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TopQ - a web-based queuing application

A case study in developing a queuing application for students and tutors with focus on navigability and design

TopQ - en webbaserad köapplikation

En fallstudie i utvecklingen av en köapplikation för studenter och handledare med fokus på navigering och design

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Abstract

Students' learning processes can be affected negatively by long waiting times to get assistance on lesson- and lab-sessions. Studies show that digital queuing systems decrease the waiting time. Thus, the purpose of this report is to investigate how to design a web-based queuing application to achieve a high perceived usability for students and tutors. Especially based on navigability and design which in accordance with research in the area has a direct impact on the usability. To achieve a high perceived usability the application was developed iteratively. In the first version the implemented functionality was built upon the result from the feasibility study combined with research in the area. After a set of user evaluations, changes from the first version were implemented to further improve the perceived usability. Lastly, another set of evaluations were performed to confirm the improvement in the final version. The results showed that the first version of the system was perceived as 84 out of 100 on the System Usability Scale (SUS) and the final version as 88 out of 100, an improvement by four units. Uniform design, no irrelevant functionality, placing buttons in conspicuous positions and having double checks to "dangerous actions" all seem to be factors contributing to the navigability, desirability and thus the usability on a queuing-application.

Sammanfattning

Studenters lärandeprocess kan påverkas negativt av långa väntetider för att få hjälp under lektions- och laborationspass. Studier visar att digitala kösystem reducerar väntetiden. Följaktligen är syftet med arbetet att undersöka hur en webb-baserad köapplikation kan designas för att uppnå en hög upplevd användbarhet hos studenter och handledare. Speciellt med avseende på navigerbarhet och design vilket enligt tidigare forskning har en direkt påverkan på användbarheten. För att uppnå en hög upplevd användbarhet utvecklades applikationen iterativt. I den första versionen implementerades funktionalitet som byggde på resultatet från förstudien i kombination med tidigare forskning. Efter användartester implementerades ändringar från den första versionen för att ytterlige förbättra användbarheten. Slutligen genomfördes ytterligare användartester för att bekräfta förbättringen i den slutgiltiga versionen. Resultatet visade att den första versionen av systemet uppfattades som 84 av 100 på systemanvändbarhetsskalan SUS och den slutgiltiga som 88 av 100, en förbättring med fyra enheter. Enhetlig design, ingen irrelevant funktionalitet, placering av knappar i iögonfallande positioner och att ha kontroller vid "farliga klick" verkar alla vara faktorer som bidrar till navigerbarheten, åtråvärdheten och där med användbarheten för en kö-applikation.

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1 | Introduction

The use of technology and digital tools for educational purposes is increasing, in particular, due to the spread of the coronavirus and the closure of schools. As a result, it has become clear that there is a lack of adequate, technical solutions for many educational purposes, such as a well-functioning way to receive help from teachers and tutors. This study aims to investigate how to design a web-based application to be used for that purpose.

1.1 Motivation

The ability and willingness to adapt to the rapid development and use of technology in education is a key for schools to deliver high-quality education in the 21st century. In particular, this has become clear during the outbreak of the coronavirus. The United Nations Educational, Scientific and Cultural Organization (UNESCO) reports that more than a hundred countries worldwide have closed all schools as part of the attempt to prevent the spread of the virus, affecting more than half of the world's student population [1]. Due to limitations in digital skills, the need to educate online increases the pressure on both students and teachers [1], [2]. This indicates a need for digital tools used for educational purposes that are easy and straightforward to use and navigate.

When the classrooms are online, the teachers and tutors need a simple and efficient way to keep track of everyone who needs help and interaction, and which of them to deal with first, some kind of queuing system. A marketing plan was developed during the feasibility study (Appendix A). The analyses indicate a great need for a straightforward and easy-to-use queuing application to reduce the waste of valuable time that should be spent on learning instead. Sajadee's study at Linköpings University shows that the use of a digital queuing system reduces the waiting time for assistance in physical classrooms as well [3]. This indicates that there will be a need for this system even after the reopening of schools.

In a survey made among students and tutors during the pre-study for this project, 90.5% of the respondents stated that they were interested in a better queuing application for lessons and lab sessions (Appendix B). On average, the respondents answered that their overall experience of the current systems used for the same purpose, on a scale from 1 to 5, was 3.4. A study done at the Eszterhazy Karoly University in Hungary showed that technical issues due to the wide variety of platforms and tools that are used in different courses could be a factor affecting students learning experience negatively [4]. This is also confirmed in our survey, where 87.2% of the respondents stated that having one single application for this purpose in all their courses would facilitate their learning experience.

Based on the reasoning above, it is therefore investigated how to design a web-based queuing application, designed for use in both lab- and tutor sessions, to be navigable and desirable to deliver good usability.

1.2 Aim

The project's purpose is to investigate how a web-based queuing application can be designed to deliver good usability, primarily based on the factors design and navigability. The web-based queuing applications aim to be used for lab and tutor sessions in schools and universities to meet the increasing need.

1.3 Research Question

How can a web-based queuing application for lab and tutor sessions be designed to be both navigable and desirable in order to deliver good usability for students and tutors?

1.4 Delimitations

Since the primary focus group for the research question is students and tutors in Sweden, especially those enrolled at universities, the limitations have been done to these specific groups. Consequently, all surveys reported in this project have been conducted and limited to the focus group. In addition, the web-based queuing application will not be available to the public during the development, only to the developers and selected test subjects.

Regarding the term "user" the report mainly refers to the focus group with students and tutors. Note, however, that the literature used in the project often refers to the word user and, in these cases, the term's primary meaning.

2 | Theory

In the section below, the underlying theory will be introduced, which is the basis for the development of the web-based queuing application. Initially, the theory of usability is presented with a focus on website usability, and the impact design and navigability have on usability. Furthermore, the theory of navigability is presented with factors that make a website navigable. The section continues with the theory of desirability, where relevant factors such as logo design, color usage, and graphics to text ratio are further described. Finally, the theory related to methodology is discussed where the focus is on user-oriented development and Usability Evaluation Methods (UEM).

2.1 Usability

This chapter introduces the theory related to usability and explains the concepts of Web site usability and user experience.

2.1.1 Definition

According to the International Organization for Standardization, usability has been defined by the standard ISO 9241-210:2010 as the *"extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use"* [5]. Thus, the term assesses how easy a user interface is to use in terms of performance and satisfaction. In addition, ISO states that usability is relevant when designing or evaluating interactions with, for example, services for development [5].

2.1.2 Website Usability

Nowadays, a huge number of websites are available where the interface and usability play a significant role in the user's acceptance of the site [6]. According to Palmer, websites need to consider usability in order to be successful and satisfy the users [7]. Furthermore, studies have shown that a usable website increases revisit rates while creating a positive attitude towards the site among the users [8]. If a delay occurs when a user clicks on a hyperlink, the home page lacks sufficient information, or if the website is challenging to use in general, the user will likely leave the page [8]. The attention currently paid to usability indicates the importance of using usability methods during the development process. Moreover, these methods have been shown to reduce costs as they reduce the need for changes after the web application has been delivered [9]. Thus, the importance of website usability is apparent.

To provide a better understanding of usability and its effect on websites, Quesenbery divides usability into five specific dimensions presented in Figure 1 [8], [10].

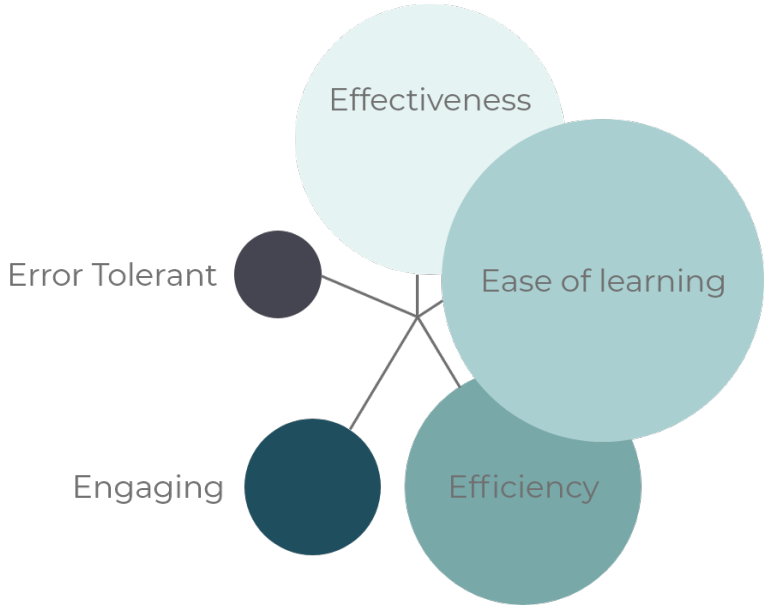

Figure 1: Illustration of Quesenbery's five dimensions with different balances

- *Effective* - the completeness and accuracy with which users achieve their goals
- *Efficient* - the speed (with accuracy) with which this work can be done
- *Engaging* - how pleasant, satisfying or interesting an interface is to use
- *Error Tolerant* - how well the product prevents errors and helps the user recover from any that occur
- *Easy to Learn* - how well the product supports both initial orientation and deeper learning

Quesenbery believes that identifying and understanding these dimensions is a good step to understand usability and its impact on websites. As the balance (Figure 1) between the dimensions differs, it is essential to identify and analyze them individually in each specific project [8].

In addition to Quesenbery's five dimensions, a website today should be easy to use and accessible to all users, including older adults and people with special needs. Accessibility is the ease to access anything; thus, security also becomes an important parameter to consider when investigating usability [11]. Braz and Robert explain that the authentication process is essential for controlling accessibility and that the design of these becomes a crucial problem to solve the conflict between security and usability [12]. Furthermore, security usability concerns how the security information should be handled in the user interface and how authentication systems should be easy to use [12]. Therefore, both security and usability are considered necessary in the authentication process, which creates problems as complex security methods are not considered easy to use [12]. According to Braz and Robert, the

conflicts might be minimized by using general heuristics principles such as minimizing the user input, making decisions in the name of the user, and notifying the user of actions taken on their behalf [12].

2.2 Navigation

This chapter will introduce theory regarding navigation and how it impacts the perceived usability of a website.

2.2.1 Definition

There are several different definitions and views on what navigation is within website designing. One definition that focuses on the efficiency in navigation is *"[...] the extent to which a visitor can follow a website's hyperlink structure to locate target contents successfully in an easy and efficient manner"* [13]. In a more general definition, navigation can be described as the path a user travels through the website [14].

2.2.2 Why is Navigation Important?

With the increased use of websites, the importance of developing sites in order to satisfy customers has grown [14]. Navigation is one key aspect since it enables the user to find its way through the site. A website that does not have efficient and user-friendly navigation risks making the user feel lost, frustrated, or disorientated, which in turn can lead to users having a bad experience or even leaving the site [15].

Smith, P.A [16] says that one significant disadvantage of websites that have been mentioned in literature is the sense of being 'lost. Even small websites can create difficulties in navigating and lead to a user feeling disorientated. The 'lostness' factor is further explained by Otter, M et al. [17] where it is stated that it should be looked at as the degradation of performance instead of the users' subjective feelings. In order to counteract this 'lostness' and deliver good usability, it is necessary to implement satisfactory navigation.

2.2.3 The Impact of Navigability on Usability

A website's primary purpose is to facilitate knowledge acquisition, and in order to do so, navigability plays a significant role [18]. Thus, when discussing usability, navigability is often brought up [18]–[21]. For instance, Quesenbery discusses navigability in connection with the dimension labeled *efficient* emphasizing the need for ideal workflows to ensure usability [10]. Furthermore, several studies have been conducted in the hope of finding connections between

various navigation structures and usability [18], [22]. For instance, in 2007, Fang explicitly investigated the correlation between specific well-adapted navigation structures and usability, discovering significant correlations between certain types of navigation structures and high usability [18].

2.2.4 What Makes a Website Navigable?

There are several aspects that influence a website's navigability, according to the literature. Regarding some of the aspects, there are divided opinions while others are generally accepted. One problem with the structuring and designing of a website is that different users have different preferences and expectations [23]. According to Zhang et al. [14] there are three fundamental questions that should be answered in order to deliver good navigability for the user: *Where am I? Where have I been? Where can I go?*

Links

One of the most important aspects when constructing a website's navigation is links. Links can be seen as the tool for traveling between the nodes in a website and plays a vital point in the navigation [24]. How these links are implemented and designed can therefore affect the efficiency and usability of a website. There are several key points to consider when implementing links [24]:

- It should be clear on pages that links are links.
- Links should be placed so that it ensures users will notice them.
- The destination of each link should be clear.

The most common indicator for a link is underlining, where the link and the underlining are blue. Another usually seen indicator is a raised "button". In addition to this, there are other methods to show what is a link. According to Farkas and Farkas [24] consideration should also be taken when naming and placing links. Users will, by habit, interpret some words such as "About Us" and "Home", as links. With placement, the reasoning is similar. Since the most common placement of links is at the top and to the left of a website, users will tend to look for links at these positions. Farkas and Farkas [24] further explain that it is essential that methods such as underlining and raised "buttons" should be avoided when it is not links. This to not fool users into clicking things on a website that is not intended to take them anywhere, which could cause misunderstandings and loss of efficiency [24].

When addressing the destination of links, there are also factors to contemplate. Rollovers, supplementary texts, and labels are typical techniques to clarify where the user will be taken if clicking a link [24]. Insufficient information about the destination can lead to increased

time spent navigating to a preferred goal. This can, in turn, impact the experience negatively and leave a user with the feeling of a poorly designed website [24].

Placement

The nature of a user's reading is to scan a website for the most important and not look through all of the content. Important information and the options for navigation should therefore be placed where the user naturally looks for them. This is supported by Chen et al. [23] that mentions placement of navigational elements in inconspicuous locations as a common factor that reduces navigability. Further, Farkas and Farkas [24] highlights that the positioning of common navigational elements should be placed at the same place on each web page since the user will, by habit, look for them at the same place.

Users can often be found scanning pages in similar patterns. A study done in 2007 [25] found that the users often scan pages in an F-pattern. This can be described in a three-step process:

1. Horizontally across the top of the page.
2. Further down the page in another horizontal line.
3. Vertically across the left side of the page.

Although a common pattern, the study found that the pattern does not always appear and is somewhat dependent on what type of page it is [25]. In-text pages, the pattern occurs but not in image-based pages.

2.3 Desirability

This chapter introduces some theoretical concepts in the realms of design that can make a web page desirable from a user perspective. Additionally, it is addressed how desirability can impact the perceived usability of a web page.

2.3.1 Definition

Desirability is a subjective factor used to assess how aesthetically pleasing a product or brand is [26]. Design is generally what makes for a desirable product. A desirable product engages users in an early stage, making them more likely to interact with the product [26]. Desirability is one of the multiple levels that form a user experience. Some of the most critical aspects of desirability when it comes to designing a web page are logo design, graphics to

text ratio, and color usage [27]–[29] . Colors are usually one of the first design elements that a user notices, and therefore it is important to consider the choice of colors carefully when designing a web application [29].

2.3.2 The Impact of Aesthetic Design on Usability

Quesenbery highlights *Engaging* as one of the five primary dimensions of usability and defines it as *"how pleasant, satisfying or interesting an interface is to use"* [10]. How pleasant, satisfying, or interesting an interface is to use can vary between different users but one key aspect that greatly affects the user's perception is the visual attractiveness of the website [30]. Visual attractiveness is affected by a range of certain aspects such as site templates, animated images, colors, and associated themes, which improve usability by impacting the users' aesthetic perception and ease-of-use [30]. In 2009, Aljukhadar and Senecal [30] performed a large-scale study of 59 different websites spanning multiple industries to examine how various usability elements drive user's attitudes and intentions towards different websites. The study showed that while site information and trust were stronger for tangibles sites (such as fact-oriented sites like Wikipedia), visual attractiveness and site interactivity were more influential for service-oriented sites [30].

