Implementing a usable web-based interface for databases to improve the efficiency of interacting with them

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Abstract

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Currently, there is a large amount of data stored in databases used by companies and organizations. Usability of databases as a key factor motivates research on Human Computer Interaction (HCI). Interaction with computers can be challenging and HCI has been used to improve the communication between users and computers [1].

Databases may include a huge amount of data while only a part of the data may be needed for users. If the data can be understood and interpreted well, and is easily accessible in a suitable format, then people can better utilize that in their work.

Professional users may be able to specify appropriate queries using Standard Query Languages, such as SQL or XQuery, to filter out desired aspects from a database. However, it is not an effective way for users who are not familiar with the database schema and the query languages. In terms of HCI, a well-designed interface can make the interaction with databases much easier and more effective. The designer of the interface should create one or more forms based on making an educated guess of users' behavior and the needed data for them. In addition, the designer should think about how to convert forms into a DBMS (DataBase Management System) query [1].

During the thesis, a review is initially done on what HCI and interaction design is and how it can be achieved. A case study is defined at Sandvik Coromant in order to help us understand the theory and how a usable interface for databases can be implemented to improve the efficiency of interacting with them.

There is a database at Sandvik Coromant which is including information about some materials and is used by expert users. An interface, implemented using Microsoft Access, is currently utilized to access and interact with the database. However, the users need some new requirements which can be addressed with designing a new interface. During the project, an investigation is done on the database, the current interface and its pros and cons. Then, an interface design methodology is selected based on the related theory. Some technical methods are chosen to implement the desired interface for the case study. Finally, two methods of interface evaluation are applied to see how the users evaluate the new interface.

Throughout the document, it is stated in detail how the investigation about the database and the current interface is done. It is also explained how the design methodology is selected and implemented. Finally, it is stated that how the new interface is evaluated.
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1. Introduction

Data is a piece of information in a form that computers can process. Data is measured and analyzed.

Nowadays, data is playing an important role in the different parts of modern society. They are very important and critical for decision making in companies and organizations. Data-driven product development are becoming more common in developing industrial goods. Therefore, utilizing the data stored in databases can be useful and at the same time challenging for users.

Sometimes only a part of data in databases may be needed for users not all the data. Some users of the data may be able to filter out desired data with specific queries using Standard Query Languages, such as SQL or XQuery. However, not all the users are familiar with the database schema and the query languages.

On the other hand, the data cannot sometimes be utilized in its original form. In other words, some data cannot be interpreted easily by human. Therefore, it is crucial to find a way to show the interpretation of the data in a good way and accessible in a suitable format.

Therefore, the need of usable databases gives the motivation for research on Human Computer Interaction (HCI). HCI is used to improve the communication between users and computers and a well-designed interface can make the interaction with databases much easier and more effective. The designer of the interface should create one or more forms based on making an educated guess of users’ behavior and the needed data for them. In addition, the designer should think about how to convert forms into a DBMS (DataBase Management System) query [1].

The purpose of the project is to review on what HCI and interaction design is and how it can be achieved. Then a case study is defined at Sandvik Coromant to investigate how a highly usable interface can be designed for domain experts of a database. The interface should make available the most commonly used features of the dataset in an effective manner. If possible, the interface should be accessible from a network-compatible smartphone device.

Sandvik Coromant is a Swedish company which provide machining solutions for manufacturing companies around the world. At Sandvik Coromant R&D, new materials are continuously developed. Each material consists of different elements in different proportions which results in different material properties. To be able to systematically understand material properties, the data is stored in a database and is used by expert users. This database gives the users at Sandvik Coromant the possibility to find a material or utilize it to develop a new material grade.

An interface, implemented using Microsoft Access, is currently utilized to help the users to access their favorite data without any knowledge of the database schema or SQL queries. However, there are some barriers and challenges in the current interface which prevent the users to work with the data efficiently. In addition, the users need some new requirements which can be addressed with designing a new interface. During the project, an investigation is done on the database, the current interface and its pros and cons. Then, an interface design methodology called user-centered design is selected based on the related theory. Then, a method based on the MoSCoW rules is applied to categorize and prioritize the requirements. Some technical methods are chosen to implement the desired interface for the case study. Finally, two methods of interface evaluation are applied to see how the users evaluate the new interface. The first
method is to distribute a questionnaire among the users to evaluate the new interface. The second method is defining few task activities as scenarios for two users.

Throughout the document, a review on HCI is done. Then, the case study is explained in detail. It is stated in detail how the investigation about the database and the current interface is done. It is also explained how the design methodology to design the new interface is selected, how the requirements are categorized and how prototypes and the final interface is implemented. The technical methods are also described in detail. Finally, it is stated that how the new interface is evaluated in detail and what the result of the evaluation and the users’ feedback is. In future work section, it is also stated what more can be implemented to improve the usability of the new interface.

