React. Typescript offers built in types. Custom types can be created to suit the system that is being developed. This provides better code readability, documentation and code validation, which collectively ensures the quality of the code.

4.1.5 GitHub

GitHub is a version control system and collaboration platform for software developers [52]. GitHub can be used for numerous file types, but it is most commonly used for code projects. In this project, only the code was submitted to GitHub, while presentations, prototype images and notes were stored in other cloud services. These are the main features used in GitHub in the development process of the artifact:

- When working in a team with multiple developers, GitHub is beneficial to keep track of changes being made by others in the team, as well as for **continuously sharing and merging code** from all of the participants.
- It is possible to **roll back to previous versions** to look into bugs and changes, without risking to loose any work.
- Experimentation with various designs and solutions can be done by **creating branches** containing different versions of the system.

4.1.6 Heroku

Heroku is a container-based cloud platform, providing functionality to build and deploy applications. The artifact was deployed by Heroku so that team members, experts and test users could access the application [53]. Heroku can deploy continuous updates from GitHub, so anytime a change has been made in the GitHub repository, the system is rebuilt and redeployed.

4.1.7 Section Summary

Only parts of the design created in Marvel has been developed using Typescript and React. The main goal of the development is to demonstrate the possibilities one have in creating the system, instead of building the system on such an early stage of the process. The development of the actual web application has also brought knowledge and understanding of how the data collection module could work, and provides a more interactive application which helps the developers and the focus group visualizing the data collection module.

4.2 System Architecture

This section describes the architecture that has been implemented in the frontend part of the system in detail. The backend is not described in this thesis as that part of the system is not developed in conjunction with this thesis. The front end architecture can be split into three main parts: The view layer, state management and the API client [54]. Figure 4.2 shows the tools used for each of these parts of the frontend application, and each part is described closer below.

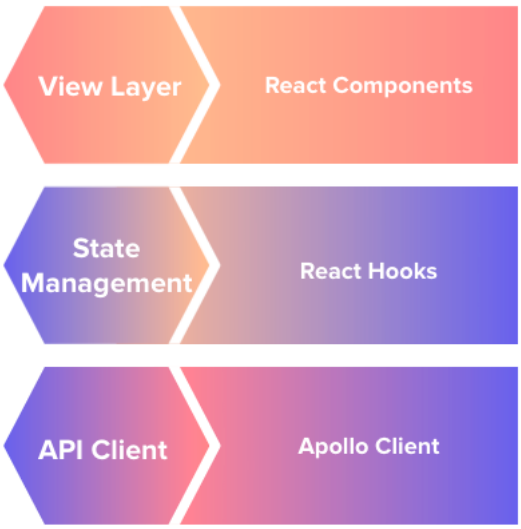

Figure 4.2: Overview of the frontend architecture

View Layer

As mentioned in section 4.1.3, the application is built by React components, where each instance of a component has its own state. React components can be initialized as a class- or a function component. These are written differently, but are the same from React´s point of view [49]. To maintain consistency in the application, only function components have been used.

Figure 4.3 shows an example of a function component used in the application. This is a very simple and small component, that presents the header of the current viewed page. As can be seen, the component has an interface, Props, which defines its properties and their types. Here, optional properties can be added. This component does not do anything but return a JSX fragment containing two div elements. Also, it is possible to add function variables and local functions to perform calculations inside the function component. Anything

inside the return statement of the component will be returned to its parent, and rendered in the view.

```tsx
interface Props {
  pageTitle: string;
}

const SubHeader: React.FC<Props> = ({ pageTitle }: Props) => {
  return (
    <>
      <div className="sub-header">
        <h2>{pageTitle}</h2>
      </div>
      <div className="line"></div>
    </>
  );
};

export default SubHeader;
```

Figure 4.3: A simple function component

State Management

The state management of an application is the communication and data sharing across components. The state of a component is an object that represents a specific instance of the component, which can be modified by the user. In React, every component can have its own state, and React Hooks can be used to control it. Also, it is possible to import multiple libraries such as Redux and Recoil to handle state management. This has not been done in the application, but can easily be added on a later stage of the development. Because React provides Hooks, which can create and manage local states on their own, this covers the need for state management in the application. Figure 4.4 shows how the initialization and updates of a state has been done in the application by using the *useState* hook. The function *updateState* takes the new state and a field as arguments, and updates the correct field with the new state. By using the *useReducer* hook, one can create a state container for any top-level component. This can be passed to any component by the *useContext* hook. To pass states from a child- to a parent component, one can use the *useEffect* hook together with a callback method. This has for instance been done in the application when the user clicks a choice in a drop down menu, as shown in figure 4.5.

```
const [antibiotics, setAntibiotics] = useState(false);


function updateState(state: number, field: string) {
    if (field === "antibiotics") {
        setAntibiotics(state);
    }
}
```

Figure 4.4: An example of how the state is initialized and updated using Hooks.

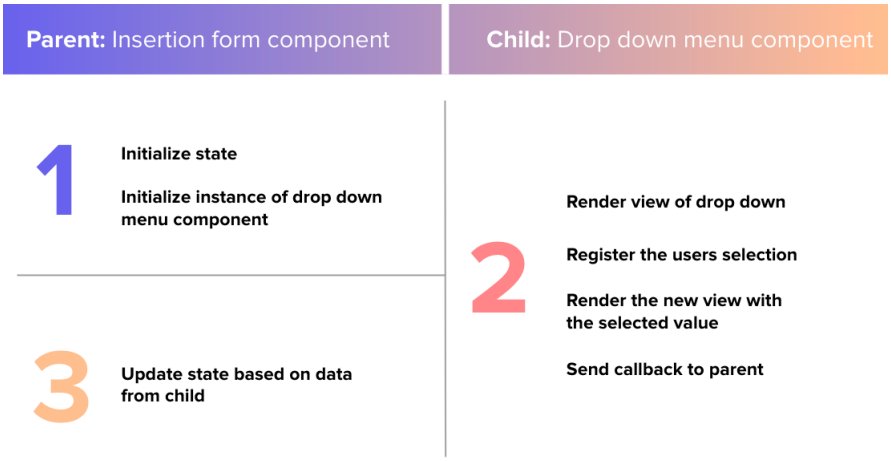

Figure 4.5: How a state is updated across components using hooks.