2.3.3 Compositional Elements

A user's first impression of a web page is strongly affected by its appearance. Usually, users look at the graphics before getting information in the form of text [28]. This means that the graphical design of a web page matters more than the actual information when it comes to delivering a good first impression [28]. The number of compositional elements and their complexity can impact the perceived aesthetic appeal of a web page [31]. A web page with too many or too complex elements is likely to be perceived as cluttered, and a web page with an insufficient number of compositional elements is likely to have a low aesthetic appeal. The aesthetic appeal of a web page is generally improved if the compositional elements share symmetry – both through its placements but also through its contents [31].

One way to determine a web page's complexity is by analyzing the ratio of graphics to text on the web page. Generally, a graphics-to-text ratio between 1:1 and 3:1 creates the impression of an easy-to-use web page [28]. In this span, a ratio of 1:1 indicates a more realistic and simple-looking web page that is easy to use, and a ratio of 3:1 indicates a fancier web page that is clearer to follow. Web pages that are in the span between 1:1 and 3:1 have generally adapted a good combination of the easy-to-use and clear-to-follow aspects [28].

Figure 2: Examples of chromatic and achromatic colors, respectively.

2.3.4 Color Usage

Colors can be either chromatic or achromatic. Chromatic colors are generally seen as more pleasant and credible than achromatic colors [32]. Therefore, chromatic colors should be considered when designing a web page to make it more desirable. Chromatic colors draw attention, and for this reason, they should be used for navigational elements. However, it is important not to use too many chromatic colors as this makes it harder to use colors as guidance for the user [32]. Achromatic colors can be used for elements that do not need to draw the users' initial attention. Figure 2 presents examples of chromatic and achromatic colors.

Colors can also be either saturated or desaturated. Saturated chromatic colors draw attention and slow users down [32]. It is important to use these colors conservatively. Otherwise, a web page can be perceived as cluttered and unprofessional. Saturated chromatic colors are most effectively used for buttons and other actionable elements [32]. This makes for an efficient way to show the user what is important on the web page, and thus a great way to guide the user on how to navigate the site in an efficient way [32]. Desaturated chromatic colors are generally perceived as more minimalistic and professional than saturated chromatic colors. These colors do not draw loads of attention and are easy to overview [32]. Desaturated chromatic colors can be used for menus, headings, backgrounds, and other large areas that do not need a lot of a user's initial attention[32]. For these elements, an achromatic color can also be used [32]. The saturation level for achromatic colors does not matter as much as for chromatic colors since these colors are more subtle to begin with. Figure 3 presents an example of different saturation levels of a red color.

For a web page to be perceived as navigable, it is also important to use colors in a way that creates a path for the user to follow [29]. This means that there should be a general theme in all color usage on a web page. Using a certain color for similar elements on the web page makes for a web page that is easy to navigate [32]. Using colors without association results in a poor visual hierarchy, making it more difficult to navigate the page [32].

Whilst using multiple colors can decrease the navigability of a web page, it is an effective way

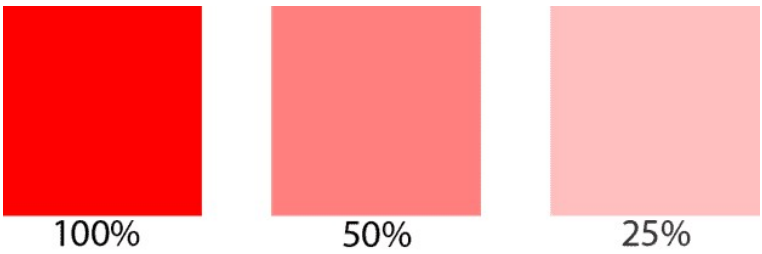

Figure 3: Three saturation levels for a red color.

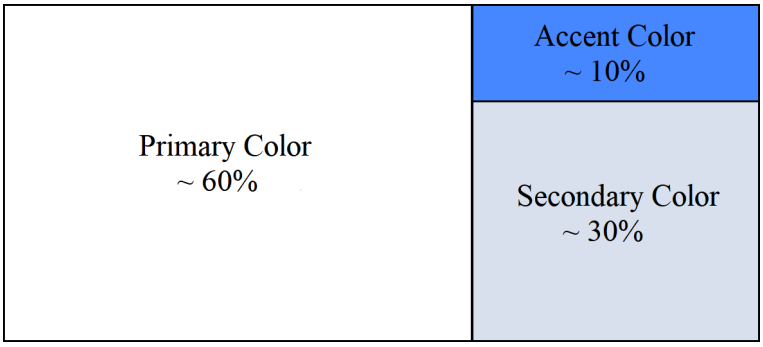

Figure 4: Example of a three-color scheme.

to keep a user interested in the page longer [32]. One simple way to keep a page navigable whilst using multiple colors is to introduce a monochromatic color scheme [32]. Doing so makes it possible to use more tones, shades, and tints within the same hue. A two-color scheme with one dominant and one highlighting color (and their respective monochromatic colors) is an effective way to make a web page more interesting without making it nonuniform [32]. In this approach, a powerful chromatic color is used as highlight, and an analogous or complementary color that is more neutral is used as a dominant color. It is also possible to use a third color, making it a three-color scheme [32]. A three-color scheme balances appealing design and simplicity in an effective way. A general rule when using a three-color scheme is to use the colors in a 60-30-10 manner. This means that the primary, secondary, and accent (highlight) color should be used on 60, 30, 10 percent of the web page, respectively [32]. Multiple primary, secondary, or accent colors can be used to make the design more interesting. However, using too many colors in a three-color scheme introduces more complexity to a web page and thus risks making it harder to navigate. An example of a three-color scheme can be seen in Figure 4.

Colors can be used to subconsciously fabricate certain attitudes towards a web page or a product. For this reason, the general evaluative appeal of color should be considered when choosing colors for a web page [29]. Research on color preference shows that warm colors (red, orange, yellow) can cause psychological arousal – and with that increased user activation [29]. Whilst user activation is certainly a good thing; warm colors come with other problems: they are often viewed as negative from a credibility perspective [29]. Cold colors (blue, green, violet) are generally preferred over warm colors when it comes to credibility. The reason for this is that cold colors are often perceived as relaxing, pleasant, and professional [29], [32]. The use of a color scheme based on cold colors is likely to give the user a credible and

professional impression [29].

2.4 Digital Tools in Education

This chapter introduces relevant theory regarding the use of digital tools in the educational environment. Digital transformation in education has traditionally been quite a slow-moving topic, but COVID-19 has affected the field and increased its importance [4].

2.4.1 Effects of Digital Queuing Applications

A study done at Linköping University [3] showed that the use of an online queuing application significantly reduces the waiting time. Further, the involvement of the application resulted in fewer complaints regarding lack of assistance. Both students and teachers benefit from an online queuing application, even in physical education. There is less traffic and movement in a physical classroom compared to traditional queuing methods, and there is no longer a need for visual observation by teachers to assists students [3]. The introduction of an online queuing application also posed some challenges, such as the initial time needed for changing the existing habits.

2.4.2 General Issues Regarding Digital Tools in Education

There are several platforms and programs that can be used in online education. Depending on the platform, some require that documents must be stored locally or on the user's cloud repository. This can raise issues of local accessibility, copyright, and digital continuity [33]. Some educational platforms are CPU-intensive and require hardware that can handle the program. Based on the operating system used by students or tutors, integration with external applications can cause problems, which slow down students' progress and affect the learning process [33].

According to Vladoiu and Constantinescu, the vast majority of people are encountering a problem regarding internet issues and lack the knowledge to use and solve problems regarding technology in their academic life [34]. Furthermore, they explain that in the world of digitization, there is a concern regarding the privacy of the internet, as more people are connected to the internet [34].

There are some other challenges with the use of it-systems in online education as well. The use of several different systems increases the risk that technical problems arise, which may affect the education [4]. According to Bogdandy et al. [4] this can be solved with the help of support materials. Another challenge is the dependence on the user's own hardware compared to the school's resources. At this, online education and teaching at the school differ as the latter enables the use of school equipment and resources, while online education

places the responsibility on students to provide sufficient equipment. This could be a big problem, but according to the study, the results show that the majority of students prefer to use their own equipment [4].

2.5 Theory Related to Methodology

This chapter introduces the methods and procedures used to evaluate the queuing system from a usability perspective.

2.5.1 User-Oriented Development

It is not always easy for software developers to fully understand how users of a system or software truly perceive it. Therefore it is often beneficial for developers to involve users during the development phase [35]. There are several different methods to involve potential users during the development phase, but one of the most common and effective ones is to allow potential users to participate in usability tests [35], [36]. Methods for performing usability tests such as *Concurrent Thinking Aloud Procedure* (CTAP) and *retrospective probing* are collectively referred to as Usability Evaluation Methods (UEM).

2.5.2 Concurrent Thinking Aloud Procedure

CTAP is a method widely used in cognitive psychology to learn how individuals process information while performing complex tasks and assignments [37]. The basic structure of the method is quite simple. During the usability test, the user is assigned a range of different tasks and is simply asked to "think aloud" while performing them[37]. As the user is performing the tasks, the observer will be able to note the user's thoughts and impressions regarding the application's functionality and design in real-time [37].

There are both strengths and weaknesses associated with the method. For instance, a study from 2010 showed that users who participated in a CTAP-oriented usability test performed the assigned tasks slower than users who were simply performing the tasks in silence [38]. However, the same study also concluded that the data gathered from users after they had performed the assigned tasks in silence was inferior and less accurate than the data obtained during the CTAP-oriented test [38].

Although the method is robust and easy to use, it has to be used correctly in order for the result to be valuable. Ericsson and Simon recommend allowing the test user to practice the procedure prior to getting the assignment [39]. This allows the user to get used to thinking out loud while performing tasks and thus enables the user to clearly focus on the task when completing the actual test. Moreover, the authors also recommend that the test user is not disturbed during the actual test to avoid interrupting the user experience [39]. Boren and

Ramey propose an alternative to the total silence approach [40] that allows the observer to communicate with the test user in a strictly controlled manner to elicit desired information [40]. However, in this approach, there is always the risk of disturbing the user experience to the degree that might impact the results [39].

2.5.3 Retrospective Probing

Similar to CTAP, *retrospective probing* is a UEM that is centered around allowing users to complete a range of assignments [37]. However, in contrast to CTAP, where results are collected by recording the user's thoughts during the assignment, retrospective probing evaluates by asking the users a range of questions after the completion of the assignments [37].

The nature of the questions can either be open-ended or specific. Open-ended questions allow the user to express their thoughts more freely and thus enable the interviewer to collect more qualitative data [37]. However, closed questions resulting in yes/no or a number on a set scale are superior when collecting quantitative data for empiric analysis [37].

An advantage the method has over CTAP is that all test users receive the same questions, which simplifies the comparison between different users [37]. Although, a disadvantage is that the users might have forgotten certain parts of their experience when the test concludes. This will potentially lower the reliability of the collected data and thus skew the results [37].

2.5.4 System Usability Scale

The System Usability Scale (SUS) is a questionnaire developed in 1996 by Brooke [41] to meet the demand for a subjective usability measure that could be quickly and easily administrated while at the same time reliable enough to be used to make comparisons of changes in user-experience from version to version of a software product [41]. Since its development, the scale has been evaluated multiple times, and the results still indicate that the scale is a robust and versatile method of measuring usability [42], [43].

SUS is a Likert scale ranging from one to five (strongly disagree to strongly agree) containing ten specific statements[41]. The SUS questionnaire should generally be presented to the users after they have had a chance to use the software being evaluated[41]. It is also best practice to ask the users to record their immediate response to each statement in order to access their initial expression[41]. If a respondent is unable to record a response to a specific statement, the middle of the scale ought to be filled in [41].

SUS yields a single number that can range between 0 and 100. A high score indicates that the usability is perceived as good, while a low score indicates that it is perceived as poor [41]. To calculate the SUS score, a score for individual statements is calculated, summed together, and then multiplied by a constant value of 2.5. The individual score for statement

1, 3, 5, 7 and 9 is calculated by subtracting 1 from the scale position while statement 2, 4, 6, 8 and 10 is calculated by subtracting the scale position from 5 [41].

The 10 original statements which make up the SUS questionnaire can be viewed below

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 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

2.5.5 Optimal Sample Size of Usability Evaluation Methods

Regarding the optimal sample size of usability evaluation methods, there is currently no clear consensus. The simple answer is, of course, that more test users equal a better overall discovery rate [36]. However, this is not a linear relationship but a relationship where the increase in discovery rate exponentially decreases for every additional test user. Moreover, there is also the element of cost that needs to be considered. Usability evaluations tend to be both time-consuming and expensive. In order to combat these issues, a general rule that identifying 80% of the total number of usability issues is simply good enough has been established [36].

When discussing user-centered usability evaluation methods (such as CTAP and *retrospective probing*) the number of participants needed to discover 80% of the usability issues varies between different studies [36], [44], [45]. In 1992, Virzi indicated that only 4-5 test users are needed to detect 80% of the usability issues, while Law and Hvannberg (2004) reported that 11 subjects were needed to reach a discovery rate of 80% [44], [45]. However, in 2010, Hwang and Gavriel put the different theories to the test by examining 27 different usability experiments using various evaluation methods [36]. The authors then used logarithmic, linear regression to predict the optimal number of test users based on the overall discovery rates recorded in the examined experiments. The result showed that nine test users ought to be sufficient to achieve a discovery rate of 80% [36].

For the System Usability Scale, it has been shown that 8-12 respondents is enough to gain a good assessment of how people view your product [46].

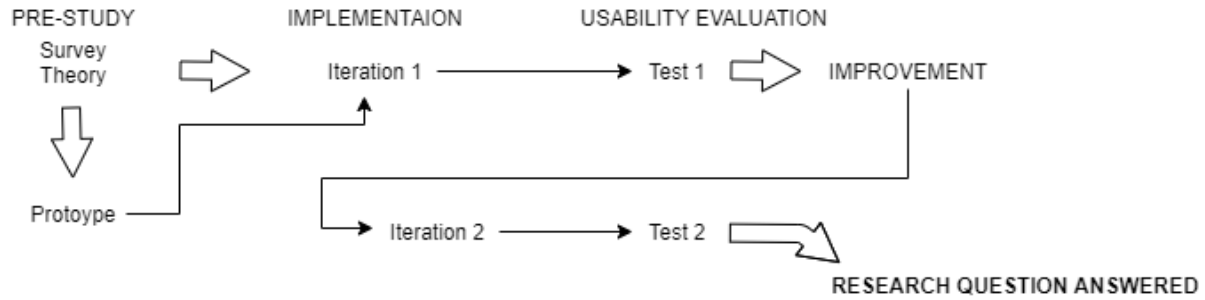

Figure 5: Illustration of the method.

3 | Method

This chapter describes the work carried out to answer the research question and ensures replicability. The workflow of the project can be seen in Figure 5 where the work consisted of three stages: pre-study, implementation, and testing. In this chapter, the pre-study is first presented, where the survey and the prototype are described. Furthermore, the implementation section describes how the web-based queuing application was realized from a technical perspective. Finally, the usability evaluations used for testing are described. In this section, the questions used for both students and tutors are presented.

3.1 Pre-Study

The purpose of the pre-study was to produce the theoretical and functional framework for the web application.

3.1.1 Survey

To examine the market's needs, market research was conducted in the form of an anonymous survey. The survey was conducted to create a better understanding of the customer segment and collect relevant information about students and their preferences regarding a queue application. The survey was conducted online using Google forms. The questionnaire was shared on social media and by email to students and tutors at Linköpings University. The survey (Appendix B) contained ten questions referring to current situation analysis and identifying preferences desired in a web-based queuing application.