There are some limitations in the project. One limitation is that only one case study could be defined to help us find how a highly usable interface can be designed. This happens because of the short time which is assigned to the project.

The second limitation is that the case study is based on designing an interface for only one database and for a few expert users. On the other hand, since they are experts and their requirements are specific, finding and fulfilling the requirements and demands are challenging. In addition, since the time is not enough, all the requirements cannot be fulfilled. Therefore, the requirements are categorized to make the prioritization easier.

The third limitation is that there is a preference on using technical methods such as programming languages and frameworks.

In addition, due to time limitation, the new interface is used by the users for a short time before evaluation and giving feedback. If they were given longer time to use it, they might provide more suggestions and feedback.
2. Related theory

2.1 Interaction Design

Interaction design means creating user interfaces which improve the way people communicate or interact. Interaction design does not mean there is a specific way to design an interface, but it promotes to utilize related methods, technologies, concepts, techniques and frameworks while taking into account the time and context [2]. Interaction design can be used for various products or systems. It can be about designing software, websites, games, mobile phones, tablets and laptops [3].

Interface designers should know who the users of the interface are, how they act or react to events, how they behave, what they expect and what technologies are available to enable the design of an effective user experience. Since the designers are seldom experts in the field of the users, the area of interaction design is a multidisciplinary field. To do the design, it is always good to get feedback from an expert user. The users may also have different ideas about special cases [2].

2.1.1 The fundamental activities for interaction design

In order to design an interface, there are four basic steps; including requirement investigation, designing alternative options, prototyping and evaluation; that should be considered and done in a cycle as shown in Figure 1 [2]:

Fulfilment of all necessary requirements demands an iterative approach, where a trial solution is evaluated and improved in the next step. For example, receiving feedback with measuring the usability may lead to certain changes or help find requirements which have not been met [2, 3].

This design approach is called user-centered design which means the demands and goals of the end users are taken into account. This type of design methodology analyzes the user’s typical tasks, creates a design, produces a prototype and tests its usability. In other words, user-centered design is thinking about what users need rather than what the system can do and involving people in the design process [3].
In a user-centered approach, evaluation of the design is central and should be done during the work to ensure that the interface is appropriate and effective. This goal can be approached by interviewing the users, modeling their behavior and even including them in the design work [2].

Gould and Lewis, who are pioneers in interface design, state three principles to design an interface [3]:

1. A good understanding of who the users are, what they are going to do with the interface and asking them to be a part of the design team or consultants.
2. Observing the users’ reactions and behavior in the early development process.
3. Amending the issues found during the test process. The iteration of design, test and measure is repeated until the requirements are fulfilled.

2.1.2 Identifying Requirements

The first step to enable designers to evaluate their work is to understand requirements. Some of the requirements may not be clear in the early stage of the design and they are discovered later.

There are some techniques to discover the requirements such as interviews, questionnaires, observing people and recording their behavior during interaction with an interface. After that, the requirements should be reviewed and modified with the help of the users of the interface. Finally, the requirements should be classified and prioritized. One way of prioritizing requirements is using the “MoSCoW rules” which classify them into:

- **Must have**: The minimum requirements such that the interface is useless without them.
- **Should have**: The requirements which are necessary if there is enough time to be fulfilled. However, the interface is still useful without them.
- **Could have**: They are less important and can easily be moved to the next phase of the development.
- **Want to have, but will not get**: The requirements which are wanted, but not met in this round. They can be fulfilled in a later development [3].

However, the method offers no way to compare the requirements with each other and how to categorize them.

2.1.3 Usability

A usable system can be defined by several items. One of them is efficiency in that doing things in the system using a reasonable amount of effort is possible. To be safe to operate in various contexts is the second thing that can lead to a usable interface. In addition, a usable interface should be easy for people to learn how to operate it. It has also high utility such that it does the operations that people want to get done. Furthermore, a usable interface is easy to remember how to work with even if people use it from time to time [2, 3].

A user-centered design mentioned in 2.1.1, in which evaluation is central, is needed to achieve a usable interface. There is a framework in user-centered design called PACT (People, Activities, Contexts, Technologies) for designing interactive systems. One way to look at usability is achieving a balance between the four principle factors of PACT: People, Activities
which people define, Contexts in which the interaction takes place and Technologies (hardware and software). The PACT framework is shown in Figure 2.

![Figure 2. PACT Framework](image)

In other words, designers try to achieve the best combination of technologies to support the activities being defined by people in different contexts. However, since achieving a balance between the factors is difficult, designers must repeatedly evaluate different combinations to reach this balance [3].