API Client

The code of the application is split into two parts, backend and frontend. These are nearly independent of each other, and only communicate through the API. For the frontend code to access the API, it is beneficial to use an API client. An API client is a set of tools and protocols that among other things creates and sends requests to the API, and monitor responses. Using API clients helps speed up the development process, as developing the tools offered by the API client is time consuming. This especially applies to application that needs to run in different browsers, as the browsers often have variation in how API requests and responses are handled [55].

The API client used in the application is the Apollo client [56], which uses GraphQL. A major benefit of using GraphQL is that specific queries can be sent to retrieve only the data needed. This reduces the chances of errors when working with the retrieved data. Apollo is easy to set up in the application as seen in figure 4.6. The required modules are imported, a client variable is

initiated and wrapped in the rendered JSX elements in an Apollo provider. The client is passed to the App component, to be used in the application. With this set up one can use Apollo to send requests containing GraphQL queries, and receive responses containing the demanded data.

```
import { ApolloClient, InMemoryCache } from "@apollo/client";

const client = new ApolloClient({
  uri: "https://dentalimplantregister.herokuapp.com/graphql",
  cache: new InMemoryCache(),
});

ReactDOM.render(
  <React.StrictMode>
    <App client={client} />
  </React.StrictMode>,
  document.getElementById("root")
);
```

Figure 4.6: The index file, which is the top-level file rendered in the application, contains the setup for Apollo.

4.3 Facilitating for Expansion

Only parts of the application has been developed yet, and there are several requirements that need to be developed to reach an ideal quality register. Just like any other web application, quality registers have to adjust to new changes in terms of browser updates, new technologies and new design trends to stay up to date. Because of this, it is important to be able to make changes to and expand the application. As presented in section 4.2, the application is developed with React, which is a component based framework for JavaScript. Using components is great for scalability as we can build up new layouts using the same components, and easily add more components. Also, each component also has a separate style sheet that can be changed without side effects. In a blog post from 2017, Sebhastian describes best practices for providing scalability in a React project [57]. Based on these, here are some of the factors considered to ensure scalability in the application, which we see as important for this project:

- **The use of local states.** Using local states in components make them less prone to errors if changes are made to other parts of the system. Therefore, if possible, operations needing access to a state should be made within the same component as the state is stored.

- **Using tools to support scalability.** To create a scalable application, the quality of the existing code has to meet a certain standard. Several of the tools presented in section 4.1 helps ensure quality such as React Router, Apollo and React Hooks. These are well documented libraries which are easy for other developers to learn. This will help developers working with the same application in the future understand the code and be able to work with it.

- **Organizing files.** Having a clear structure in the file system is crucial to make it simple to work with. This includes naming and directory structure. The file names in the application are made to be self explanatory for developers to easily understand which components are in which files. They also have a style sheet with the exact same name as the component.

Another important factor for scalability is how the frontend and backend communicates. The backend provides an API for communication with the frontend. By separating the code in such a way, it is ensured that some part of the code can be updated without having to make major changes to any other part. Also, multiple views connected to the same database can be created. This means that the backend part of the system could be used for instance in multiple countries, or regions with different requirements regarding view and user interaction.

4.4 Design Choices Based on Design Guidelines

The design guidelines presented in section 2.3 were central during the entire development process. We ensured the guidelines concerning form content was followed by constantly evaluating the prototype with the focus group. The guidelines concerning the form layout was more straight forward to take into consideration during the development and are not based on opinions. Consequently, these were taken into consideration and followed from the start. Finally, the guidelines concerning input types were somewhere in between the other two when it comes to how straight forward they were. Whether to use radio buttons, drop-down menus or check lists has been determined through the evaluations based on the experts opinions. However, we started out following the guidelines, and these were presented during the discussions.

Chapter 5

Demonstration and Evaluation

As presented in section 1.3, demonstration is the fourth step in the design science process, followed by an evaluation of the artifact. These activities are closely related, and may be carried out simultaneously. An agile development process has been used for this project, which entails that both demonstration and evaluation has been carried out multiple times throughout the process. In addition to these "sprintly" demonstrations and evaluations, a final evaluation was performed towards the end of the project.

Semi-structured interviews were chosen as the evaluation form, both in the continuous evaluations, and the final evaluation. This format facilitates that the interviewee can add comments in addition to the planned questions. And the interviewer can come up with follow-up questions as they arise. The chance to gather more information than planned beforehand ensures that a qualitative evaluation can take place, and that valuable feedback is not ignored. The semi-structured interviews are time- and resource consuming compared to other evaluation methods such as questionnaires and surveys. An important benefit of semi-structured interviews is that they facilitate for qualitative data gathering, which is suitable for the qualitative nature of the artifact. To ensure the evaluation would be comprehensive, the continuous semi-structured interviews, presented in section 5.1, was carried out in a focus group consisting of several experts.