3.1.2 Marketing Plan

During the feasibility study, a marketing plan was made to investigate the need for the service, identify competitors and determine how the application was to differ from the existing

alternatives. The marketing plan initially includes an NABC-analysis as a basis for the environmental analysis. The environmental analysis consists of a PEST analysis followed by Porter's five-force model, a competition analysis, and finally, a SWOT analysis. Furthermore, the market goals were developed, the customer segments were identified, and the market was analyzed with a positioning map. The analyzes then formed the basis for a marketing mix.

3.1.3 Prototype

A prototype was made during the feasibility study, which forms the basis for the development of the website. The prototype created the structure of the web-based queuing application and quickly showed navigability and design issues. The prototype was created with Figma, which is explicitly used for web application prototypes and includes increased functionality with buttons and bootstrap elements.

3.2 Implementation

The queuing application is implemented with multiple different techniques and packages. The implementation was performed iterative where the first iteration was performed before the first usability evaluation. Based on the outcome of this evaluation, measures were implemented in iteration two before the last usability evaluation, see Figure 5. This approach was chosen as an iterative workflow with usability evaluations between the iterations enables implementation based on the test subjects' opinions.

3.2.1 Back-End

The back-end is composed of a Python web-server powered by the Flask framework. The primary purpose of the back-end is to provide a REST API for the client to interact with. It will also manage a SQL database that will store the data needed for the application to function correctly. The server will also be responsible for serving the client files.

Versions:

1. Python 3.8.2
2. Flask 1.1.2
3. SQLAlchemy 1.3.23
4. stripe 2.56.0
5. bcrypt 3.2.0
6. Flask-JWT-Extended 4.1.0

3.2.2 Front-End

The front-end is structured as a single-page application, i.e., loading new pages will be handled by the client. In development, TypeScript and SCSS will replace regular JavaScript and CSS primarily to increase developer efficiency and project maintainability. The code will then be transpiled and packaged by Snowpack to generate the files for distribution. With the purpose of simplifying the development, the libraries JQuery, Bootstrap, copy-to-clipboard, and jwt-decode will be used. These libraries come with pre-built functionality for many standardized tasks.

Versions:

1. JQuery 3.5.1
2. Bootstrap 4.6.0
3. Snowpack 3.0.11
4. TypeScript 4.1.5
5. copy-to-clipboard 3.3.1
6. jwt-decode 3.1.2

3.2.3 Deployment

For deploying the web application to the internet, the service ngrok is used. Ngrok makes it easy to expose our local development server to the internet via a public URL which will be used during the usability evaluations.

3.3 Usability Evaluations

During the project, two separate usability evaluations took place – one after each iteration of web development. Both usability evaluations had the same structure where the test subjects first had to solve a number of tasks while thinking out load in accordance with CTAP. The test subject then had to answer a number of questions in accordance with the retrospective probing methodology. Finally, the subjects filled in a SUS questionnaire. These usability evaluations were performed with an implementation iteration between, see Figure 5. Each test group contained nine subjects in accordance with Hwang and Gavriel's study on the optimal sample size for usability evaluations [36]. The participants chosen had to be students or tutors with experience from using another online queuing application. The usability evaluations were conducted using both CTAP, *retrospective probing*, and the *System Usability Scale* (see sections 2.4.2, 2.4.3, and 2.4.4).

First, the user was given a set of tasks to perform while thinking out loud in accordance with CTAP. The purpose was to capture the user's initial impressions of the queuing system. Students and tutors will use different functionality in the application; a student wants to, for example, queue up while a tutor wants to be able to create a room and manage the queue. Thus the research team constructed two different sets of tasks for the evaluation, one for students and one for tutors. The tasks were constructed to simulate potential activities undertaken by students and tutors in a lab/tutor environment and contained descriptions such as "Create an account on TopQ". For the complete list of tasks, view the lists presented below. Prior to the actual tasks, the subjects were allowed to practice CTAP by solving a simple logical puzzle in obedience to Ericsson and Simon's recommendation [39].

After the completion of the tasks, the subjects were asked a range of questions regarding their experience in accordance with the retrospective probing methodology. The aim of this part of the evaluation was to elicit thoughts and impressions specifically connected to the design and navigation aspects of the website. In line with Birns [37], closed questions such as "How would you rate the website's design from one to five where one is very bad and five is very good?" were asked in order to gather quantitative data for comparisons. Meanwhile, open-ended questions such as "What is your overall expression of the queuing system?" were used to gather qualitative and reflective data, which could be used to improve the usability further during the second iteration. For the complete list of questions, view the list presented below.

Lastly, to discover if the overall usability of the web-based queuing system had improved after the second iteration, each test subject filled out a SUS questionnaire in compliance with the instructions given in section 2.5.4.

Following each evaluation, the results were compiled and analyzed. The results are presented in section 4.3. In order to decide which perceived issues needed to be resolved, each issue was thoroughly examined from three perspectives: number of mentions, implementation difficulty, and connection to navigation, design, or usability. Each issue was then categorized into three different categories: *Implement*, *Implement if time is left*, and *Do not implement*. The result can be seen in section 4.3 where the measures were implemented in iteration 2, before the second usability evaluation.

3.3.1 Usability Evaluation After Iteration 1

The first usability evaluation took place after iteration 1 and contained nine subjects, three of whom were tutors and six students at Linköping University. The usability evaluation was performed online via a video link where the user used screen sharing features when performing the tasks. As previously mentioned, ngrok was used to create secure tunnels to our localhost.

Tasks for students:

1. Create an account on TopQ
2. Log in with your new account
3. Access the lab session with room id: 1 through a code/link
4. Queue up
5. Remove your queue ticket
6. Join another pre-existing room by entering room id: 2
7. Leave the room
8. Log out from TopQ

Tasks for tutors:

1. Log in using email: admin@topq.se and password: admin
2. Queue up
3. Remove your queue ticket
4. Click the zoom-link on another ticket and "help" the student
5. Remove the "helped" student's ticket from the queue
6. Demote another admin to member
7. Promote a premium member to admin
8. Create a room
9. Copy the link used to invite students to your room
10. Join another pre-existing room by entering room id: 2
11. Leave the room
12. Log out from TopQ

Questions:

1. What is your overall impression of the queuing system?
2. What do you like the most about the queuing system?
3. What do you dislike the most about the queuing system?

4. Did it feel natural to navigate the queuing system?
5. How would you rate the website's navigability from one to five where one is not at all navigable and five is very navigable?
6. Did anything feel difficult to find?
7. If you could change anything to make the site more navigable, what would you change?
8. What is your overall impression of the website's graphical design?
9. Was the design in line with your expectations?
10. How would you rate the website's design from one to five where one is very bad, and five is very good?
11. Did anything feel unappealing to you?

3.3.2 Usability Evaluation After Iteration 2

The second usability evaluation then took place after iteration 2 with nine subjects, the same three tutors as before, and six different students ad Linköping University. The usability evaluation was performed the same way as the first but with some added tasks for students and tutors, which can be seen below.

Tasks for students:

1. Create an account on TopQ
2. Log in with your new account
3. Access the lab session with room id: *[individual room id]*
4. Queue up
5. Change what you need help with
6. Remove your queue ticket
7. Join another pre-existing room by entering room id: *[individual room id]*
8. Leave the room
9. Log out from TopQ

Tasks for tutors:

1. Log in using email: admin@topq.se and password: admin

2. Click the zoom-link on another ticket and "help" the student
3. Remove the "helped" student's ticket from the queue
4. Demote another admin to member
5. Promote a premium member to admin
6. Create a room
7. Copy the link used to invite students to your room
8. Join another pre-existing room by entering room id: *[individual room id]*
9. Queue up
10. Change what you need help with
11. Remove your queue ticket
12. Leave the room
13. Log out from TopQ

4 | Results

This section presents the results obtained from this research. The purpose of this report is to examine the design and navigability aspects of a web page. The results presented will be based on these aspects.

4.1 Pre-Study

The following section will present the results obtained in the pre-study.

4.1.1 Survey

An anonymous survey conducted in the pre-study was used to investigate market needs and collect relevant information about students' and tutors' preferences in a web-based queuing application. The most important results are presented in the sections below, but the total outcome of the survey can be seen in Appendix B.

Forty-two people responded to the survey (30 students and 12 tutors). The survey showed that 81% used some kind of queuing system and the most common queuing systems were:

- Microsoft Teams - 23 people
- Zoom - 13 people
- Camedin - 4 people

The average value of students' and tutors' broad experience of their respective queuing system was 3.32 on a scale from 1 to 5. The survey showed that 90.5% were interested in a better queuing application for lessons and lab sessions. The results from the questions regarding what features they would request in a queuing application are presented in Figure 6.

4.1.2 Prototype

The final prototype can be seen in Figure 7 and aims to provide an overview of how TopQ could be implemented. The colors and logo were not used in the development, but the prototype was used as a basis for how the website would be structured. The prototype contained, among other things, a landing page and a room page which can be seen in Figure 8.

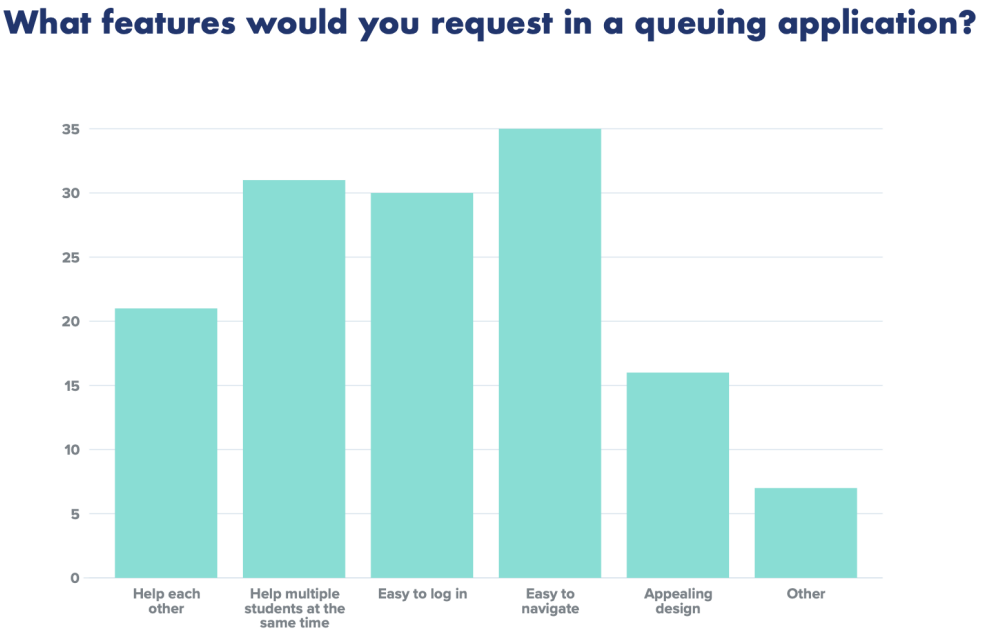

Figure 6: Result from the question: What features would you request in a queuing application?

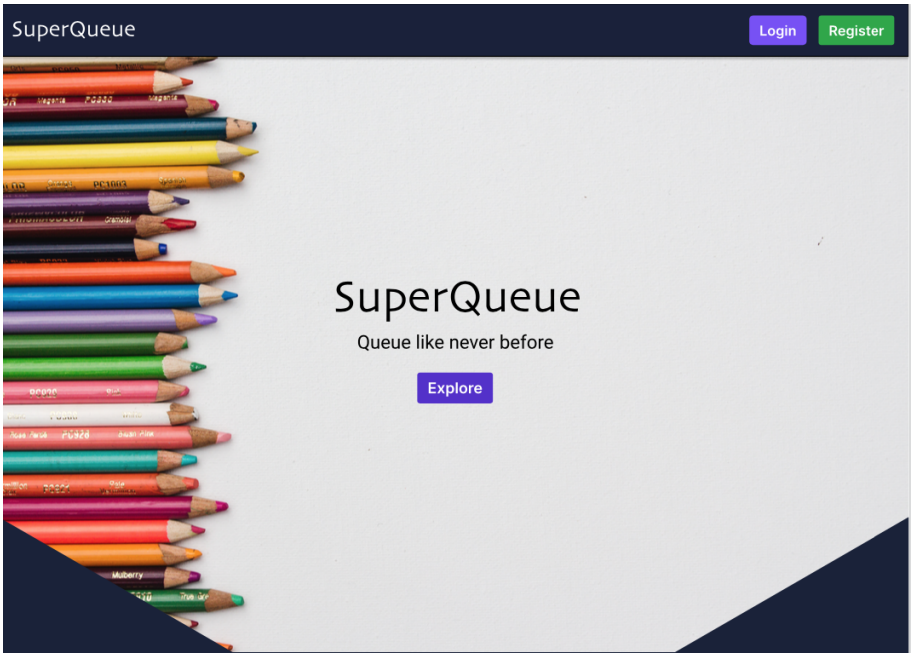

Figure 7: The start page of the prototype done in the feasibility study

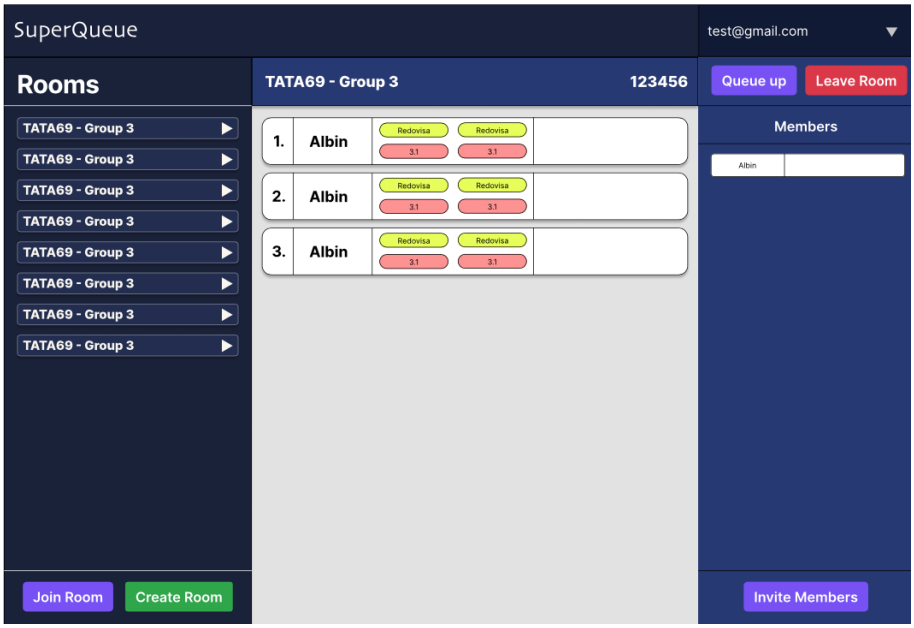

Figure 8: The room page of the prototype done in the feasibility study

4.2 Implementation

This chapter presents the result of the implemented web-based queuing application developed in accordance with the pre-study, the theory, and the user evaluations. At the end of the chapter, an account is given of which technical tools were used during the implementation and why.

4.2.1 General Design

When designing TopQ, the focus has been an appealing and easy-to-navigate interface with a consistent design and color chart according to Figure 9. This has been done by implementing an uncluttered website that consists of three elements - navbar, main container, and footer. As the user navigates around the website, new content is loaded into the main container. A hovering effect has also been implemented over all clickable objects (Figure 10).

4.2.2 Landing Page, Navbar and Footer

As shown in Figure 11, TopQ's landing page consists of three different sections in addition to the navbar and footer. These sections are used to clarify the purpose and benefits of TopQ. The page was also created with the aim to be minimalistic and uncluttered.