**2.1.4 Designing websites**

One important interface to interact with the users is a website. Designers should know who is going to utilize the website and what is their aim for using it. Since the websites grow quickly due to discovering new demands from users, navigation of the users through the websites becomes a major issue. The web interface should enable people to learn the structure of the website easily and find their path to the part of the website where they are seeking for. In addition, it is important to show to users where they are in the website to help them to navigate further. It can be done by an appropriate web address on each page of the website, or by well-defined titles for each page. The website should also show a clear status to the users and give feedback about what is going on. Although one of the feedbacks may be showing errors to the users, the design should prevent the users to make any mistake. On the other hand, if users make a mistake working with the website, they should have a chance to leave the unwanted state easily, for example supporting undo and redo [4].

Another factor that should be considered is consistency in the whole website; for example, all the links should be shown in blue color and underlined.

Furthermore, designing the homepage in a website is very important and should include a directory, summary of the most important content in the website and a search facility. A search facility is very useful to users who prefer to find what they want instead of being guided [3].

One of the common types of a webpage is a web form and there are some guidelines to keep a web form interface simple in order to not distract users; for example: The labels should be
located close to each input type for better understanding. In addition, the size of input fields should match the expected answer from users.

On the other hand, if there is any input that can easily be mistyped, it is recommended to utilize checkboxes, radio buttons or drop-down menus to restrict the number of selections. Radio buttons are a good choice for up to four options. If more than four options are required, a drop-down menu should be used to save the screen space. The selectable options should be ordered in a meaningful sequence. For example, Monday, Tuesday, etc. for weekdays. However, if there is no other meaning for ordering them, they should be ordered alphabetically.

Another point in designing a web form interface is giving feedback to users. Error messages should explain to the users what the problem or mistake is and how it can be solved. In addition, when an error occurs, the other completed fields should not be cleared. Furthermore, The errors should be visible to users by using color, icons and text [5, 6].

2.1.5 Accessibility over different platforms

When designing websites, it should be considered to make the website accessible over different platforms in order to make it usable by as many people as possible who are using mobile devices or those with slow network connections. In the case of a web interface, it can be made accessible by using the correct HTML elements. In order to make an interface accessible for mobile devices, there are some points that should be considered. One of them is making interface controls, such as buttons, accessible on touch screens as well as desktops and laptops.

In addition, to make an interface accessible over mobile phones, users should be able to import their input in mobile version of an interface as easy as they can on laptops.

Furthermore, there is another concept called “responsive design” which means making the layouts and other features of applications change dynamically based on the screen size and the resolution. In other words, the interface design and layouts should be compatible with mobile devices, tablets, laptops and larger screens. Therefore, they will be usable and accessible to all users. One point that should be considered in this case is utilizing compatible layouts for mobile devices. A multi-column layout cannot be presented in mobile devices in the same way as wider screens. In addition, some context should be removed in mobile devices to prevent distraction. This can be done via a responsive layout using technologies like media queries or viewport. A media query is an important component in responsive design to query the resolution of a screen to adapt layouts based on the screens. Viewport is the user’s visible area of a web page which depends on the size of the screen.

Furthermore, since users usually scroll websites vertically on screens, a horizontal scroll may cause a poor user experience.

The size of images presented in a website is another thing that needs consideration. Smaller images should be prepared for mobile devices, since narrow screens do not need large images and they will probably be loading on slow network connections. On the other hand, since many mobile devices have high-resolution screens, images with higher resolution should be provided for them [7].
3. Case Study

In order to realize our understanding about HCI, interface usability and accessibility, and design techniques, one case study in Sandvik Coromant is defined.

3.1 Company

Sandvik Coromant is a Swedish company which has 8000 employees and is represented in 130 countries. Sandvik Coromant supplies tools, tooling solutions and services to the metal cutting industry. It is part of the business area Sandvik Machining Solutions which is within the global industrial group Sandvik [8].

3.2 Database

At Sandvik Coromant R&D, new materials are continuously developed. Each material consists of different elements in different proportions which results in different material properties. To be able to systematically understand material properties, the data is stored in a database. This database gives the users at Sandvik Coromant the possibility to find a material or utilize it to develop a new material grade.

3.3 Current interface

The users at Sandvik Coromant need to access the data stored in the database. In order to access to the database, there should be an interface to help the users to access their favorite data without any knowledge of the database schema or SQL queries. Currently, there is an interface, implemented using Microsoft Access, which the users utilize to interact with the database. The interface accesses to the database, allows the users to search for a material, shows the search results in a table, allows users to change the material components and shows the results in another table.