5.1 Continuous User Evaluation Through Semi-structured Interviews With Focus Group

Throughout the project, semi-structured interviews have been carried out with the help of a focus group, consisting of experts within dental health, dental implants and quality registers. We know that when implementing a new system, the requirements may change during the time of implementation, and new needs and challenges may be discovered along the way. With this in mind, we chose to work in sprints and evaluate the artifact for every sprint, as the implementation was going on. This could be time saving as we would spend less time implementing functionality that would later be removed, due to change of requirements. This continuous evaluation was conducted together with the focus group.

5.1.1 The Conduct of the Evaluation

As mentioned we gathered the focus group once per sprint, to discuss new needs, challenges and findings that arose. As well as performing a demonstration of the work that had been done, and evaluating the in progress prototype. We did a total of seven sprints, where we started with the Open Clinica prototype as the starting point for the new prototype, and started the development based on the feedback gathered about the Open Clinica prototype, and feedback from the focus group. Following is a description of each sprint, with focus on the demonstration of the work that was done during the sprints, and the evaluation of the work done by the focus group.

Sprint 1

In sprint 1, we had not started the development of the prototype. Therefore focus was on gathering data about the benefits and disadvantages of the Open Clinica prototype. We took this data into consideration when starting the development of the prototype. Also, we spent time establishing requirements in terms of user stories and use case diagrams. These were presented to the focus group at the end of the sprint to demonstrate how we would work in the upcoming sprints, and evaluate which user stories and use cases to prioritize.

Sprint 2

The first draft of the prototype was presented to the focus group. Multiple design choices that could be used for the forms were presented, as well as for the "patient history" component. Examples of these are shown in figure 5.1 and

5.2. The focus group gave their feedback of which designs they preferred, and additional feedback to improve the design.

Figure 5.1: Three different design choices for registering multiple implants. These were created during the second sprint, and later reevaluated.

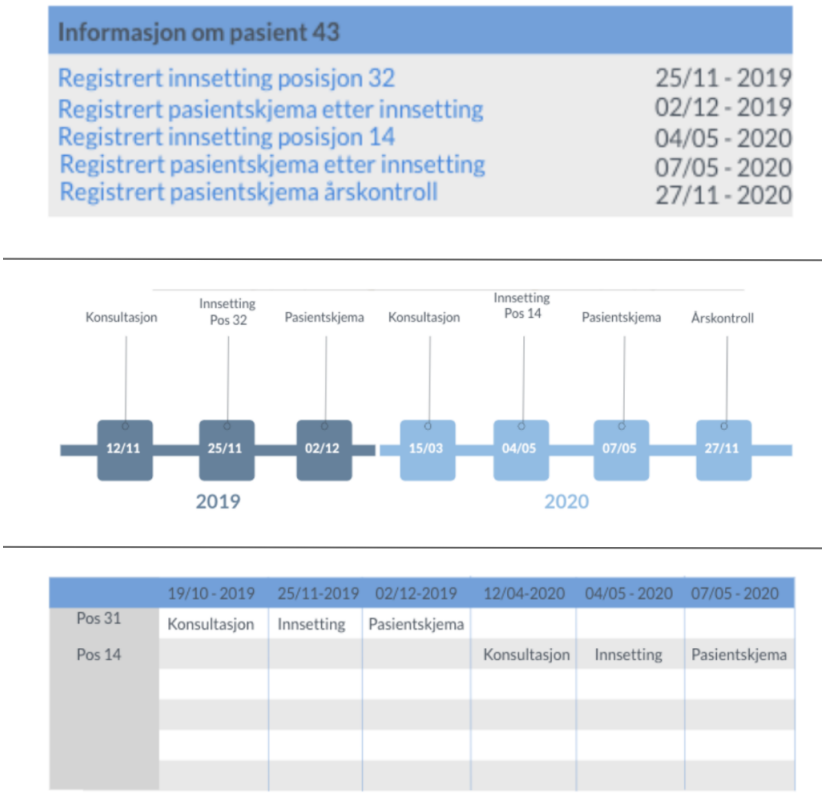

Figure 5.2: Three different design choices for displaying the history of a patient. These were created during the second sprint, and later reevaluated.

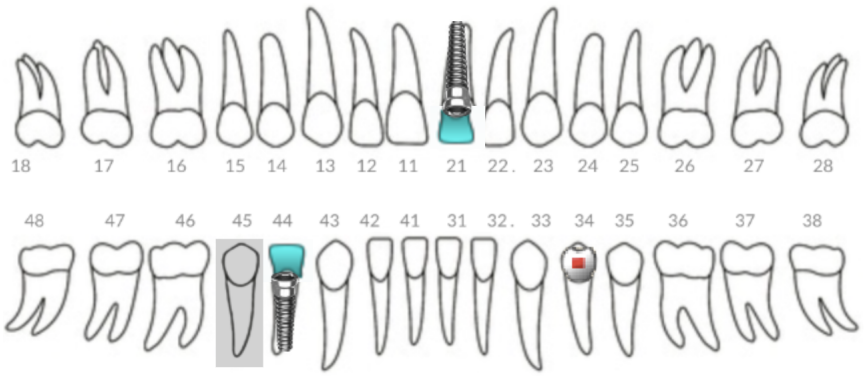

Figure 5.3: An interactive tooth diagram presents registered operations, implants and prosthetic, as well as registered diagnoses. The diagram can display extended information about a specific position.