The first section of the landing page contains an animation as well as the "Buy TopQ" button, which is intended for schools. Through this button, schools can be referred to TopQ's school

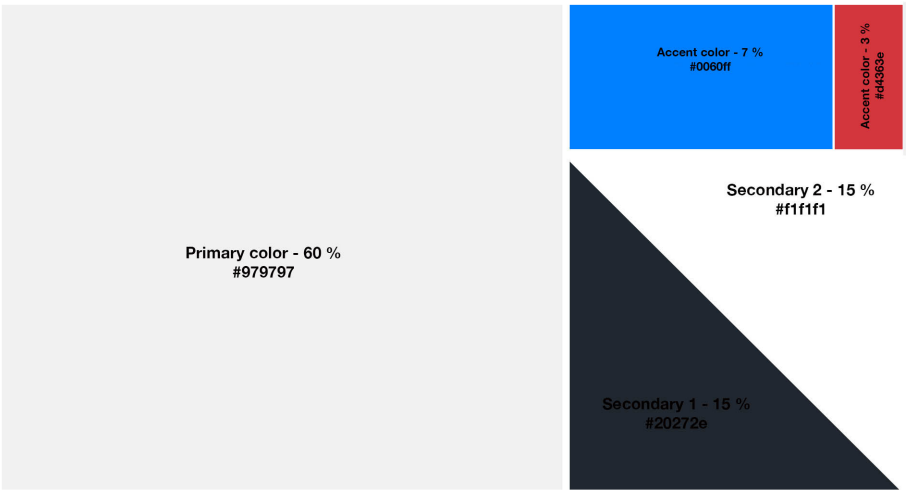

Figure 9: TopQ's color scheme

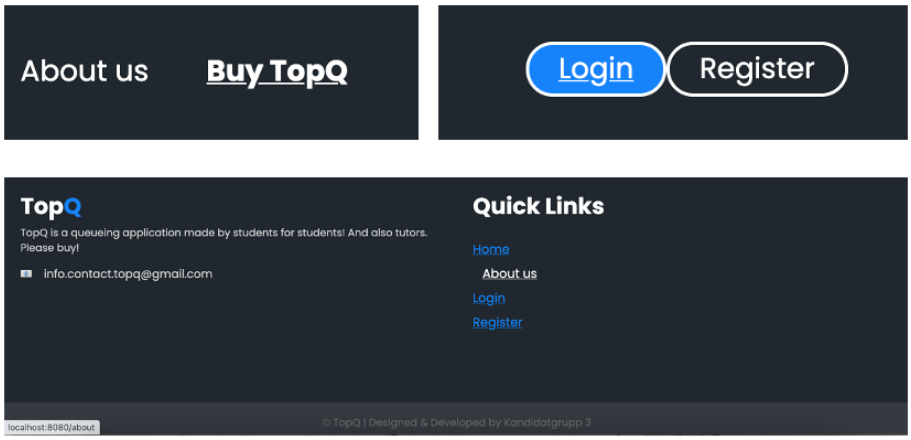

Figure 10: Three different examples of the hovering effect

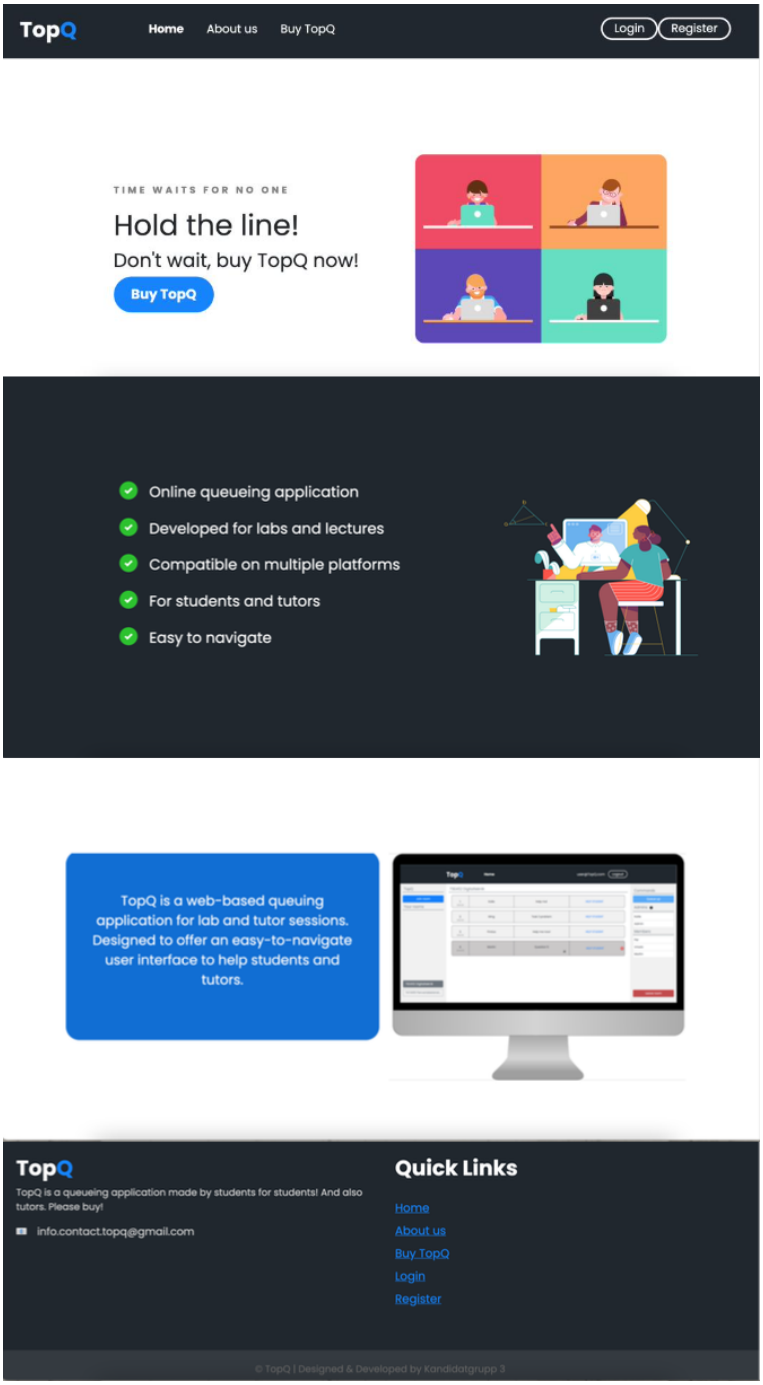

Figure 11: TopQ's landing page with navbar and footer

Figure 12: TopQ's navbar from a non-logged in perspective

Figure 13: TopQ's navbar from a logged in perspective

page. The following section also contains an image and six check-marks explaining TopQ's purpose. The last section contains a small information box about TopQ and a picture with a preview of the queue room for students and tutors. The footer at the bottom of the landing page contains TopQ's contact information and five quick links.

The navigation menu, containing the links "Home", "About us" and "Buy TopQ", was placed in the navbar at the top of the landing page. The login and register buttons for students and tutors were placed at the top right of the navbar. The navbar shows different links whether the user is logged in or not. Figure 12 shows the navbar from the perspective of a non-logged-in user, and no matter where they are on the website, they can always log in and register through the links in the navbar. Figure 13 on the other hand, shows logged-in users' perspectives where they are unable to reach the page for schools (Buy TopQ), and the login and registration buttons have been changed to the user's e-mail and a logout button.

4.2.3 Login and Registration

To enable the authentication of users, the research team used registration- and login functions. Figure 12 shows that the buttons for these functionalities are placed in the upper right corner in the navbar, making them available at the same place on all pages on the website. The user can quickly jump between the login- and registration page through the link at the bottom of each form, as shown in Figure 14.

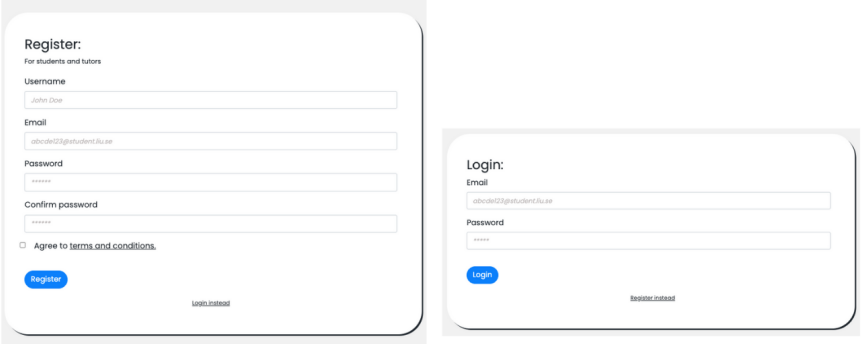

Figure 14: The login- and register forms on TopQ.

Figure 15: The student-view on the room-page.

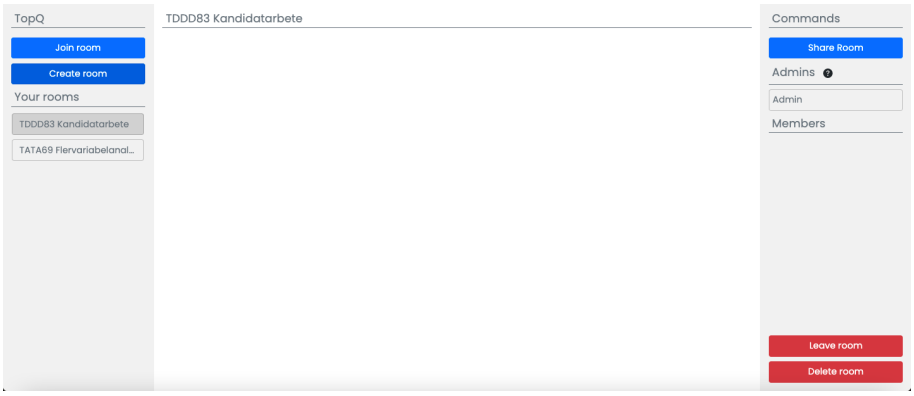

Figure 16: The admin-view on the room-page.

4.2.4 Room Page

After signing in, the user is redirected to the room page. This page is what constitutes the entire queuing system. The queue system is designed as a three-column system, and the functionality varies depending on whether the logged-in user is admin for the current room or not (see Figure 15 and 16). The left column holds general functions for rooms, like joining a new room, seeing and jumping between the rooms in which you are a member, and, if you have an admin account, create new rooms. The middle panel represents the queue and contains queue tickets from students currently waiting for assistance. The middle panel also holds functionality for the queue tickets, such as editing your description or leaving the queue and, if you are an admin, remove handled tickets. Lastly, the right panel holds functions for the room you are currently seeing, such as queue-up or leave the room and, if you are an admin, delete the room. Also, the right panel contains information on other members of the room, both admins and students, and a pop-up modal for more information and guidelines on the admin-administration.

The buttons have been placed in accordance with previous research and the result of the user evaluations. The color choices are in line with the color chart in Figure 9 and the rest of the application. The buttons have the accent color and match all other buttons except

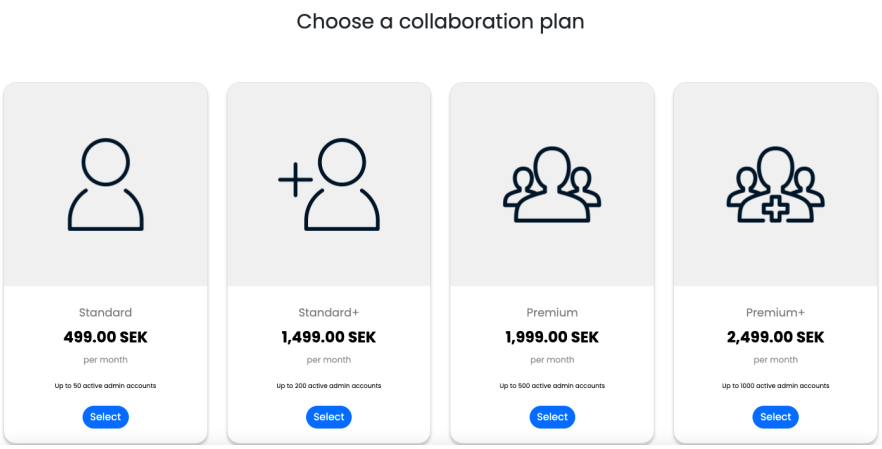

Figure 17: TopQ's checkout-section.

for buttons representing "dangerous" actions which have been giving a red, complementary color.

4.2.5 Checkout

The checkout and payment pages are only available from a signed-in school account. This means that as a student or tutor, and thereby user of the actual queuing system, you do not have access to these pages. The schools register on the TopQ school page and then sign in on the login page, just like other members.

After signing in to a school account, the school user gets redirected to the checkout page (see Figure 17) from where you can select a collaboration plan and then get redirected to the payment page and continue the purchase (see Figure 18). The school users can also, through the customer portal, see their current collaboration plan and their billing history.

4.2.6 Functionality

All functionality on the web application has been implemented with a clear focus on clarity for the user and making the website as appealing and easy-to-use as possible. All buttons are big enough to hold a descriptive word showing where they lead or what they do. Additionally, all buttons have the same color. Furthermore, all input fields needing information from the user have an instructive label telling the user what they need to do. To help the user, even more, all fields also have a placeholder to exemplify the needed input.

Another example of clear guidance for the user is the feedback that is given when a required field is empty in a form (see Figure 19). The feedback points out where the problem is, making it easy for the user to do the right thing before it is possible to send the form. Another example is the need for password confirmation when creating an account. If the

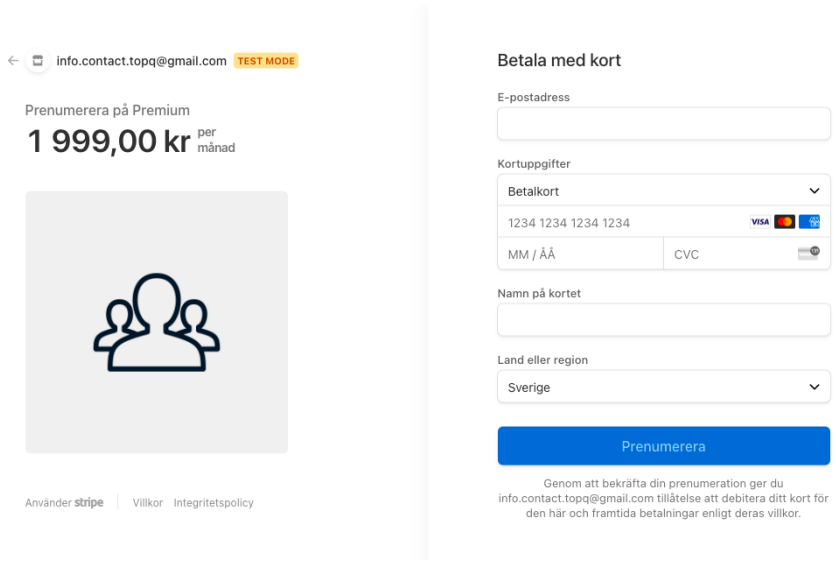

Figure 18: TopQ's payment-page.

passwords do not match, the user receives an alert and has to try again, as shown in Figure 20. Furthermore, for all "dangerous" actions that cannot be undone, there are double-checks asking the user if they want to proceed or go back, aiming to help the user avoid making mistakes. Lastly, a hovering effect has been added to all clickable objects as described and illustrated in section 4.2.1.

4.2.7 Technical Environment and Tools

The web-based queuing application was developed in accordance with and with the use of the techniques and packages presented in the method chapter (section 3.2). The back-end is composed of a Python web-server powered by the Flask framework as well as SQLAlchemy for the development of the database. To develop the front-end, HTML was used together with TypeScript and SCSS to increase developer efficiency. However, the files were then transpiled and packaged by Snowpack for distribution. Before the user evaluations, ngrok was used to create secure tunnels to localhost.