However, there are some barriers and challenges in the current interface which prevent the users at Sandvik Coromant to work with the data efficiently. On the other hand, there are some new requirements which can be addressed by implementation of a new interface. Therefore, implementation of a new interface based on the users’ preference is defined as a case study in this project.

3.4 Domain experts

The main users of the database and the interface include expert users from various parts of the Sandvik Coromant R&D organization who mainly use the database during material development to effectively design new material grades at Sandvik Coromant R&D in Västberga, Sweden.
4. Methods and techniques used

As it was mentioned, at Sandvik Coromant there is a database and an interface to get access to it. Initially in this project, an investigation was done on the database, the current interface and its pros and cons. After that, an interface design methodology was selected. Some technical methods were chosen to implement the desired interface for the case study. Finally, two methods of interface evaluation were applied.

4.1 Investigation of the existing solution

In order to be familiarized with the mentioned database, one of the database and interface experts who was a representative of all the expert users was interviewed. Several interviews with the user were held in different phases of the project.

4.1.1 Investigation of the database

There were two interviews with the expert user to explain the goal of the database, which tables would be going to be used for the project and how the database was set up. One of the meetings was held at Sandvik Coromant in Sandviken about one hour and the second one was held at Sandvik Coromant in Västberga about one and a half hour.

4.1.2 Investigation of the available back-end functionalities in existing solution

Firstly, one interview was held at Sandvik Coromant in Sandviken with the interviewed expert to go through the back-end functionalities and their outcome in the current interface. The user showed the functionalities and talked about what functionalities could be implemented in the back-end part of the project. After the first meeting, the implementation was started and two more meetings were planned with the same user, one at Sandvik Coromant in Sandviken and one in Västberga, to go through back-end functionalities in more detail. In addition, some of the simpler issues were discussed by means of emails.

4.1.3 Investigation of the user’s opinions about the current interface

During the first interview with the user at Sandvik Coromant in Sandviken, the user was also asked to talk about what the users can do with the current interface, what they expect in the new interface, what concerns they have and what they see as issues in the current interface.

After the first meeting, one prototype of the expected interface was implemented. The prototype included the search part to enable the users to search a material in the database. During the second interview with the user, he was asked to search a material with the current and the new interface, to pick up the issues he found, to give feedback on how to improve this part and to compare the current and the new interface for the special task in searching a material. The user’s behavior was also observed to find the issues of both interfaces.
4.2 Interface design methodology

The design methodology used for the project was user-centered design, as mentioned in section 2.1.1. In addition, the method which was used for defining the requirements of the project was based on the MoSCoW rules as explained in section 2.1.2.

There were several meetings with one of the expert users during the work and his suggestions, feedbacks and requirements were seriously taken into consideration. During the first meeting, the user explained the goal of the database, the current interface and their requirements, for example: retrieving the data from the database and showing them as a table, implementation of the back-end functionalities and having a responsive web design. These requirements were considered as a “Must have” requirement in MoSCoW rules. After that, the initial implementation based on the recognized requirements was done. However, it did not fulfill all the requirements since the implementation was done incrementally during the project.

During the second interview with the user, he was asked to evaluate the new prototype. The user gave feedback on the backend functionalities, which was considered later for the next prototype. He also added search option for the data in the database as a new “Must have” requirement. Having flexible options to make an advanced search facility was considered as a “Should have” requirement. To define these requirements, the user was asked to participate in the designing of the interface via drawing a simple sketch. The new feedback and requirements were considered for the next prototype. The new prototype included the flexible search option and responsive web design.

During the third interview, the user was asked to work with the current interface to find the pros and cons of that. He was also asked to evaluate the new prototype by using it. This time, certain options in the search part were suggested to be modified as a “Should have” requirement. Another “Should have” requirement was that the interface would enable the users to save their modifications on the data into an excel file. After that, a new requirement came up as a “Want to have, but will not get” requirement which was about having a machine learning framework that would be applied on the new interface to analyze the data. Based on the new evaluation and the defined requirements during the meeting, the next prototype was implemented which included some tables to show the data of the database. The responsiveness of the design was considered again during the further prototyping.

During the fourth interview, the new prototype was presented to the expert users of the interface at Sandvik Coromant in Västberga. They gave their feedback on the new prototype and discussed about how the search part could be improved by adding some “Should have” requirements. The requirements included freezing the position of some data on the tables and make other data scrollable. They also added the requirement of having the interface in two languages, English and Swedish, as a “Could have” requirement. Their feedback, suggestions and the new requirements were considered for the next prototype.