Sprint 3

During the third sprint the focus was mainly on the data collection. The focus group spent most of the time on evaluating which words to use in the form, what data to collect and which type of components to use for each data field. We kept focus on this during all the following sprints as well to ensure that the final data collection would make a good foundation for research and quality assurance.During sprint 3, the focus group suggested to include a tooth diagram in the prototype, to visualize patient history. Following, the diagram presented in figure 5.3 was designed. The diagram shows the current state of the patient history, and by selecting a specific position, the users can view detailed information about the position. This component provides an overview of the registered data, and the information in presents is easily accessible for the users.

Sprint 4 to 7

The following sprints consisted of reevaluating the data collection and the design. We also realized that the time frame of the project would not allow us to finish implementing the data collection, but rather create a suggestion that will have to be further evaluated. Both the design and the form data was updated between each sprint, and the participants in the focus group spent time in between the meetings investigating the data collection.

5.1.2 Results of the Evaluation

A total of seven sprints, and thus seven demonstrations and evaluations of the work, resulted in a suggestion for parts of a dental implant quality register in the form of a high fidelity prototype for entering data insertions and removals. The prototype does not include all the functionality that the final system ideally should, but is still a valuable tool in the further development. More discussion of the use of the artifact is presented in chapter 6. As shown in figure 5.1 and 5.2, we presented multiple design choices for the components in the prototype. Figure 5.4 shows how the component in figure 5.2 turned out, and as can be seen, they have been continuously updated throughout the sprints to be user friendly.

Also, the form components were updated continuously, and the final form had several changes compared to the initial suggestion. These changes concerns both which words to use in the form, what data to collect and which type of components to use for each data field. A major change that were made to the insertion form, was that instead of having one form, it was split into three separate forms. The reason for this was that during the evaluation, one of the

challenges was to find a way to be able to register multiple implant insertions in the same operation. Some suggestions to this was presented during sprint 2 as shown in figure 5.1. Through the evaluation we realized that almost all fields would have to be registered per implant, and the form could then grow very big when inserting multiple implants in one operation. Consequently, the form was split into three forms. The data fields included in each of these forms is presented in table 5.1.

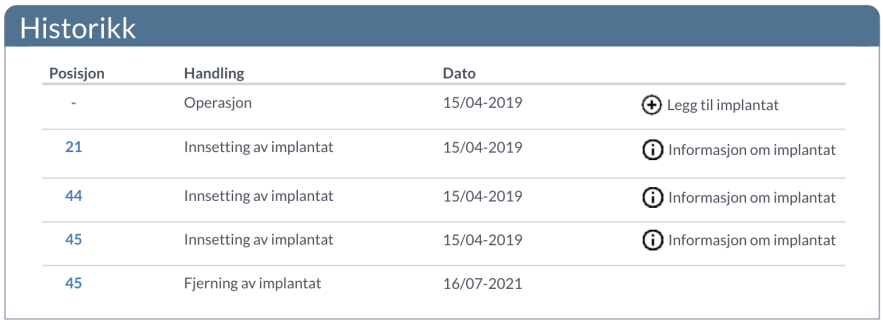

Figure 5.4: The final result of the history component. The component is both used for presenting the history of a patient, and contains navigation component to information about implants, form for registering a new implant, and displaying information about one single tooth position.

Goal of form	**Data fields**
Register a patient.	clinic SSN
Register an operation.	treatment clinic date of operation antibiotic prophylaxis name of antibiotic dose of antibiotic duration of antibiotic treatment
Register an implant insertion.	31 seconds planned prosthetic construction recommended time for load Number of joints position from position to Reason for missing tooth Reason for removal of tooth Description of removal of tooth time since loss of tooth reconstruction of jaw method for reconstruction material membrane time since reconstruction supplier of implant implant length implant diameter reference number LOT number position HELFO-refund

Table 5.1: An overview of what data to be collected per patient, operation and implant insertion.

5.2 User Evaluation of the Final Artifact

In addition to the continuous semi-structured interviews presented in section 5.1, a final semi-structured interview was conducted. The goal of this interview was to perform an evaluation by an expert that had not participated during the process of implementing the artifact. In this way, the artifact could then be seen from a different perspective and the interviewee would not know the reasons for the design choices that had been made. The interviewee was also an expert within dental health, with specialization and a long career in the field of dental implants. Ideally, several interviews should be performed, but within the time frame of the project, this was not possible.

5.2.1 The Conduct of the Evaluation

We met up with the interviewee at the Department of Clinical Dentistry for the interview. With permission from the interviewee, we set up a camera to record the interview. In addition to recording the interview, a screen recorder was used to see exactly what the interviewee did when she was given tasks. The videos was then transcribed to be used for the evaluation.

The conduct of the semi-structured interview was split into two parts. The first part would evaluate the data that is gathered in the artifact. The interviewee was asked to give feedback regarding the correctness of terms that were used, if any collected data was unnecessary, or if any relevant data was not gathered. The second part of the interview consisted of a walk through of the artifact, where the interviewee was asked to perform several tasks using the artifact, and give feedback along the way. The interviewee would also comment if she did not understand something, or if she saw any potential for improvement regarding the design. The structure of the interview was as follows:

1. A short presentation including the motivation for the project, and a brief introduction to using the artifact.
2. A walk through of the data collection in the artifact, where the interviewee gave her feedback along the way.
3. Some pre-written open questions about the data collection:
   (a) "Do you have comments on the wording that has been used?"
   (b) "Do you see the data that is collected as relevant, or is any data redundant?"
   (c) "Can you think of any data that should be collected in addition to what has been presented?"

(d) Any follow-up questions to the interviewees comments.

4. A user test of the artifact. The interviewee was presented with a set of tasks to carry out, and tell the interviewer what she was thinking and seeing along the way. The walk through consisted of a total of nine tasks. Following are some examples of tasks:

   (a) Register a new patient in the system.