In this section the tools and modules which affecting the research question and, or are visible to the user are further presented, motivated and described.

- Flask modules
  - *Flask-JWT-Extended* was used to implement password-protected functionality on the website only visible to logged-in users. The module makes it possible to condition the access to some functionality using a JWT Web Token which is obtained on the client-side after a successful login. This is much more efficient than to use, for example, if-statements for the same purposes.

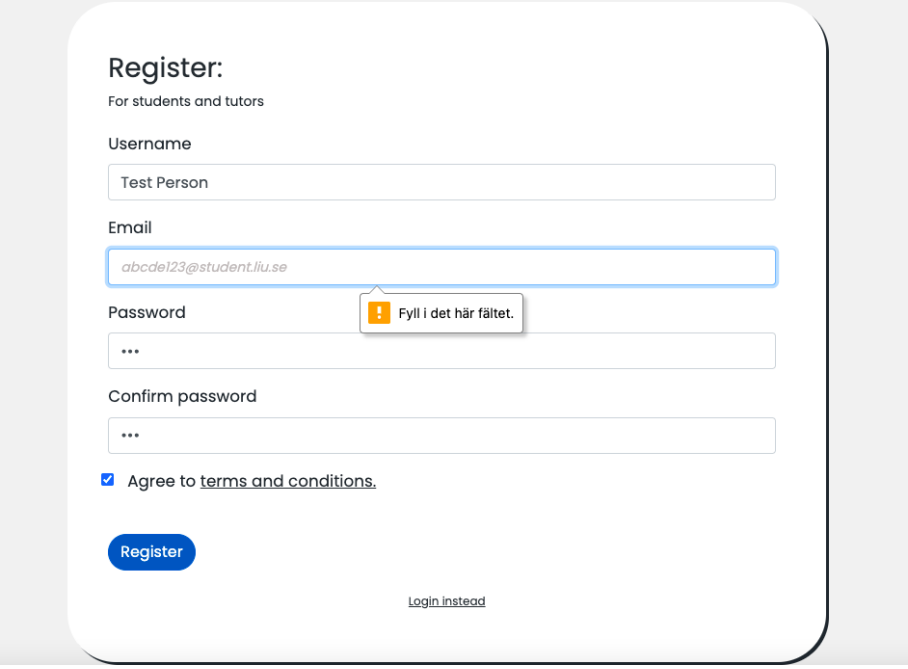

Figure 19: Example of form-validation on TopQ.

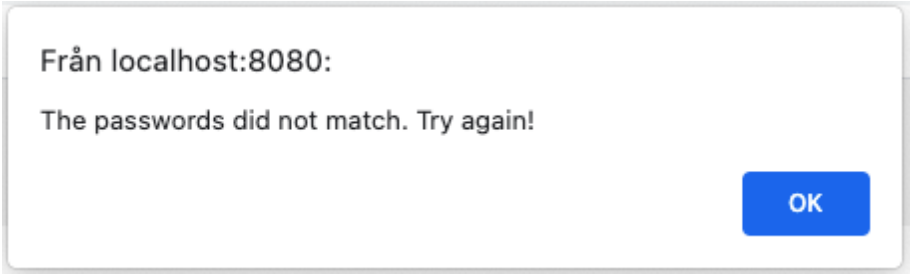

Figure 20: Alert when the password confirmation fails.

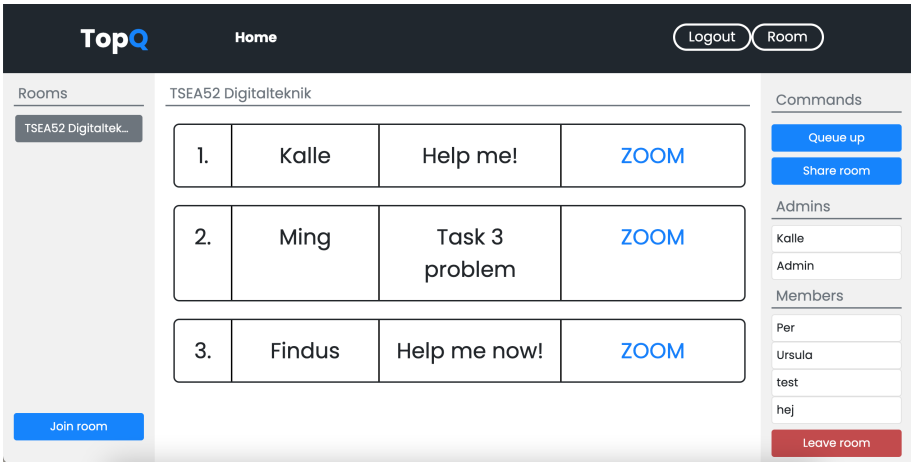

Figure 21: TopQ's queuing-page after iteration 1.

- *Flask-CORS* was used for handling Cross-Origin Resource Sharing (CORS), which makes cross-origin AJAX possible and allows communication via HTTP methods.

- *Stripe* was used to enable payments in the application. Implementing the prebuilt checkout from Stripe is a much easier way to implement secure payments than to develop a similar solution from scratch.

- *Bootstrap 4.6.0* was used to implement templates in HTML and CSS. This enabled the implementation of many important design-aspects described in section 2.3.

4.3 Usability Evaluations

This section presents the results from the two user evaluations that took place during and after the development of the queuing system.

4.3.1 Usability Evaluation After Iteration 1

The first usability evaluation took place after iteration 1, on the first version of the web application and with nine test users. The purpose of this evaluation was to improve the application by finding out the test users' thoughts and ideas on navigation and design. Furthermore, the research team wanted to ensure that the functionally of the website was in line with the users' expectations. The result from the evaluation was then taken into consideration during the development in the next iteration, iteration 2.

The following figures show parts of the web-application's design after iteration 1. Figure 21 shows the queuing page and Figure 22 the queue-up modal. The landing-page was very similar to the one after iteration 2 and is presented in Figure 11 (4.2.2).

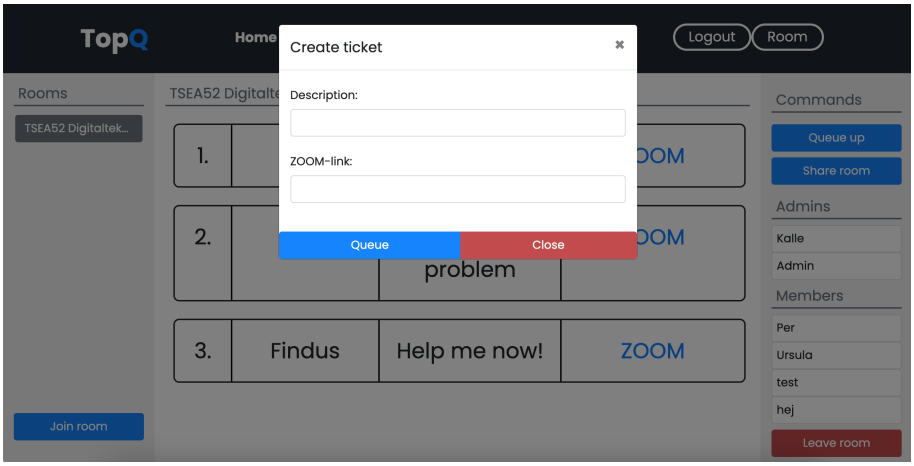

Figure 22: The queue-up modal after iteration 1.

CTAP

To begin with, the test users were to perform a set of given tasks presented in section 3.3.1 and at the same time think aloud in accordance with the CTAP-method. The most important thoughts that arose during this part of the test are summarized below.

- Stylish, clean and simple design. The color choices are nice, and the pictures on the landing page were appreciated.
- The Login-, Log out-, and Register-buttons are in the upper-right corner, as expected.
- A confirmation on the written password is missing when you register a new account.
- Confusing that the Rooms-button in the navbar is showing when I am already on that page. Where does it lead?
- Most tasks were very intuitive, however, some of the buttons are not where I first thought they would be, even if I found them quickly.
- The functionality of admins is not obvious. More information is requested.
- The labels in the queue-up form should be more instructive.
- It is too easy to make a mistake. It would feel more secure with double-checks on certain "dangerous" actions.

Retrospective Probing Methodology

After the completion of the tasks, the subjects were asked a range of questions regarding their experience in accordance with the retrospective probing methodology (see section 3.3.1).

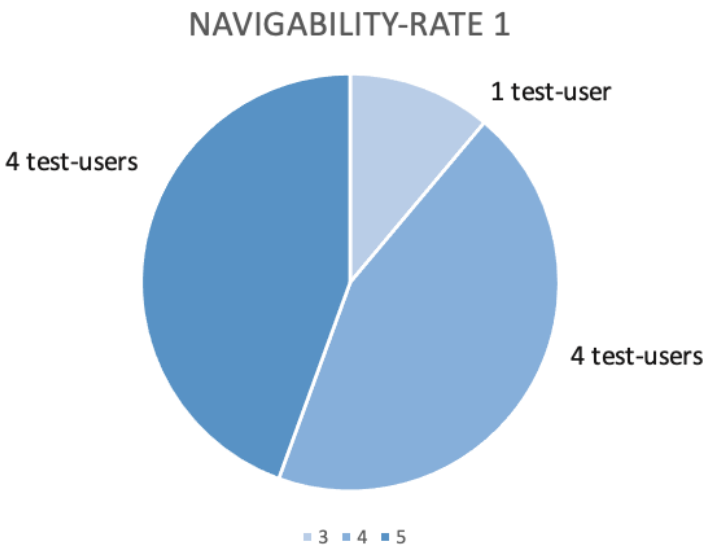

Figure 23: The result of the navigability rate after iteration 1.

That way, thoughts and impressions connected explicitly to the design and navigation aspects of the website could be elicited. The most important ideas are summarized in this section, and to see the whole outcome, see Appendix C.

The users' overall experience of the application, question 1 (section 3.3.1) was mostly positive. Commonly used words were easy to navigate, simple, clean, and smooth. Also, it was appreciated that no unnecessary functionality was implemented, which made the application easy and straightforward to use. However, the subjects had some inputs on things that could have been better, such as words that could be exchanged and buttons that could be moved to another place on the page.

When answering question 6 (3.3.1), regarding if anything was hard to find, the most common answers were the "join room"-button and the "queue up"-button. Additionally, the rooms button in the navbar was mentioned several times and described as confusing. The same buttons were brought up in question 7 as well (3.3.1) regarding what to change to make the application more navigable. Also, many of the test users here requested more instructive labels on the queue-up modal. The subjects were requested to rate the navigability on a scale from 1 to 5. The result is given in Figure 23.

Regarding the graphical design, the users' overall experience, question 8 (3.3.1), was positive as well. On question 9 (3.3.1) all of the users responded that the design was in line with or even better than their expectations. Many of the subjects liked the landing page, the choice of colors, the pictures, and that it felt modern. However, the design of the queue tickets was not that appreciated, as many users thought it was not in line with the rest of the system. The subjects were requested to rate the website's on a scale from 1 to 5. The result is given in Figure 24.

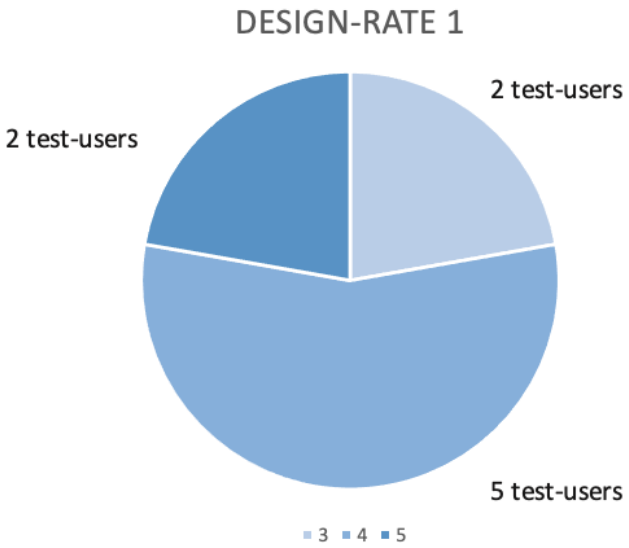

Figure 24: The result of the design rate after iteration 1.

	Test user									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	***Average***
I think that I would like to use this system frequently	4	4	5	4	4	5	4	3	3	4,00
I found the system unnecessarily complex	2	1	2	1	4	1	1	2	1	1,67
I thought the system was easy to use	4	4	5	5	4	4	5	3	5	4,33
I think that I would need the support of a technical person to be able to use this system	1	2	1	2	1	1	1	1	1	1,22
I found the various functions in this system were well-integrated	3	4	4	4	3	5	5	3	4	3,89
I thought there was too much inconsistency in this system	2	2	1	2	1	1	1	2	1	1,44
I would imagine that most people would learn this system very quickly	5	5	5	5	5	5	4	5	5	4,89
I found the system very cumbersome to use	2	2	1	1	2	1	1	1	1	1,33
I felt very confident using the system	3	3	5	5	2	5	5	4	3	3,89
I needed to learn a lot of things before I could get going with this system	2	2	2	1	1	1	1	4	2	1,78
										84

Figure 25: The result of the SUS after iteration 1.

SUS

Lastly, the test users answered an anonymous survey, a SUS-questionnaire including the questions presented in section 2.5.4. The result of the survey was then used to see if the web-based queuing system had improved after the second iteration by comparing the results from this SUS questionnaire with the one done after the next iteration. The SUS result was 84 on a scale from 0 to 100, and the full result is presented in Figure 25.

4.3.2 Changes After Iteration 1

After the usability evaluations made after iteration 1, the results were compiled and categorized as described in section 3.3. Thereafter, a decision was made on which measures to take and which not to take as presented in this section.

Measures taken

Based on the result from the first usability evaluation, a number of measures were to be taken before the next test. The most important measures are presented below.

1. Add confirmation of password: *In task 1 for students (see section 3.3.1), three of the students stated that they were missing a confirmation on the chosen password when they created an account on TopQ.*

2. Add an information-modal to clarify the admin functionality: *When performing some of the tasks and then answering the questions, many of the tutors stated that they did not quite understand the admin functionality.*

3. Limit to one queue-ticket per student: *When describing the overall experience of the system, one of the tutors requested a limitation of one queue ticket per student at a time to avoid misuse of queue tickets.*

4. Remove possibility for admins to queue-up: *When performing the tasks, the tutors expressed that the queue-up button was confusing to them since they were admins in the room.*

5. Change design on queue tickets: *A number of test users pointed out the design of the queue tickets as bad and not in line with the rest of the system.*

6. Move buttons to the top of the page: *When performing the tasks and then answering the questions, several subjects mentioned that some of the buttons in the queuing system were not where they expected them to be, often on the top of the page is where they looked first.*

7. Remove Rooms-button from navbar when on room-page: *Several test users described this button as confusing when they already were on the room page.*

8. Add an about-us page: *Some of the subjects requested more information on the creators of the application. Also, more pages to visit were requested.*

9. Add double-checks to dangerous-actions: *When performing "dangerous" actions like leaving a room or deleting a ticket, many of the test users expressed that they did not feel safe and were scared to make a mistake since they did not receive any warnings.*

Measures not taken

Some parts of the application either only got positive feedback or no feedback at all during the first usability evaluation. Therefore, a decision was made not to change those parameters. These parameters are listed below:

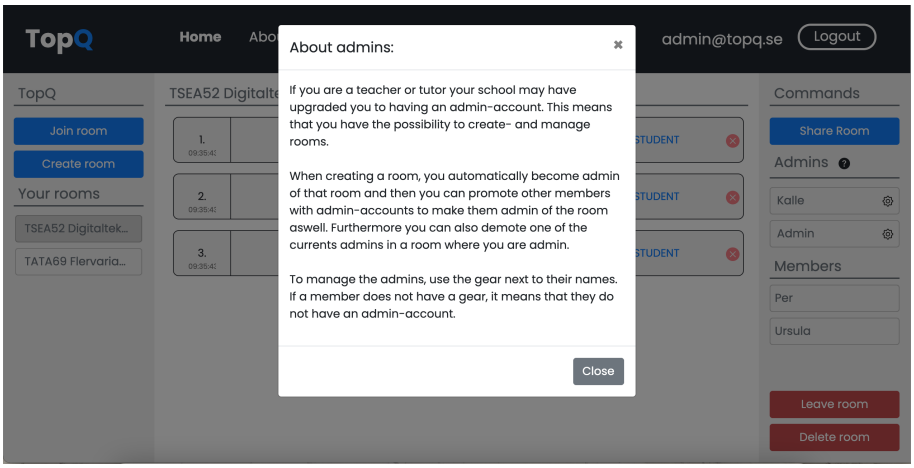

Figure 26: Information-modal to clarify the admin functionality after iteration 2

- The color scheme: *Regarding the colors used on the application, there were a few positive comments from different subjects during the user evaluations which is why the same scheme was kept during the next iteration.*

- The landing page: *The landing page's design and placement of links were appreciated by almost all of the subjects, therefore there were almost no changes done to that page during iteration 2.*

- The design of the buttons: *During the first user evaluations the majority of the subjects liked the design and color choices of the different buttons. Therefore, only the placement and not the design of the buttons were changed during the second iteration.*

4.3.3 Usability Evaluation After Iteration 2

The second and last usability evaluation took place after iteration 2, when improvements from the first usability evaluation had been implemented. The purpose was to ensure that the website had improved through a navigable and desirable perspective after the initial usability evaluation.