During the fifth meeting, a technical developer was asked to check the general project from the technical point of view and the new prototype was uploaded to the server to enable testing it. Testing the prototype remotely from the server and also testing it on the mobile phone showed some issues about responsiveness. For example, the prototype was not compatible over different browsers. Another issue was that it was not practical on the mobile phones which was against the defined “Must have” requirements. The detected issues were considered and resolved.
During the sixth interview with the user, he evaluated the new prototype and came up with issues about the data presentation; for example: the number of decimals in floating numbers or the name of the columns in the tables. He also defined a new “Must have” requirement which was *enabling the users to change the proportions of a material to create a new material*. The user was asked to have a suggestion for fulfilling the requirement to be considered in the new prototype.

When the prototype fulfilled the “Must have” and some of the “Should have” requirements and it was tested, the user was asked to evaluate this and he worked with both PC and mobile versions of the new interface and he was satisfied. Then a formal evaluation by scenarios and questionnaires were prepared to do the final evaluation. The method for the final evaluation of the new interface is explained in section 4.4 in detail and the evaluation results are explained in section 5.4.

### 4.3 Technical methods

In order to satisfy the requirement of accessibility on different platforms, a web-based interface was implemented. Therefore, the implementation of the project was divided into client side and server side. The technical methods are using C# language, SQL, Javascript, HTML5, CSS3, Bootstrap framework, SPA (Single Page Application) concept, Ajax etc. which are explained in more detail below.

Since the considered database is on a server, getting access to the server and some operations on the server was done on the server side. The framework which was used in the project to implement the client and server sides was ASP.NET. C# was used as a back-end language on the server.

ASP.NET is an open source web application framework from Microsoft to build web applications and services with .NET. It provides developers to code in both server-side and client-side on Windows. To set up the communication between browser and server, ASP.NET works on top of the HTTP protocol. It creates websites and interactive, data-driven web applications based on HTML5, CSS3 and JavaScript and can scale to many users. It also includes a wide range of controls for designing the HTML pages [9].

On the other hand, the web interface and some other operations and calculations, which do not need the server, were done in the client side. The client side was implemented by HTML5, CSS3, Javascript, Ajax and bootstrap framework.

In order to keep the interface fast enough, the concept of Single Page Application (SPA) was used. SPA is an application that loads a single HTML page once, which means when a user is interacting the application, SPA dynamically updates the page instead of reloading the web page [10]. To achieve a SPA application, Ajax is utilized which is a web development technique to create richer web applications. In fact, it is a new name for existing technologies: the DOM, JavaScript and XMLHttpRequest. It helps developers to create dynamic websites and asynchronously communicate with servers. Some well-known companies such as Google Gmail utilize Ajax techniques to provide users with rich interfaces [11].

As mentioned before, the interface should be responsive which means a web page can adjust itself to look appropriately on all types of devices including desktops, tablets and phones. In
order to create a responsive and mobile-compatible web page, CSS3, HTML5 and Bootstrap framework were applied to resize, hide or show, shrink or enlarge, or move the content of elements in the web page in response to the device used to access the database [12].

Bootstrap is one of the most popular front-end frameworks which is produced by Mark Otto and Jakob Thornton at Twitter in August 2011 [13]. Bootstrap is an open source and free toolkit to develop responsive and mobile-compatible web pages using HTML, CSS and Javascript. Bootstrap provides web developers several useful elements by only adding a few CSS and Javascript plugins [14].

4.4 Evaluation methods

In order to evaluate the final improved interface and compare it with the current interface, two methods were applied: Questionnaire and Scenario.

4.4.1 Questionnaire

A tool called System Usability Scale (SUS) was utilized as a base with five answer options from strongly agree to strongly disagree [15]. SUS provides a reliable tool for measuring the usability created by John Brooke in 1986. SUS is a simple 10-item questionnaire. It has become an industry standard and can effectively differentiate between usable and unusable systems.

The questions in SUS are as follows:

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

The questions that were added to the SUS to customize it for our purpose are as follows:

11. I think the mobile version of the system is helpful.
12. I think there is no point in having a mobile version of the system.
13. I think the mobile version of the system has the same capabilities as the PC version.
14. I think the facilities in the mobile version is not as good as the PC version.
15. Compared to the current interface, the new interface is easier to use.
16. I prefer to use the current interface, because I find it easier to work.
17. I think the new interface is more consistent than the current interface.
18. I think the new interface is not as well-integrated as the current interface.

The final questionnaire which was used for the evaluation of the new interface can be seen in Appendix, Table 1.
In order to score the usability of a system using SUS, the following steps should be applied [15]:

- Values 1-5 are given to “Strongly Disagree”-“Strongly Agree” items respectively which are used as users’ responses.
- If the question number is odd, one is subtracted from the user response.
- If the question number is even, the user response is subtracted from 5.
- In SUS scoring, the scaled responses are added up and the total is multiplied by 2.5. However, since more customized questions are added to SUS and there are 18 questions, the total should be multiplied by 1.39.