   (b) Register a new implant insertion to an existing operation.

   (c) Look into the information that has been gathered concerning a specific tooth position for a specific patient.

   (d) Register the removal of an implant.

   (e) Before submitting a form, navigate back and forth in the form to change some of the data you added.

5. Questions regarding the design and the ease of use of the artifact. Some of the questions:

   (a) Did you at any point think you were presented with too much information? And if so, did this increase the degree of difficulty of your task?

   (b) Did you find buttons and input fields clearly visible?

   (c) What do you think of the registration of patients, operations and implants being split into three different forms? Do you see any value or constraints of this design choice?

   (d) Do you see any value of having access to a dental implants register in your everyday work?

   (e) Have you experienced having a lack of information about a patient or a dental implant, that this register can provide?

6. Follow up questions to the interviewees responses to the questions above.

5.2.2 Results of the Evaluation

Regarding Data Collection

The interviewee gave feedback on multiple fields regarding the data collection. Several fields of the data gathering forms are drop down menus where an option is selected from a set of predefined options. It is important that these options covers the outcomes that a user wants to register. If not, results can be incorrect data registration. The interviewee found several fields that, in her opinion, was

not covering, not precise, or not consistent with the standards used by dental health experts. The drop down menu shown in 5.5 was created throughout the implementation process with help from the focus group. For instance, the focus group presented the options *up to two weeks, up to eight weeks* and *over eight weeks* as consistent with the standards. The interviewee said this was incorrect in her opinion, and that the options also include *up to six weeks*, as this is commonly used for insertions in the lower jaw. Another example shown in 5.5 is the *planned prosthetic construction* radio button selection. The interviewee made a comment that she did not understand what was meant by *plate prosthetic*. This is an important indication of poor wording. If an expert who has worked in the field for over twenty years does not understand the option, chances are that many users would be confused by this. After some explanation of what was meant by the option, the interviewee suggested to use the word *tire prosthesis* instead. She also made a comment that the *tire prosthesis* should further be specified regarding how the prosthesis is attached to the patients jaw.

The interviewee had similar comments in multiple parts of the form, and suggested changes to a total of 11 out of 33 fields in the form. These will be valuable feedback for further development of the register, and should be considered equally with the results of the evaluations with the focus group.

Figure 5.5: The form section for describing planned prosthetic construction for an implant

Task	Time	Clicks	Minimum clicks
Register a patient.	28 seconds	2	2
Register an operation.	46 seconds	4	4
Register an implant insertion.	31 seconds	7	7
Find information about the implant on position 21.	3 seconds	1	1
Register an implant removal. When reaching the last step of the form, go back to the first step to check the data you added.	26 seconds	11	7
Find information about the existing patient "Hans Hansen", and look into details about his tooth position 45.	52 seconds	4	3

Table 5.2: Results from the walkthrough of the prototype

Regarding Design

When performing the tasks presented in section 5.2.1 the interviewee explained what functionality she thought the different components would have, and the reason she chose to do what she did. Table 5.2 shows the time and number of clicks she spent performing the different tasks. The tasks that would include filling in information in forms lacks the actual fill in, because this was not possible with the tools that were used. This means that filling in the forms would take much longer time than presented in the table, but the table shows the time the interviewee spent navigating through the form, and observing the form components that were displayed.

Regarding the Need of a Dental Implant Quality Register

Appendix A presents the interviewees answers to the questions that were asked during the semi-structured interview. Questions two to six concerns the need of a dental implant quality register. In the answers to these questions, the interviewee states that the implant she uses is based on her own experience, and that she thinks there is a lack of access to information about the quality of implants. Furthermore, she mentioned her knowledge to the quality register for Norwegian hip joint prosthesis, and highlights the importance of seeing trends over time, and compare the different suppliers. When asked about her opinion of developing a dental implant quality register she answers that this will be important.

The prototype we have implemented represents a stand-alone system, independent from other systems the dentists use. Another approach could be to have the system integrated in a familiar application such as Opus Dental. We asked the interviewee about her opinion about this. In her answer she highlighted fewer logins as a benefit of an integration and stated that "everything that can be integrated is good".

Summarizing these answers, it can be seen that the interviewee sees the need of a dental implant quality register, and that there is a lack of access to information to support the decision making of implant insertions. The interviewees opinions regarding the need of a dental implant quality register will be further discussed in chapter 6, along with the other information gathered from the evaluation.

5.3 Evaluation Summary

When adding up the results of the focus group evaluation, and the semi-structured interview, we have gathered the opinions of several experts, and reviewed the results of the focus group evaluations multiple times. These "sprintly" evaluations has been very effective, and helped us ensure that the artifact reaches the expectations of the experts. Also the final semi-structured interview gave important feedback regarding both design and data collection. Having someone who has not been a part of the implementation process evaluate the artifact was important to gather more information about the success and drawbacks of the prototype.

5.3.1 Limitations and Drawbacks of the Evaluation

Both the continuous evaluation with the focus group, and the final semi-structured interview has some limitations and drawbacks. Firstly, the focus group consistently consisted of the same group of experts. This has both benefits and disadvantages. A major benefit is that the group knows what has been discussed in the past, and is up to date with the implementation process and the needs that has been established. But a disadvantage is that the group can easily get locked in the same mindset, and overlook important factors. Therefore, if the scope of the project would have room for it, we should ideally conduct the semi-structured interview with several interviewees. This could give us more feedback seen from different perspectives based on the knowledge, experience and opinion of multiple experts. Also, users with less experience within dental implants could be interviewed, as it is conceivable that clinicians with less experience in that field also will use the system. The walkthrough of the artifact

also had some limitations, as a result of the tools and technologies that were used. This is further discussed in section 6.2. These limitations and drawbacks of both the evaluation methods and the tools we have used is important to take into consideration when analysing the evaluation.