The following figures show parts of the web application's design after iteration two and especially show the measures that were implemented. Figure 26 shows the information-modal that has been implemented in accordance with measure 2. Another important measure was the fifth one, where a number of test users wanted to change the design of the queue tickets. This has been implemented, as seen in Figure 27, with smaller queue tickets and a different color on your own. The last two figures, Figure 28 and 29 have been done according to measure 8 and 9 respectively. According to measure 1 a confirmation of password have been added which can be seen in Figure 14 (section 4.2.3).

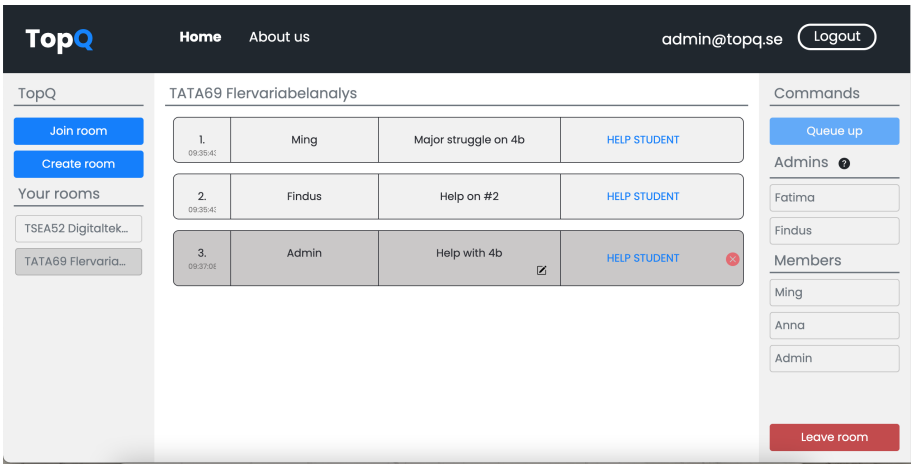

Figure 27: New design on queue tickets and buttons on top of page after iteration 2

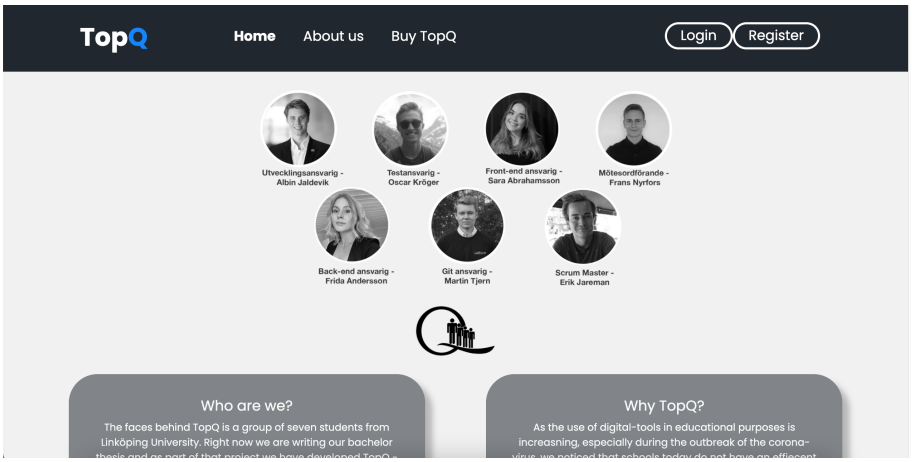

Figure 28: Added about-us page after iteration 2

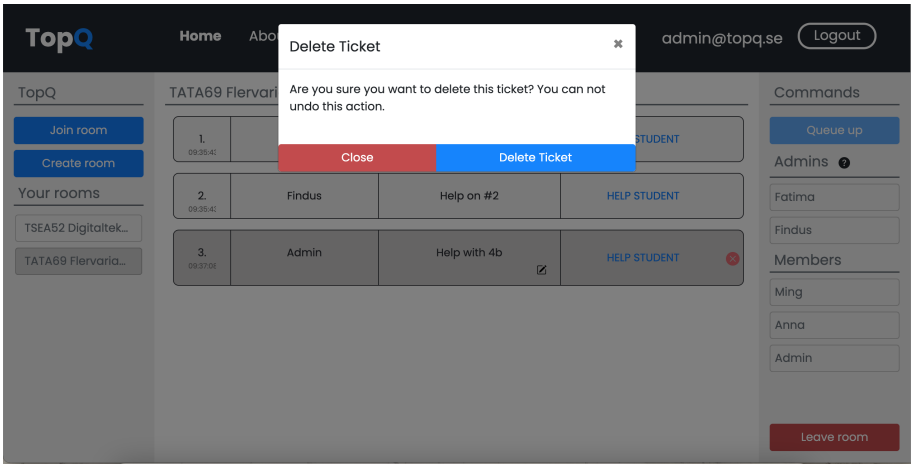

Figure 29: Example of double-checks when deleting a ticket after iteration 2

CTAP

At the beginning of the usability evaluation, the students and tutors performed different tasks and at the same time used the CTAP-method previously described. The most important thoughts that have not already been presented are summarized and presented below.

- Good to have a confirmation of the written password on the register page
- Easy to find "Join Room" and "Queue Up" buttons
- Feels intuitive to change the description of my problem on my queue ticket
- It feels safe with double-checks on the "dangerous" actions
- The "leave room" action is easily found through the red button in the bottom-right corner
- The information-modal for admin was clear and made the functionality of admins more obvious
- The titles "Promote" and "Demote" are not that intuitive, can be "Make admin" and "Remove from admin" instead

Retrospective Probing Methodology

Subjects were asked questions in accordance with the retrospective probing methodology (see section 3.3.1) after completing the tasks. The most important thoughts are presented below, and the complete result can be seen in Appendix C.

Similar to the initial usability evaluation, all subjects had a positive experience of TopQ, according to question 1 (section 3.3.1). Many used words such as clean, professional, intuitive, and those color elements are used effectively for buttons. The subjects felt that the website was clear and appreciated the double-checks of "dangerous" actions. Test subject 5, a tutor, explained in question 2 (section 3.3.1) that the queuing application had a *"[...] good overview and fits the purpose, unlike Zoom and Teams"*.

The results from question 5 (section 3.3.1), where subjects were asked to rate the website's navigability from 1 to 5, are given in Figure 30. As for what needs to be changed to make the application more navigable in question 7, two test users suggested that instead of listing all members in the right-side panel, they can be listed in a modal.

When answering questions about the graphical design, question 8 (section 3.3.1), 8 of 9 subjects had a positive overall impression while one explained that the design was *"A little boring but if it had been more color it might have been harder to find things"*. Each test subject thought that the design was in line with their expectations, and the result from question 9, which rated the website from 1 to 5, is presented in Figure 31.

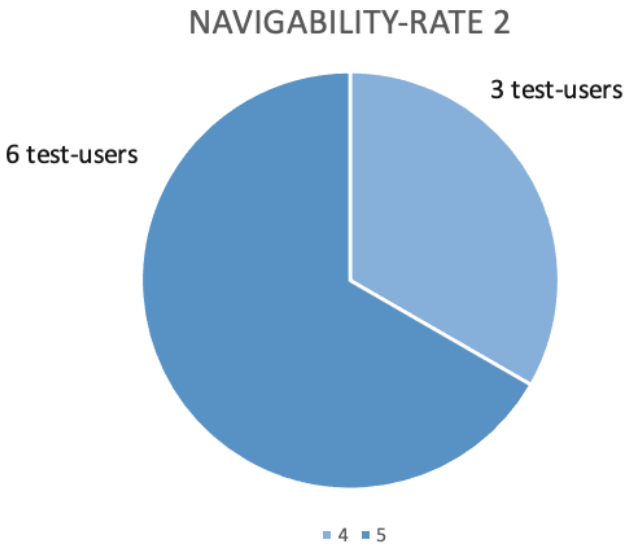

Figure 30: The result of the navigability rate after iteration 2.

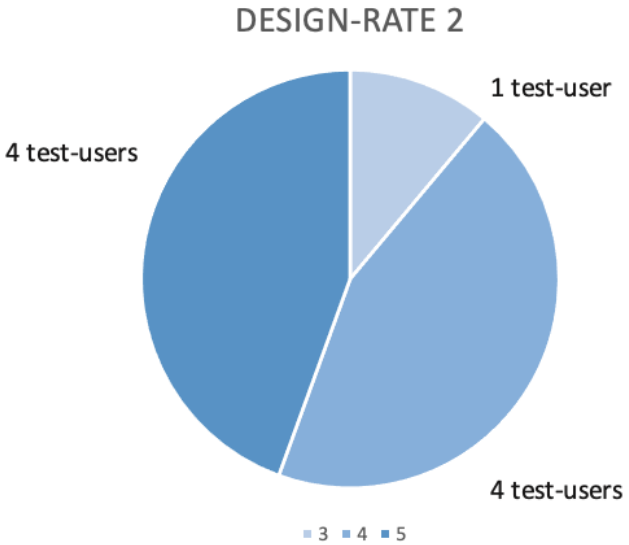

Figure 31: The result of the design rate after iteration 2.

	Test user									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	***Average***
I think that I would like to use this system frequently	4	4	5	4	5	4	5	4	3	4,22
I found the system unnecessarily complex	1	1	2	1	1	1	1	1	1	1,11
I thought the system was easy to use	4	4	4	5	3	5	5	5	5	4,44
I think that I would need the support of a technical person to be able to use this system	1	1	1	1	2	2	1	1	1	1,22
I found the various functions in this system were well-integrated	4	4	4	4	4	5	5	4	4	4,22
I thought there was too much inconsistency in this system	1	2	3	1	1	2	1	2	2	1,67
I would imagine that most people would learn this system very quickly	5	5	5	5	5	5	5	5	5	5,00
I found the system very cumbersome to use	1	1	4	1	2	1	1	1	1	1,44
I felt very confident using the system	5	4	5	4	3	4	5	5	4	4,33
I needed to learn a lot of things before I could get going with this system	1	1	2	1	4	1	1	2	1	1,56
										88

Figure 32: The result of the SUS after iteration 2.

SUS

The last task for the subjects was to answer an anonymous survey, the previously mentioned SUS questionnaire. By comparing the results of this survey with the results of the first usability evaluation, the research team was able to see if the web-based queuing application had improved. The results are presented in Figure 32. As shown, the final SUS result was 88 on a scale from 0 to 100, with an improvement of 4 points from the first test.

5 | Discussion

This chapter discusses the methodology and result of the research, analyzing weaknesses and improvements with the method.

5.1 Results

The following sections discusses the result of the research based on the methodology chosen for the project.

5.1.1 Pre-Study

The anonymous survey conducted in the pre-study showed a great need among students and tutors for a better web-based queuing application used for lessons and lab sessions. The question "What features would you request in a queuing application" was asked to examine students' and tutors' preferences. In terms of how the application should be designed, the answers showed that the majority wanted an application that is easy to navigate, and some also requested an appealing design. These features are directly relevant to the project's research question. The feature "Easy to log in" was also requested by the majority, which is considered to go hand in hand with the feature "Easy to navigate" previously described. As the three functions mentioned above were frequently requested and relevant to the project's research question, these were implemented in the web-based queuing application.

Regarding what functions would be available to students and tutors on the queuing application, the same question showed two particularly in-demand features. The first feature, which was also most frequently requested out of these two, was the feature "Help multiple students at the same time." This is a feature that has an impact on students' and tutors' views on the application's usability since it can quickly reduce the waiting time. However, as the report's purpose is primarily to investigate usability from a navigable and desirable perspective, the feature was not fully implemented. Although when students describe their problems in their queue ticket, there is an opportunity for tutors to quickly get an overview of what the students need help with and, based on this, make decisions about smaller teaching sessions.

The second out of these two functions was the ability to help each other. Also, in this case, a similar reasoning was made about the purpose of the report but with the decision to implement this in the web-based queuing application. By letting the link "Help Student" be available to everyone in the queue and offer students to describe their problems, the feature could be implemented without compromising the application's navigability or design. This is supported by the results of the usability evaluations where the link was not seen as an issue from a navigability and design perspective.

5.1.2 Usability Evaluations After Iteration 1

During usability evaluation 1, the system design, navigation, and usability were generally well-received by the test participants. This was in line with the research team's expectations seeing as the system had been developed in accordance with research-supported navigation and design principles. However, usability evaluation 1 still generated multiple actionable findings which were later implemented and further evaluated during usability evaluation 2. Usability evaluation 1 consisted of three different parts: CTAP, retrospective probing, and SUS. The following sections describe the findings generated through each method in greater detail.

CTAP

As described in 2.5.2, CTAP is a usability evaluation method based on allowing test users to think out loud when performing specific tasks [37]. The method's purpose is to capture the initial impression of each test subject and to use the insights gained to further improve the system in question [37]. The list of tasks used in usability evaluation 1 can be viewed in paragraph 4.3.1.

Six actionable findings regarding design, navigation and usability were discovered in the CTAP-section of usability evaluation 1. Some findings (such as password confirmation when registering and double-checks when leaving rooms or removing queue tickets) had already been anticipated by the research team, whereas some findings were more surprising and thus very important for the next development phase. For instance, the lack of information on admin-functionality had never been discussed by the research team prior to the evaluation. In order to decide which perceived issues needed to be resolved, each issue was thoroughly examined from three perspectives: number of mentions, implementation difficulty, and connection to navigation, design, or usability. Although some of the identified issues (such as button placement and double-checks) were prioritized higher than others (such as Rooms-button visibility), all issues presented in section 4.3 were addressed and rectified. This is because the research team concluded that all of those issues had the potential to increase the system's usability if addressed. Some issues were addressed based on suggestions from test users (given in the CTAP or retrospective probing sections of the evaluation), while others demanded more thought and thus had to be solved through discussions within the research team. For instance, the placement of the "join room"-button was adjusted based solely on direct input from test users. Meanwhile, the lack of information on admin-functionally was missing a specific suggestion for improvement and thus had to be discussed more thoroughly. In the end, the research team concluded that the issue was best solved using a small button containing a question mark icon beside the "Admin" heading.