This process converts the range of user responses from 0 to 100. There are several ways to interpret the obtained SUS score. Three of the interpretations are shown in Figure 3 [16].

4.4.2 Scenario

In order to evaluate and improve the interface for the future, in addition to the questionnaire, a few task activities were also considered as scenarios. Two of the database users were asked to participate in performing the activities. These activities were divided into smaller parts as follows:

- Search your favorite material in the database
- Try to manipulate the available data
- Try to delete one of the materials and do the search again

The participants were asked to do these activities one by one. They were told there was not any pressure for time or doing the activities properly. A diagram of the scenario is shown in Figure 4:
5. Results

5.1 Results on investigation of the existing solution

5.1.1 Results on investigation of the database

The result of the interview with the database expert shows that the database is on the server of Sandvik Coromant’s domain and is set up by Microsoft Access. The database is used during material development to effectively design new material grades at Sandvik Coromant R&D organization. Understanding their goals of having the database and the interface helps to find a better design to achieve their goals more easily.

5.1.2 Results on investigation of the available back-end functionalities in existing solution

The interview about the back-end functionalities led to a better understanding of the functionality implementation. There are a lot of mathematical calculations implemented in VBA (Visual Basic for Applications) and the results of the calculations are shown to the users by the current interface.

Investigation in this area showed that the existing back-end implementations should be reimplemented to make it more readable and easier for the experts to modify the source code if they need. Therefore, the source code was divided into smaller parts and reimplemented in JavaScript files.

In addition, the lack of source code documentation was also detected during the investigation and the implementation process. This issue was also resolved with writing comments on each function in the new implementation.

5.1.3 Results on investigation of the user’s opinions about the current interface

The investigation of the users’ feedback on the current interface led to the requirements in terms of utility, usability and accessibility over different platforms. Some of these requirements had already been implemented in the current interface. However, because of changing framework and programming languages, a reimplementaiton was required. Two of these requirements were:

- **Getting access to the database**: The first requirement, which can be considered as a utility requirement, is getting access to the database and creating appropriate SQL queries to achieve the users’ goals.

- **Search option in the database**: There is a requirement to give ability to users to search their desired materials in the database. This option is already available in the interface. However, it is not flexible enough to enable users to search based on different properties. In other words, the search option should give the users flexibility to know only approximate values for different elements, or other properties, not an exact value of them. This requirement can be counted in both terms of utility and usability.
Another result of this type of investigation is finding other requirements which had not already been taken into consideration in the current interface and caused major issues. These requirements are:

- **Easy-to-use interface**: The current interface is not usable and easy-to-use enough. It is complicated to find what options are available in the current interface and the goals of the users are not centered. The requirement is having a usable interface which enables them to look at the data in the database and manipulate the data. The interface should be simple, easy to work with and should help the users to find what they need.

- **Accessible interface over different platforms**: One requirement is having a web-based user interface, which also brings the second requirement, namely responsiveness. In other words, the interface should be smartphone-compatible since using smartphones is more comfortable and accessible than personal computers. This facility enables the users to utilize the database and the interface everywhere they prefer.

### 5.2 Results on using the selected design methodology

Since the goals of the users was in the center of focus and due to the user-centered design and MoSCoW rules, several meetings and interviews were held with the users. The selection of control options in the page was done based on the web design guidelines in [5, 6] and with the consideration of users’ preferences. Meetings and discussions with the users continued throughout the development from the start to the end of the project and their feedback and suggestions were seriously taken into account. They were sometimes asked to schematically design their desired interface with a simple drawing.

In addition, the good result of using MoSCoW rules during the design was that the users’ requirements could be defined and prioritized better. We could categorize the requirements into “Must have”, “Should have”, “Could have” and “Want to have, but will not get” and since the time was limited and there were many requirements, the method helped to get a better result in a specified time. Although the requirements of the project based on MoSCoW rules were mentioned before, it is worth mentioning a summary of the requirements as one of the results of using the MoSCoW and user-centered design. It comes as follows:

- Some of the “Must have” requirements are retrieving the data from the database, having a search facility, having mathematical functionalities in the background, having a facility to change the proportions of a material to create a new material, having a web-based and responsive interface to be compatible on mobile phones.
- Some of the “Should have” requirements are having a flexible and advanced search facility, ability to save the changes which are made by the users into an excel file, and freezing the position of some data on the tables and make other data scrollable.
- One of the “Could have” requirements is having the interface in two languages, English and Swedish.
- One of the “Want to have, but will not get” requirements is having a machine learning framework that can be applied on the new interface to analyze the data.
5.3 Final results on using technical methods

The result of using the technical methods mentioned in 4.3 are shown in Figure 5 to Figure 10. It is worth mentioning since the data in the database are confidential, the names and the content of the tables are not real.