Chapter 6

Findings and Discussion

6.1 Contribution to the Knowledge Base and Answers to the Research Questions

The conduct of research contributes to the knowledge base by revealing new information about the need of a Norwegian dental implant quality register, and which procedures can provide benefits during the process of development. More discussion about the contribution to the base of knowledge is presented in the following subsections, handling the findings regarding our research questions.

6.1.1 Research Question 1

What needs could a Norwegian dental implant quality register serve?

Through both of our evaluation methods with focus groups and interviewing an expert, we have found that experts sees the need of a Norwegian dental implant quality register. This statement is supported by the excerpt from the final semi-structured interview, where the expert states that "*There is a lack of access to this information*", where *this information"* refers to information about the quality of the implants on the market. Furthermore, she says that except of the departments own studies, they only find information about the quality from the suppliers. The suppliers wants to sell their products, and can theoretically hold back information or post biased research to their favor. The expert also mentions her familiarity with the Norwegian register for hip joint prosthesis, and how she has seen important data being published by the register, especially when it comes to comparing different suppliers. As most of the published data comes from suppliers, these comparisons are not done in the dental implant market. Having a quality register without financial gain, does not only give

access to information, but also prevents the published information from being biased and facilitates comparison. The expert also highlights the importance of seeing trends over time, and not just relying on her own experience, which she adds is her way of selecting which dental implants to use.

To summarize and answer the research question 1, a Norwegian dental implant quality register can ensure access to information to clinicians in the field, both regarding patient history, unbiased statistics, comparisons of implants across suppliers and provide a database for further research. The data will be collected from Norwegian clinics, which ensures research and insertions is based on data gathered from insertions made with the techniques that are used in Norwegian clinics. In addition to providing information, a register will set a standard for reporting insertions and removals, which contributes to more thorough work among clinicians.

6.1.2 Research Question 2

How can one conduct the development of a user interface to facilitate valuable data collection in a dental implant quality register?

The development process has taken the Norwegian dental implant quality register from an idea, to a interactive prototype that can be used as a starting point and demonstration for further work. The process of designing the user interface has been heavily influenced by experts in dental health and dental implants. We have seen that this is a necessity as they will be the primary users, especially of the flows we have created, regarding insertion and removal of implants, and viewing patient history. Further, it will also be beneficial to have the system evaluated by patients, user experience and user interface designers. Having an evaluation with a designer may have revealed weaknesses of the prototype that may not have been brought to light. Weaknesses of the prototype could also have been brought to light by conducting a quantitative evaluation, as such evaluations tend to cover more edge cases and gather opinions of a larger variety of the user group.

The agile development method has been efficient, as well as gathering a focus group instead of doing multiple interviews with one interviewee at a time. Having the final evaluation with someone outside of the focus group gave valuable feedback, and seeing the prototype with "new eyes" clearly had an impact on the evaluation. Seeing the result of the development process, it can be said that the conduction was a success as it developed a useful tool for further work, and provided knowledge among the team working with the project. The project would also benefit from having evaluations by designers at the stage of the process it is at.

6.1.3 Research Question 3

Can the development of a user interface for data collection in a quality register for dental implants be used as a boundary object to facilitate understanding of the domain? If so, what experiences were made from the development process?

With the definition of a boundary object that is presented in section 2.4, prototypes can be used as boundary objects. Table 6.1 shows how different stakeholders can use the prototype for different purposes, which in all ways contributes to their work. So far, there are not several teams working with the prototype, so it is mainly the designer/developer and the user functionality, that has been used. However, table 1 shows how the prototype can continue to be used as a boundary object during further development.

Regarding the experiences of using the prototype as a boundary object, it has been especially useful for collecting user feedback. The experience has showed that the focus group participated more actively when shown the prototype vs just by discussing the design and data collection without any visualization. Also in the final interview, the prototype was used frequently to collect feedback and present the ideas and concepts of the system. Overall, the boundary object played the most important part in the communication between the designer and the users. Furthermore, the communication with the developers, which in our case would be the other participating master students, and the improvement of user experience benefited from the use of the boundary object.

Stakeholder	**Use of boundary object**
Designer	Collect user feedback Improve user experience Tool for communication with organizational teams and developers
Users	Tool for understanding the domain Tool for giving feedback
Developers	Instructions for development Tool for communication
Organizational teams	Tool for pitching in marketing Tool for communication

Table 6.1: Use of the prototype as a boundary object

6.1.4 Research Question 4

What are the benefits and disadvantages of an isolated application for data collection in a dental implant quality register compared to integrating the data collection in existing journal systems?

Integrating the data collection of the dental implant quality register in an existing journal system comes with numerous benefits. One essential benefit is that it creates less work for the clinicians reporting to the system, compared to isolating the register in a separate application. The evaluation of the Open Clinica prototype showed that several clinicians values an efficient register, and does not want the data reporting to take up much time of their day. By integrating it, the workload of learning a new system will be reduced and less data will have to be registered multiple times. By reducing the number of times data fields are register, one also reduces the chance of errors being registered, and data not being updated. This is an important argument for achieving an integration.