Retrospective Probing

During the retrospective probing section of usability evaluation 1, each participant was asked a range of qualitative and quantitative questions regarding their experience (see section 3.3.1 to review the complete list of questions). During the qualitative part, most test users expanded their views on issues already mentioned during the CTAP-section of the evaluation, as well as highlighting potential adjustments that could be made to improve the system. Therefore, the issues identified during the qualitative part of the retrospective probing section of the usability evaluation have already been discussed in the previous paragraph.

The quantitative part of the retrospective probing section allowed the test users to grade the navigation and aesthetic design of the overall system on a scale from 1 to 5. The average grade of overall navigation was 4.22 out of 5, which could be considered as relatively high (for full breakdown see Figure 23). However, this was expected by the research team seeing as the website was constructed using well-supported navigation principles previously presented in section 2.2 and discussed in section 5.1.6.

When asked to account for their overall impression of the queuing system, many test users highlighted positive aspects related to navigation. Two of the answers collected can be viewed below:

- *It was easy and smooth to navigate. I think I could have understood and done it without you giving me the tasks. Clear and easy!*
- *Simple application, nice graphic design, few but good buttons that make you understand where to click. Good system with the queue, easy to understand.*

These answers indicate that the navigation aspect of the system was satisfactory and thus supports the research behind it. Although the general grade was relatively high, the usability evaluation still assisted the research team in identifying several issues related to better navigation, which explains why the grade was not higher.

The average grade of the system's aesthetic design was 4.0, which also could be considered relatively high yet expected since the site was developed in accordance with research-supported design principles presented in section 2.3 and discussed in section 5.1.5.

SUS

SUS was used in order to get a quantitative measure of the system's overall usability. The SUS-score after the first usability evaluation was calculated to 84 (see Figure 25 for full breakdown). 84 is considered to be a relatively high score and indicates above-average usability according to Bangor's empirical evaluation of the method [42]. As previously stated, a high usability score was expected since the application was implemented in accordance with

research-supported navigation and design principles, which both greatly affect the usability of a specific system according to previously mentioned research [10], [20], [22], [30]. Potential reasons for the relatively high results are discussed in sections 5.1.5 and 5.1.6.

5.1.3 Changes After Iteration 1

As presented in section 4.3.2 changes were made to some parts of the website during iteration 2 while others were kept the same as in iteration 1. Thereby, the parts that was not changed, such as the color scheme and the design of the buttons were not tested in this study which is why it is not reasonable to say that they contribute to the perceived usability. However, no comments from the user evaluations indicates that these parameters had a negative impact on the usability either. Instead, the measures that were taken are the parameters on which we can evaluate the result and find conclusions regarding their impact on the navigability, desirability and thereby the usability.

Changing the design of the queue-tickets to make it more uniform with the rest of the room-page was one of the measures that were taken during iteration 2. After iteration 1 and during the first usability evaluations the tickets and the text on these were perceived as "too big" by several of the test subjects, especially compared to other graphic-elements on the page. A user's first impression of a web page is strongly affected by its appearance meaning that, in terms of a first impression, the graphical design is often more important than the actual information [28]. When the design of the queue-tickets was too big and not uniform with the rest of the page the graphical design may have been perceived as unpleasant which could have affected the subjects first impressions of the page. Additionally, the graphics to text ratio should be in the span of 1:1 and 3:1 to deliver a sense of being easy-to-use and clear-to-follow [28]. The size of the tickets as well as the text on them may have been out of this span and thereby affecting the perceived navigability in a negative matter.

Another measure taken during iteration 2 was the removal of some functionality for different types of users. For example, a tutor with an admin-account no longer have the possibility to queue-up in a room where the person is admin. Also, the functionality of sharing a room was removed from the regular user-view since it was considered only to be relevant for the tutors. A website with too many graphic elements is likely to be perceived as cluttered which could impact on the perceived aesthetic appeal of the page [31]. By removing some of the buttons that were pointed out as irrelevant during the evaluations the perceived desirability might increase. In addition, navigation is an important aspect on a website as it enables the user to find their way through the website [15]. A good navigability avoids the feeling of being lost among users [15]. Minimizing the possible actions to only those that are necessary for the specific user can reduce the feeling of getting lost and thus increase the navigability of the website.

Another change during iteration 2 was the placement on some of the buttons on the room-page. During the first usability evaluations, some subjects mentioned that some buttons were difficult to find because they were too far down the page. Users often scan pages in an

F-pattern starting horizontally across the top of the page [25]. Placing navigational elements in inconspicuous locations is a factor that reduces navigability [23]. Moving the mentioned buttons to the top of the page can therefore increase the navigability of the website as the buttons are likely to be easier to find.

Lastly, a number on controls were implemented on "dangerous actions" such as a password control when creating an account and double-checks when leaving the queue as a student or deleting a room as an admin. Not having any double-checks on such actions may have caused the users to feel insecure when navigating the application as indicated by comments from the subjects during the evaluations. Adding controls will therefore likely contribute to increased usability.

5.1.4 Usability Evaluations After Iteration 2

During usability evaluation 2, the system design, navigation, and usability were yet again generally well received by the test participants. This was in line with the research team's expectations seeing as the system had been developed in accordance with research-supported navigation and design principles as well as adjusted after previous feedback. Therefore, usability evaluation 2 did not generate that many actionable findings.

Similar to usability evaluation 1, usability evaluation 2 consisted of three different parts: CTAP, retrospective probing, and SUS. The following sections describe the findings generated through each method in greater detail.

CTAP

During the CTAP-section of the usability evaluation, the feedback was mainly positive. This was expected, seeing as the research team had adjusted most of the issues discovered during the first usability evaluation. Moreover, previous research indicates that nine test users are enough to discover 80% of the potential issues, and as there were nine participants in the first usability evaluation, it is reasonable to assume that most issues already had been identified.

Retrospective Probing

There was a significant difference in the quantitative part of the retrospective probing section during the second usability evaluation compared to the first. To start with, the average grade of overall navigation had increased from 4.22 to 4.66. This clearly indicates that the adjustments after usability evaluation 1 greatly improved the overall navigation. The average grade of aesthetic design increased from 4.0 to 4.33. This, too, is a significant improvement and indicates that the minor changes made in the design were enough to boost the user's overall perception significantly. Both results were somewhat surprising since the research

team did not anticipate that the adjustments would cause the grades to change that much. However, the result indicates that somewhat minor issues can impact perceived usability negatively among users even though overall design and navigation are well implemented.

SUS

The SUS-score also increased from 84 to 88 after the adjustments made post usability evaluation 1. This change was less apparent than the changes in overall perceived navigation and aesthetic design and thus more in line with the research team's expectations. A SUS-score of 88 indicates very good system usability, which in turn indicates that TopQ indeed is an example of how one could build a queuing application with great usability by ensuring good aesthetic design and navigation.

5.1.5 Desirability

In this section, the design choices made when designing TopQ are presented. These design choices are also explained from a theoretical standpoint using previous research presented in section 2.3. A discussion on whether the design choices have been successful or not is also held.

Compositional Elements

When designing TopQ, the design and placement of compositional elements was inspired by known research on the subject. The number of compositional elements was chosen with the ambition to fall in the span between "too few" and "too many" [31]. Since these terms are highly subjective, a good result on the design-oriented questions on the user tests was considered as sufficient evidence that the chosen quantity of compositional elements was correct.

Previous research suggests that compositional elements that share symmetry through their content and their placement make for an increased aesthetic appeal [31]. Therefore, both these aspects were considered carefully when designing TopQ. For example, sidebars on the room page were designed in a similar style to create symmetry on the web page. All buttons were also designed with similar styling to increase the number of hidden symmetries one can find on the web page. Designing these compositional elements with a similar style could be one of the reasons why the overall impression of the web page's aesthetic appeal was very good in the usability evaluations. Another reason for the positive outcome of the design-oriented parts of the usability evaluations could be that TopQ was designed with a specific graphics-to-text ratio in mind. As presented in the theory section, a graphics-to-text ratio between 1:1 and 3:1 generally makes for a simplistic web page that is easy to follow [28].

TopQ was designed with this span as a baseline, and choices for ticket size, sidebar width, and image sizing on all the web page was chosen accordingly.

Color Usage

There are many aspects to consider when choosing a color scheme for a web page. When designing TopQ, it was decided that the color scheme was to be based on findings from previous research. Two accent colors were chosen, and all other color choices were made with the intent of not drawing attention from the accent colors. These decisions were made since previous research suggests using the colors that draw the most attention for buttons and navigational elements [32]. All color choices were made with the intent of creating a three-color scheme. According to previous research on color usage, this type of color scheme effectively balances appealing design and simplicity [32]. Since the user tests confirmed that TopQ is a good looking web page, it is possible that the color choices made was successful and that the design-related theory used is correct. However, the colors on the web page was not changed at all between the two user tests, and therefore, no conclusion can be drawn on whether this is actually true or not.

5.1.6 Navigation

As mentioned in section 4.3, the overall result for the navigability received a relatively high number throughout the iterations. This is in line with the expectations since the navigability was based on theoretical background from the beginning. The literature mentions the importance of designing a website so that users feel satisfied and at ease with using it [14]. Well-implemented navigation also helps to counteract the 'lostness' factor that can occur on an overly cluttered and complex site [16], [17]. Based on this, TopQ was designed in order to create an easy-to-navigate and desirable website, where a simple navigation structure makes it easy both to learn and understand what steps to take at the desired time. In its design, TopQ is a stripped-down page with minimal content in addition to the actual functions and pages needed to provide a complete queuing application. This was reflected in the usability evaluations as well, where questions regarding the simplicity and easy-to-use aspect were positively answered. However, some difference in score were achieved between the usability evaluations which could be in aspect of the changes that were done to the application.

One question in the SUS-survey was "I found the system very cumbersome to use." which score decreased in the second usability evaluation. This question can involve multiple aspects and not only navigation. However, since navigation is defined as *"[...] the extent to which a visitor can follow a website's hyperlink structure to locate target contents successfully in an easy and efficient manner"* [13] this decrease in score could be due to the changes that impacts the navigability. Another possible explanation for the score is misunderstanding of the question. The user subject answered the similar questions "I thought the system was easy to use" with a score of 4 on a 1 to 5 scale and "I found the system unnecessarily complex"

with a 2. These answers are a bit contradictory to the first question and argumentation can be made that the answer that stands out is the first one and could possibly be due to misunderstanding.

Links

The link structure and positioning of elements have a particular impact on an application's navigability. With this in regard, several methods were used on TopQ to clarify the elements that enabled navigation on the page. Underlined links in the footer, rounded buttons in the navbar, and a uniform color theme are concrete examples. The naming of links within TopQ is also supported by previous research. Some names are perceived by habit as navigational elements, and incorrect use of this can lead to confusion among users [24]. This was considered when naming buttons, primarily in the navbar. One question in the user test was "I thought the system was easy to use", where the results were mainly positive, which could be due to both the research-supported navigational structure and the user-input changes that were made.

Placement

The positioning of content within TopQ has also been made to further increase the navigability and usability of the website. The key elements and functions that users need during a lab or lecture have been placed at the top of the pages to make them easy to see which is in line with the common F-pattern that users use to scan a webpage [25]. The positioning is also important in order to give a natural experience and eliminate the time spent searching for the desired button/action. This is supported by previous research, which mentions that placement in inconspicuous places reduces the navigability [23]. This was addressed from the start but also between the usability evaluations. The exact position of some buttons on the "Room"-page page was adjusted between the iterations since comments about somewhat inconspicuous placements were made in the first evaluation. Positioning elements according to both previous research and user suggestions could be contributing factors to the improvement in the second set of usability evaluation.

Further, navigational elements should be placed at the same place throughout the different pages of an application [24]. However, the different pages in TopQ do not contain a multitude of navigational elements and functions that exists in multiple pages, which makes this a rather small part of the implementation. The login and register page are one example where consequent positioning is used. The navbar and footer are also kept the same throughout the website, with the difference being the logged in vs. logged out view. One change that were made between the test was which buttons were visible for the users at different times. For example the "Room"-button's placement in the navbar was commented by a few users. The action was not to move the button but instead make it visible only if the logged in user was not at the "Room"-page in order to avoid confusion. The increase in overall navigability

and in questions such as “I found the system easy to use” could be based on changes like these.

5.2 Method-criticism

This section discusses the study’s methodology and analyzes any weaknesses that may have affected the study’s result.

5.2.1 Survey

During the pre-study, a survey was conducted to analyze the market for a web-based queuing application. The survey consisted of questions shown on a single page, which made it possible for the respondents to see all questions when they open the survey. This might have been a disadvantage if the respondents thought the survey was too long and did not answer the questions for that reason. Furthermore, the survey had questions regarding both the interest in a web-based queuing application as well as key features in a potential queuing application. Another disadvantage of the survey was that a large part of the questions were about the respondent in order to get the right target group, which may have removed the focus from the key questions. For certain questions in the survey, the respondents had the opportunity to fill in their own answer alternative to capture more information on, for example, missing features in the currently used queuing-solutions. If the question was not clearly formulated and accurate, the answer could have been affected. Furthermore, the survey was distributed to students and tutors at Linköping University, so in a context outside of Linköping University, it is not possible to assess validity which is why it could have been of interest to have respondents from other universities as well. Additionally, the survey was quantitative and one could argue that having a larger number of respondents would result in a more substantiated results and conclusions.

5.2.2 Prototype

The result of the survey was discussed within the research team, and a prototype of the application was made in Figma. The prototype was used only to make the initial part of the front-end development of TopQ easier, and for that reason, Figma is not discussed as one of the tools in this report. The research team applied an iterative method working on the project, which made it possible to receive continuous feedback on the work from the other group members, supervisors, and test subjects. It was, therefore, possible to find problems with the implementation at an early stage before certain functions were too deeply integrated into the system. One way that the amount of user input could have been increased is if users gave input on the prototype before the implementation began. However, due to a lack of time, the research team decided not to let users give their input on the prototype, and instead started the development right away.

5.2.3 Usability Evaluations

The CTAP method was used during both usability evaluations to gain insight into how the test subjects processed information when performing the various tasks. The method worked well, and none of the test subjects experienced any difficulties thinking aloud while performing the tasks. The prior logical puzzle was appreciated by the test subjects to practice the CTAP-method. If more time and greater access to test persons had existed, a larger test group could have been chosen to increase reliability. The size of the test group was 9 people for each test, an assessment that, according to previous research [36] is considered an optimal number for CTAP and Retrospective probing. However, one could argue that the number of test users is insufficient when drawing conclusions from the SUS-questionnaire seeing as quantitative surveys usually require a greater number of respondents than qualitative studies. However, as specified in section 2.5.5, previous research has shown that the SUS-questionnaire still provides a great assessment of the overall usability from only 8-12 respondents [46]. That is why the research team felt comfortable using the survey even though the number of respondents was limited to nine.

The test subjects consisted of both students and tutors. The students varied between the tests, but the tutors were the same due to the time-aspect as well as the difficulties in finding tutors that were available for user evaluations during the right period of time. When the tutors performed the user evaluation for the second time, they already had good knowledge of the system. This fact may affect the result. The fact that they already knew the data and were familiar with the web-based queuing application TopQ could affect the result and validity on their perceived navigability as learning how to use the web-site is an important factor that affects navigability. Furthermore, it could have affected the results that the tutors had tried both versions of TopQ and therefore easier could make comparisons among the two versions.

Initially, the idea was to have the exact same tasks and questions in both of the usability evaluations. However, as the subjects during the first evaluation requested some new functionally, the possibility to change description on the queue-tickets, a decision was made to add a task on that functionality in the second evaluation. Not having the exact same tasks in both evaluations could have had an impact on the results validity. However, the questions were the same, no tasks were removed and only one was added making the difference among the two evaluations rather small.