First, the search facility is shown to the users which gives them flexibility to search based on different options. They can also combine their options with the logical operators AND and OR. They can also give a range for the option that they choose. This part was implemented in HTML5 and CSS3. In order to have a responsive design, Bootstrap was used to divide the page as a grid of 12 columns. To show the interface in any web browser, there are attributes in CSS that should be set. There is also the button “Search Part” as it is shown in Figure 5 such that the users can see or hide the search area based on their preference. This option could be reached by “collapse” class available in Bootstrap to indicate a collapsible element.

Figure 5 is the interface that can be displayed in any web browser in laptops or PCs.

![New Interface](image)

*Figure 5. Search Part - The PC version*

The mobile version of the search facility is working on iPhone and it looks like Figure 6. Here, the power of Bootstrap to make a responsive web design can be seen. The resolution of the device is queried in CSS and then based on the resolution, one of the designs in Figure 5 or Figure 6 is shown to the users.

A sample of the search result is shown in Figure 7 for any browsers in laptops and PCs. This part was implemented by Ajax which helps to have a SPA and makes the loading process fast. In other words, there is a method implemented in Javascript which gets the options for searching from the HTML file and sends a message to the server-side application via Ajax technology. The server-side application which was implemented in C# is connected to the database, retrieves the requested data and sends the search result back to the user. After that, the Javascript file receives the result and shows or updates the search table. Ajax technology updates the search table without reloading other parts of the webpage.
A sample of the mobile version of the search result is shown in Figure 8. The table is scrollable on iPhone.
When the users click to add one or more materials, they are added to the main tables, “Table 1” and “Table 2”. “Table 1” is a table including the selected materials from the search result and enables the users to manipulate the data. When the users manipulate the data in “Table 1” and press the corresponding “Update” button in “Table 2”, the data in “Table 2” are updated. In other words, “Table 2” has many functionalities which are working in the background. These functions were implemented in Javascript and calculate values for each column of the tables. The functions should have been implemented in the server-side application, from the security point of view. However, since the webpage is only accessed by the authorized users, these functions were implemented in the client-side in order to save time for the users.

The main tables for the laptop and PC versions are shown in Figure 9.
The mobile version of the main tables is shown in Figure 10.

![Figure 10. Main tables in the new interface - The mobile version](image)

5.4 Results on evaluation

The results of the evaluation are presented in the following sections, which includes the questionnaire results and the scenario analysis.

5.4.1 Results on the questionnaire

The users of the new interface were interviewed during the process of interface design. They discussed about their expectation and their ideas how to improve the current interface. The interface was evaluated several times during the process in meetings. Eventually, a final version was ready for evaluation. The users were asked to test the new interface for three weeks and then answer the questionnaire which is shown in Appendix, Table 1.

Nine users who are the domain experts at Sandvik Coromant R&D participated in the evaluation. They were told that if they felt they could not answer a specific question, they could choose “Neutral” among the options. After receiving the answers, they were scored with the SUS technique mentioned in 4.4.1.

The evaluation result for the usability of the new interface is 73.21 and based on the interpretations of SUS score which is shown in Figure 3, the obtained score for the usability evaluation of the new interface can be interpreted in three ways:

- Between “Good” and “Excellent” in “Adjective Ratings”
- “C” in “Grade Scale”
- “Acceptable” in “Acceptability Ranges”.

5.4.2 Results on the scenarios

As it is mentioned in section 4.4.2, two database users were asked to work with the current and the new interfaces.

First, the users were asked to work with the current interface and their behavior and process were observed during three tasks. It shows the following results:

The users were requested to search a material in the database. It showed that the limitation with the current interface is that they need to know arbitrary parameters of the material in order to be able to find it.

In addition, they were asked to manipulate the data and see the result. Although the functionality works, it takes time to do this task due to the interface.

Furthermore, the users were asked to delete one of the materials and search another material again. Although doing the process is slow, the functionality works.

On the other hand, the users were asked to work with the new interface and similarly, their behavior and process were observed during the three tasks. It shows the following results:

When they were asked to search a material in the database, they did the task faster than working with the current interface. In addition, they had flexibility to search a material based on more options. One point which was observed is that the users tried to input their search with “Enter” button on the keyboard instead of clicking the “search” button.

During the task of manipulation of the data, it was observed that they could do it fast. However, it was noticed that there were some useless columns in tables which users were not interested in.

One other point which will be fixed in the next phase is that the users were looking for a way to save the changes.