There are also challenges of integrating the register to an existing EDR system. One being that it requires consistent use of the same EDR system on a national level. In Norway, per 2022, Opus Dental is used by most dental clinics. With other EDR systems such as Dentrix Ascend and Dentimax being used in a few clinics. Additionally, gaining access to implementing this integration could be difficult, and one might need selling points to the selected system arguing the integration. The expert from our semi-structured interview, specifies the disadvantage of gaining knowledge of the implants from suppliers, as the information they provide is financially motivated. If an integration of the register where to take place, this factor must also be considered. The journal systems do not sell implants, but may have other financial gains from the register, which could affect the outcome of the register.

A middle ground between a full integration and an isolated register, could be to implement a separate register, but with integration towards journal systems to collect data, which would need to be based in standardized APIs. This would reduce the degree of impact of financial motivations from the journal system supplier. Additionally it would ensure correctness of data and that the data is updated. This solution is probably more realistic than fully integrating the system, and solves some of the disadvantages of the isolated register. However, this solution also requires cooperation with journal system suppliers, which is a decisive factor for this issue.

6.2 Reflection Over Tools and Frameworks

The tools used for developing the artifact is described in section 4.1. We stuck to the same tools through the project, but some of them had drawbacks, or were not used to their full potential. Following is a reflection on the most essential tools:

6.2.1 Marvel

The artifact is made in Marvel, which is not for creating a fully working system, but a prototype which can give an indication of how the final system should be. The limitations of using marvel for designing and playing the walkthrough compared to a functional application is as follows:

1. In marvel one can not type in input fields, check radio buttons, or select drop down options. This was part of the reason for why we did a separate evaluation of the data collection as presented in section 5.2.1. The results from the data collection evaluation substitutes for this limitation. However, if we could have them in the prototype we could possibly uncover more drawbacks.

2. All components of a marvel prototype are static, and independent of each other. This means that if one component changes in an image, one will have to implement the entire image with the changed component, instead of just updating the component. This is time consuming to implement, and therefore not all possible flows of the system has been implemented. When performing the evaluation, several buttons and links were therefore not clickable, as the interviewee did not need them to perform the tasks she was asked to. If these had been implemented, we could have had the chance to create more complex tasks, and reveal more drawbacks of the system.

There are several tools such as Marvel, which offers more or less the same functionality. Some of these are more complex, and have the possibility to for instance make interactive form component and animations. However, since Marvel has limited functionality, it is easier to get familiar with, and less complex. When choosing which tool to use for prototyping, I was already familiar with Marvel, which played an important role in the choice. We carried out valuable evaluations using the prototype made in Marvel, but they might have brought even more value with extended functionality. But with the time frame of the project, and the fact that the artifact is the first prototype, I would consider Marvel sufficient.

6.2.2 Trello

Trello was used to keep track of the tasks during the development, and section them based on their progression status. This worked well, but the use of Trello could have been extended to the entire team including the focus group. This would help the team work together, and keep track of the progression.

6.3 Improvements Based on the Open Clinica Prototype

As presented in section 2.5.1, feedback from the evaluation of the Open Clinica prototype was central during the development of the new prototype. The following actions were taken to ensure the new prototype would be improved on some of the reported shortcomings:

The system gathers more information than needed which is inconvenient and time consuming

To ensure no unnecessary data is collected, evaluations have been conducted continuously. During these evaluations the focus group of experts have reevaluated the data collection multiple times, and looked into the need of every data field that is being collected. In addition to the evaluation with the focus group, the evaluation of the final artifact was conducted with an expert who could see the artifact from a new perspective. During the final evaluation the expert did not report any unnecessary collected data.

Open Clinica has poor form structure, regarding poor order and duplicated fields

Also the form structure was discussed continuously with the focus group. The order of the fields was reevaluated based on the experience of the experts and their thoughts of how the order would come most natural. Duplication of fields has been discussed a lot, as this is an major pain point for the clinicians which is time consuming and unnecessary. To avoid duplication, we have divided the form into three sub sections. These sections represents a patient, an operation and an implant. The division causes the need of some more clicks to complete the forms, but the focus group saw this as more efficient than causing duplication.

These were the shortcomings that were mainly focused on during the development of this projects prototype. The other listed shortcomings in section 2.5.1 were not focused directly on.

Chapter 7

Conclusion and Further Work

This thesis presents a prototype for the data registration module for a dental implant quality register. The prototype aims to function as a boundary object to support the development of the register. Further potential use of the prototype includes guiding the implementation process of the final register, and to be used as a tool for communication between the instances involved in the process. A summary of the design science process is presented in this section, as well as a suggestion to further research regarding the use of the prototype in the coming process of the implementation of a dental implant quality register.

7.1 Conclusion

By following the design science methodology we have designed and evaluated a prototype, used as a boundary object, to solve relevant problems related to the development process of a dental implant quality register. The prototype presents a suggestion for the data collection module of a dental implant quality register. In addition to this suggestion, the prototype is a boundary object which works as a tool for communication between stakeholders, for collecting user feedback, improve user experience, and provide understanding of the domain. The design choices were made based on existing theory to develop a solution to a defined problem, as described by Peffers et al. [17].

The process uncovered valuable information about the use of prototypes as boundary objects in the development of a dental implant quality register. Through the use of the boundary object, we defined a suggestion for a data collection in collaboration with experts in dental implants and dental health.

7.2 Further Work

The prototype presented in this thesis has potential for improvement that has been uncovered through the conducted evaluation procedure. The scope of the prototype only includes the data registration module, and does not take error handling or security into account. These are important requirements in any data registration module, and should ideally be implemented and evaluated before the implementation of the final application.

Furthermore, several features has been suggested through the process, and should be taken into consideration during further development. Some of them are essential in a quality register, while some would be beneficial for user experience and facilitate for efficient work for clinicians. Following are some of the functionality that has been suggested:

- Send consent forms to patients, and for the patients to fill in and send them back.
- Gather patient-reported outcome measures (PROM) [58].
- Collect feedback from patients after implant insertions and removals.
- Provide more interaction in the patients' tooth diagram, like drag-and-drop components for adding diagnoses.
- Generate structured data for statistics and research.

The gathering of PROM includes data regarding how the patients experienced the treatment and the following time. This could also include a yearly patient report to ensure that any late effects of the treatment is registered. In the recommendations for the inclusion of PROM in clinical quality registries, Ruseckaite et al. highlights the importance of PROM. In connection with the study, a total of 62 statements of recommendations were identified and these could be used as guidelines for the implementation of PROM.

During the semi-structured interview, the interviewee provided feedback concerning the data values that are being registered. This feedback should be taken into consideration, and a suggestion would be to present the feedback to a focus group again. However, the implementation of an actual application could also be done simultaneously with the further planning of the data structure. The implementation could use the prototype as a starting point, and through agile development improve the suggestion from the prototype.

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Appendix A

Answers from semi-structured interview

Regarding the interviewees experience and opinions about the need of a dental implant quality register

Q1: What is your experience with dental implants?

I inserted my first implant third of may in 2002, and have inserted them for about twenty years. I insert approximately 500-600 implants yearly. I also lead the education of dentist students, where I hold lectures about dental implants. I also hold lectures for dentists in Norway, and the suppliers of dental implants. I use three different implant systems regularly.

Q2: How do you select which implants to use?

We have three different types which are mainly used in Norway. The prosthetist usually chooses which implant to use, and some prosthetist only use implants from one specified supplier. Patients are often referred to me without a specific implant to be inserted, and in these cases I choose the implant myself.

Q3: Where do you get information about which implants to use?

The implant I choose is based on my own experience. The implants from the different suppliers have different characteristics such as width and length. I think the most important factor when selecting an implant is what prosthetic construction will be put on top of the implant, and that is often what I base my choice of implant on.

Q4: What is your opinion on access to information about the quality of implants?

There is a lack of access to this information. The suppliers have statistics of how much they sell. Here (at the Department of Clinical Dentistry) we carry out research about the results of implant insertions over sprints of five years, but we do not keep statistics of these results. The suppliers have life time guarantee of the implants, which means that if an implant falls out, the clinic will get a new one for free. The suppliers then have information about how many of their own implants have fallen out, but this information is not accessible for clinicians.

The interviewee also adds that she knows of the register for hip joint prosthesis, and highlights the importance of seeing trends over time, and compare the different suppliers.

Q5: What knowledge do you generally have about quality registers?

I would say I have good knowledge of quality registers, and have been working closely with orthopedic surgeons who have been working with quality registers over 25 years. When I started working in the field in 2002, we wrote a form for every implant insertion, which were supposed to contribute to a quality register. But these were sent to the hospital without being transcribed and collected in one joint database. It ended up with the papers piling up and eventually being shredded.

Q6: What is your opinion on having a dental implant quality register?

I think it is important. It is interesting research as there is little information except the one that comes from the suppliers. The information from suppliers can not necessarily be trusted as they want to sell their implants and have economical intentions. An insertion of an implant makes a major impact on the patients life, and one should therefore have reliable research that supports the choices one makes. A register forces clinicians to do a good job, and report their results.

Regarding design

These questions were asked after the walk through of the prototype, so that the interviewee had gotten familiar with the design.

Q7: Do you think the screens are clear?

Yes, they were all clear and easy to understand.

Q8: Did you, at any point, feel you were prompted with too much information in one screen?

No, I found the screens fine.

Q9: Do you think the buttons and input fields were clearly presented?

Yes.

Q10: What do you think about the division of the forms for operations and implants?

That's fine with me, but the fewer clicks and the fewer pages make it more user-friendly.

Q11: What do you think about the division of each form, where all the forms are divided into sections?

Same as the previous answer.

Q12: What do you think about this being registered in a separate system compared to having it integrated in e.g. opus dental?

Everything that can be integrated is good, the fewer logins and user codes one must keep in mind, the better. But, it is important that the data gets where it needs to go, preferably free of charge.

Regarding the value of the register

Q13: Do you see any value of having access to the patient history that is registered in the insertion form?

I would like access to the cause of tooth loss, medical history, medication use and if the patient is smoking.

Q14: Have you previously experienced lack of information that can be found here?

Not sure what is meant by this, but in a registry, all such data will be important. The more specific one can be, the easier it can be to see connections.

Q15: Do you see any value of using a quality register for dental implants?

Yes, of course! This makes it possible to see if one type of implant performs worse than others, and can be taken off the market earlier. In addition, one can

get a lot of data about the patients, cause of tooth loss, duration of implant, whether there is a difference in operator, whether smoking, medication affects the course and more.

Q16: What are your expectations for a quality register for dental implants?

I hope it can be as good as the hip prosthesis register, where we can get a lot of good research, preferably more PhD candidates and new knowledge.

Q17: How does the register fit your everyday work?

As long as it is easily accessible, it quickly becomes a habit to use.

Q18: What integrations do you think could be useful: What information do you think the system can obtain automatically, and what else would you like the system to do automatically?

Tooth number, otherwise I have too little knowledge of what is possible already.

Q19: Are there any variables that are registered that you think provide little value to include?

The reason for extraction and the cause of tooth loss is a little butter on the pork, except for agenesis. But I would like to know when tooth loss and chorus long between loss and insertion.

Q20: Are there any variables we do not register that you think would be valuable to include?

Yes, whether it is 1 or 2 step operation, ie with healing distance or cover screw, and if so when distance operation?