Furthermore, it was observed from the task of deleting and searching a material again that the users could do it quickly without any interruptions.
6. Analysis

Observing the users’ behavior in interaction with the current interface shows that the search facility is not flexible enough to enable the users to search a material based on various options. On the other hand, they have flexibility with the new interface to search a material based on more options. In addition, this flexibility in the search facility helps the users to do the process in the new interface faster than in the current interface.

Furthermore, the users could manipulate the data in the new interface faster than in the current interface. The reason is the design of the table columns and access to them in the current interface is not organized enough to allow the users to do the process quickly. In fact, the design of the current interface is a barrier for manipulating data and the problem has been solved in the new interface. However, it was noticed that there were some useless columns in tables which users were not interested in. Therefore, in the next phase, they should be removed to make the process even faster.

One point which was observed is that the users expected to input their search with the “Enter” button on the keyboard. Therefore, it should be amended later in the next phase. They can currently only do this with clicking the “search” button.

One other observation which will be fixed in the next phase is that there is no way to save the result or export it to a given file format to be stored in a local folder.
7. Conclusions

Nowadays, many companies are storing their data in databases to use it later. Users of the databases should be able to interact with the databases properly. One challenge is the users do not necessarily know the schema of the databases or do not know how to specify appropriate queries to retrieve their desired data from them. Therefore, the concept of HCI and a usable interface has become important and at the same time challenging.

In the project, a review was done on HCI, interaction design, its cyclic process, usability and accessibility concepts and how to design a web interface.

After doing a review on theoretical parts, a case study was defined at Sandvik Coromant to help us to find how a usable interface can be designed and implemented. The users of the interface are domain experts at Sandvik Coromant R&D, who currently utilize an interface to connect to a database and related functionality. However, the users had some new requirements such as having a usable web-based interface compatible with mobile phones.

In order to design a usable interface, user-centered design methodology was used and the users were interviewed about their requirements and expectations several times during the interface design. The defined requirements were categorized by MoSCoW rules for a better efficiency. The prototypes and the final version of the design were implemented by using C# language, SQL, Javascript, HTML5, CSS3, Bootstrap framework, SPA (Single Page Application) concept, Ajax etc.

Finally, the users evaluated the last version of the new interface via a questionnaire and scenarios.

The scenario tasks performed by the users showed that the users were comfortable and satisfied with the new user interface. However, some issues were noticed that were required to be amended at a later point.

The questionnaire, which is an extension of SUS, was distributed among the expert users to evaluate the new interface and the obtained score is 73.21 which can be interpreted as “Between Good and Excellent” in “Adjective ratings”, or “C” in “Grade Scale”, or “Acceptable” in “Acceptability Ranges”.
8. Future work

As it was mentioned before, there is a “Should have” requirement which is a facility in the interface to save the changes made by the users into an excel file. This facility can avoid repetition work by the users and save their time. Since the time is not enough to do it currently, it is considered as a future work.

Since the users of the new interface are not only Swedish people, the new interface is in English. However, making the interface in two languages, English and Swedish, is a “Could have” requirement which can be done in future.

Applying a machine learning framework on the data in the new interface is a “Want to have, but will not get” requirement which can be done in the future. This framework may help the users to analyze the data better.

The new interface was used by the users for a short time before evaluation and they also provided feedback on that. If they are given longer time to use it, they may provide more suggestions and feedback. Therefore, conducting the second survey after six months is considered as a future work. Based on that, more requirements or adjustments will be defined and done.

Currently, the data are only represented by tables. The visualization of the data can be improved by supplementary graphs. Graphs can represent an immense amount of data in a way which helps the users to have a better interpretation of data. Therefore, the visualization of the data by graphs can be done as a future work.

In the implemented interface, there is no option to customize it for the users. Giving the possibility to them to create their own account helps them to personalize it and save their changes in the interface for the future access. Therefore, this option can be considered as a future work.
References


Table 1. The used questionnaire for the evaluation of the new interface.

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I think that I would like to use the new system frequently.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. I found the new system unnecessarily complex.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. I thought the new system was easy to use.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. I think that I would need the support of a technical person to be able to use the new system.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. I found the various functions in the new system were well integrated.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. I thought there was too much inconsistency in the new system.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. I would imagine that most people would learn to use the new system very quickly.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. I found the new system very cumbersome to use.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. I felt very confident using the new system.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. I needed to learn a lot of things before I could get going with the new system.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. I think the mobile version of the new system is helpful.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. I think there is no point in having a mobile version of the new system.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. I think the mobile version of the new system has the same capabilities as the PC version.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. I think the facilities in the mobile version is not as good as the PC version.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. Compared to the current system, the new system is easier to use.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. I prefer to use the current system, because I find it easier to work.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. I think the new system is more consistent than the current system.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. I think the new system is not as well-integrated as the current system.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>