Multiple issues were raised by only one person which made it difficult to assess which areas for improvement would be considered important and thus necessary to address. When similar views were mentioned by several test subjects, it was easier to conclude those issues as important, and therefore focus on those in the implementation. Each issue was discussed within the research team after the usability evaluations and was categorized based on the three perspectives: *Number of mentions*, *Implementation difficulty*, and *Connection to navigation, design or usability*. The implementation continued after every issue was divided into the categories: *Implement*, *Implement if time is left*, and *Do not implement*.

One could argue that the lostness method ought to have been used when evaluating navigability. However, since the application design was quite one-dimensional and most potential tasks could be performed using one or two clicks, the research team decided that the method would not provide any useful or insightful results.

The research team hoped to perform user evaluations with as many students and tutors as possible. However, it has proved difficult to randomly select test subjects that could be included in the usability evaluations. Most of the test subjects consisted of students whom the authors of this report knew and that, in many cases, study or work at Linköping University. The fact that all subjects had similar background could have affected the results. Having test-users from additional schools and universities had most likely given a more nuanced result. Furthermore, since usability evaluations were performed by all members of the research team, it could cause uncertainty if the test subject received extent different information depending on whom held their evaluation. When different persons describe the evaluations, certain parts might get highlighted more than others during the presentation, which can affect the test result.

5.2.4 Source Criticism

Since most of the sources are scientific articles published in journals or conferences, reliability is considered high. The research team focused on using academic, peer-reviewed sources to be as reliable as possible when writing the theoretical background. Web development is an area under constant progression and characterized by continuous and rapid change. This means that scientific articles quickly become outdated. The research team aimed to use as recently published articles as possible, preferably within 10 years from today. The field of usability and test evaluations are not outdated as fast as web development, which makes older references relevant to a greater extent, for example [16], [24], [45]. In addition, some articles refer to other scientific articles long since their publication, but these still contain information and theory relevant for this project, for example [9], [14], [39]. Although some information in these articles is outdated, there is also a lot of relevant information.

Some theoretical topics are mentioned with only one source supporting it. Although the sources are scientific and could be considered reliable, multiple different sources would increase the validity of the specific topic since there could be subjective thoughts even in a scientific source.

5.3 The Work in a Wider Context

The following section primarily discusses how the work conducted in this study can affect society in a broader context.

5.3.1 Ethics of Accessibility

The main focus of the study is, as previously stated, how to design a queuing application to deliver good usability. This can, however, be viewed as part of the greater subject of developing good and helpful IT applications for educational purposes. The increasing use of these types of applications in education is often primarily motivated by the overall gain in efficiency they promise to provide. This might be true in most cases, but there is always a risk that new tools work better for some than others. For example, a digital tool like TopQ might work great for a student with a well-functioning computer or phone and previous technical experience, but it risks not providing the intended results for students with less favorable positions. This is, of course, something that has to be taking into consideration, both when implementing tools like TopQ and when integrating them into education. However, these risks will always be present and should be considered while working with these types of applications.

5.3.2 Ethics of Lucrative Design

Developing a good design for a tool like TopQ is, especially ethically speaking, quite different from delivering good design to, for example, an e-commerce store. The main difference is how the user relates to the revenue model. For e-commerce, the design and navigability of the site can affect the spending decisions of a customer, which might not always provide additional value to the customer. This stands in contrast to technical tools such as TopQ, where the application's usability has a stronger relationship to the perceived value of the user instead of the revenue of TopQ. Therefore, the primary conclusion is that it can be considered favorable, ethically speaking, to improve the design of a digital tool in contrast to, for example, e-commerce.

6 | Conclusion

The project's purpose was to investigate how a web-based queuing application can be designed to deliver good usability based on the factors design and navigability. To achieve this, the following research question was formulated:

How can a web-based queuing application for lab and tutor sessions be designed to be both navigable and desirable in order to deliver good usability for students and tutors?

The result, which was obtained through iterations of research-based development combined with feedback from usability evaluation, indicates that, although development based on theoretical principles results in high usability, usability evaluations are necessary to increase perceived usability among actual users further. After further reviewing the results of the usability evaluation in combination with the research-supported principles used in the development phase, the following conclusions have been drawn:

- The design of the queue-tickets in the first usability evaluation was perceived as "too big" and not uniform with the rest of the page. By changing these and thus making the design on the ticket side more uniform, the design could be perceived as more appealing based on the outcome of the second test, which indicates that a uniform design is preferable.
- The second measure taken in iteration 2 meant removing functionality that was not relevant to specific users. Studies [31] show that websites with a lot of functionality can be perceived as cluttered. As these unnecessary functions were removed before the second usability evaluation, many considered that the website was uncluttered, which indicates that the functionality should be kept to a minimum and that there should only be relevant things.
- Another measure taken in iteration 2 and which mainly affects the navigability is the placement of the buttons. When these were moved to more conspicuous places, as mentioned important in the theory [23], the result and navigability were improved based on the fact that the test subjects did not find it as difficult to find the buttons.
- The measure of adding double-checks on "dangerous actions" helped increase the navigability as the subjects felt less insecure navigating the website after these were added.

Based on all the measures taken during iteration 2, including those listed above, it can be concluded that they had a positive impact on navigability and design, and thus usability. This conclusion can be drawn as the change has led to an increase in the SUS score from 84 to 88, which indicates very good usability. Based on this, TopQ has shown how a web-based queuing application can be designed to deliver good usability by following well-supported aesthetic design and navigability principles in combination with usability evaluation, and thus answering the research question.

Suggestions for Future Work

If work on the TopQ platform would be continued, the feedback from the usability evaluation together with suggestions from the research team highlights some potential features to implement next.

A potential feature is that the students, instead of writing a message in the problem description, could use some tag system to communicate to the tutors and other students what they need help with. Using tags instead of text was a part of the initial prototype of TopQ but was later removed due to time constraint issues. Using tags instead of text has multiple potential benefits. Firstly, using tags could make it easier to analyze which students require similar help. This could be achieved visually by, for example, coloring the possible tags in different colors to make it easier for the tutor to get an overview of who needs help with what. It could also be achieved more directly by adding the feature to sort and filter for different tags. Using tags can also improve the experience for students to create tickets as it can be both faster and more intuitive than writing plain text.

Another feature suggestion, which is also related to usability, is to add some interactive tutorials of the system on the first usage. The users are currently informed about the features of the platform via text and manual exploration. Some results from the usability evaluations suggested that some features were hard to understand. An improved walkthrough for new users might help solve this issue. If TopQ would be developed further, one should keep in mind that new usability evaluations might be required to ensure the quality of these new features since the previously conducted evaluations only cover the current set of features.

Regarding the research part of the work, multiple related questions out of the scope of this study could be relevant to investigate further. Many of these related questions are relevant since the field of digital tools in education is highly relevant in general. The primary focus of this paper is web-based queuing applications, but it could be interesting to conduct further studies with similar digital education tools such as tools used for online examination. This study also primarily focuses on university students; it could also be helpful to investigate whether the results would be similar for other educational groups. Since the study is limited to the question of how these types of tools should be designed to achieve good usability, it would potentially be helpful to investigate further how the tools affect the overall quality of education in the broader sense.

Lastly, the decision was made not to change certain things based on the fact that no indication was given that it was negative in the usability evaluations, e.g., selection of color scheme and color of the buttons. As these items have not been specifically tested, including how changing them affects navigability and design, no conclusion can be drawn as to how it contributes to usability. It is worth mentioning, however, that these have been developed in accordance with the theory and many test subjects have had positive opinions about these factors. Further tests and research on those aspects could have been of interest to, in a even wider sense, be able to answer the research question.

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APPENDIX

Part II

Appendix

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A | Marketing Plan

A.1 Introduction

This section introduces some background information on why the research team want to develop our business idea. Additionally, our vision and the business idea are specified.

A.1.1 Background

The authors of this report are all students who on a regular basis utilize different queuing applications for student/tutor sessions in their studies. Most of the time there are more students than tutors, and the queuing applications are used to let the tutor know who is next in line to ask questions. The idea for this project is partly based on the authors' collective belief that queuing applications are more extensively used now than ever due to an increase of distance education because of Covid-19, and partly on the belief that there are no queuing applications designed specifically for student/tutor sessions. For these reasons, a survey study was issued to investigate if there is a demand for a queuing application made specifically for student/tutor sessions amongst Swedish students (Appendix B). Many respondents stated that they were interested in this type of system, and that it would be convenient to have one queuing system to be used in all their courses.

A.1.2 Vision and Business Idea

Our vision is to create a queuing application that satisfies a student's every need. Our business idea is to create a web-based queuing application specifically designed to be used in student and tutor sessions at schools and universities. The queuing application should be developed in a way that makes it easy for students to log on and have all their queues in one place. It should be easy to understand and to navigate, and it should meet the increased demand of queuing applications amongst students.

A.2 NABC-Analysis

Need

The use of technology and digital tools for educational purposes is increasing, in particular, due to the outbreak of the coronavirus [1]. At the same time, the role of the teacher in the students learning process is different today than it was before when teaching mostly consisted of providing knowledge to the students through traditional lectures [2]. For those

kinds of activities, there are many digital tools available. However, today a much bigger part of teaching involves interaction with students and encouraging them to learning through participating [2]. When, in addition to that, the classrooms are online, teachers and tutors need a simple and effective way to keep track of everyone who needs help and interaction and whom of them to deal with first. Due to limitations in digital skills, the pressure on both teachers and students is increasing with the need to educate online [1]. The huge variety of platforms and tools that are used in different courses today affects the students overall experience of online education [3]. If, in addition to that, the tools are difficult to understand it will affect the quality of the education since learning how to use all of them will be time-consuming, time that is taken from the actual education.This indicates that there is a need for a digital, web-based queuing application, intended to use both for lab- and tutor sessions, that is easy and straightforward to use and navigate in.

Approach

To fulfil this need a web-based queuing application for lab and tutor sessions will be developed from scratch. This application will be designed to offer an easy-to-navigate user interface to help the users, both students and tutors, on how to use it for their own purposes. Furthermore, the website will be comfortable to navigate and offer a uniform and appealing design throughout the whole website. The development will be based on empirical studies in research-based design and navigation principles and the process will be agile as an evaluation will be made by the users in the middle of the development process. All of this to provide great perceived usability. This web-application offers the schools and universities the possibility to have one single digital tool used for the purpose of queuing to get help on lessons and lab-sessions. Additionally, the application will provide possibilities to make lessons and lab-sessions more efficient since the student will be able to add a description to their tickets in the queue to show what they need help with, making it easy for tutors to help several groups at the same time and for students to help each other. To conclude, our web-based queuing application will save valuable time in education, both for teachers and students, by offering a uniform, effective and easy system for queuing on lessons and lab-sessions.

Benefits

Our queuing application for lab and tutor sessions will be easy to understand, use and navigate. Additionally, it will deliver an appealing design. All of them are factors requested by many of the respondents in the survey done in the pre-study (Appendix B). This will result in the following benefits for the schools and universities:

- In the survey done in the pre-study, many respondents stated that they think it would be easier to have the same system on all courses. Also, the respondents requested that the queuing application should have many of the characteristics our application will

have. By using this application, satisfaction among both teachers and students will increase, which will show in increasing motivation and study results.

- Investing in the application will make it easier for the employed teachers. They will not have to put working hours into learning and figuring out how to solve the problem of a system for queuing on lab- and tutor sessions. It is better if the school has a system for this which all teachers get to learn one time, and then it will work smoothly on its own, giving the teacher the possibility to focus on the quality of the education.

- Satisfied students and employees together with good study results will give the school a better reputation.

Competition

What can be identified as competitors is the systems currently used for the same purposes as our application. These were identified, through the survey done in the pre-study (Appendix B), as:

- Zoom
- Teams
- Camedin
- Discord
- Excel

The majority of the identified competitors are not meant as a queuing system in the first place but used for that purpose by different solutions from teachers and tutors. In reality, some of these competitors may act as a partner for TopQ which will function only as a queuing system and as a complement, the schools will have to use a digital tool for web-meetings, such as Zoom or Teams for example.

A.3 External Analysis

The external analysis was done using a PEST-analysis and Porter's five forces. The results from these two were put together and presented as a SWOT-analysis.

A.3.1 PEST-analysis

Political Factors

One big change in the politics in Europe recently was the GDPR legislation which came into force in May 2018 in all EU-countries. GDPR includes rules and regulations regarding the handling of personal data which all companies have to know of [4]. If TopQ collect and handle any personal data, it is important to take this into consideration and make sure to follow all the rules in the GDPR legislation.

Another legislation that may affect our application is the Swedish Public Procurement Act. Probably the expense the schools will pay for our application will not reach over the threshold for public procurement [5]. But if it would, it could affect our application as it affects the buying process and how it should be implemented.

Economic Factors

Regarding economic factors, for the application to be successful there is a need for schools and universities to want to invest in it. In Sweden education is free and the wealth in the schools depends on how much money is budgeted for education by the government. This means that the economic situation for schools and universities depends on the overall economic situation in Sweden. In the Swedish governments budget proposal for 2021 the budget for education and research is presented as follows:

Table 1: Budget-proposal 2021: Education and Research (billion swedish crowns) [6]

2019, outcome	**2020, prognosis**	**2021, estimated**	**2022, estimated**	**2023, estimated**
78.5	82.9	91.2	90.8	89.5

This indicates that, according to the proposal, the economy of schools and universities will remain at the same level in the coming years, which is positive for our application.

Social Factors

Statistiska Centralbyrån (SCB) reports that the number of people in Sweden who choose to further their education after high school is increasing [7]. This is a social factor which is affecting our offer in a positive way as our application aims towards schools and universities. It indicates that there will be a continuing need for our solution.

Technological Factors

The increasing use of technology for educational purposes, especially due to the current global pandemic, is a factor that is favorable for the queuing-application. Going back to physical education after the pandemic can pose a potential risk as the need for digital tools might not be the same. However, in a study done at Linköpings University by Sajadee, during physical education, Sadjadee came to the conclusion that electronic queuing by using a digital queuing-system is effective, also in classrooms, since the students' waiting time for assistance is reduced significantly [8]. This leads to great opportunities for the application to establish as a digital tool adding value to the quality of the education, during the pandemic as well as after.

A.3.2 Porter's Five Forces

Customer Bargaining Power

In order to study the bargaining power of customers, the ability to replace the offer with something else is studied [9]. If there are many choices for the customer, this means that the bargaining power is high and vice versa if the options are few [9].

As seen in the result of the pre-study (Appendix B), the schools and universities already have other solutions used for the same purposes as the queuing-application. Often, the digital tools they are using are free or included in some package of programs that the schools already pay for. Given this, the customer's bargaining power is rather high. However, our application will be developed only for the purpose of efficient queuing and in accordance with the previous research of being navigable and having an appealing design. The survey showed that an application with all these advantages does not exist on the market today which makes customers' bargaining power somewhat lower.

Suppliers Bargaining Power

The suppliers' bargaining power depends primarily on how many suppliers there are that offer the same service or product, how easy it would be to replace a supplier and how much of the finished product is dependent on the suppliers [9].

Our service is an online web-application. The resources needed are programming- tools and languages. In addition, networks are required to use the service. All resources are delivered by rather many suppliers and there are a lot of options for TopQ if any of them will need to be replaced, given this, the supplier's bargaining power is quite low.

Threats of Substitutes

When the substitutes are studied, consideration is given to whether it is easy to exchange the service or product for another that meets the same needs and how good the substitutes are compared to our offer [9].

Through the survey done during the feasibility study the programs currently used for the same purpose as our queuing-system was identified. The majority of these programs do not have a function for queuing which makes them substitutes and not direct competitors. Using these programs, the teacher have to come up with their own solution, for example queuing through messages in a chat. A result of this is that every queuing-system works differently, even if they use the same program.

The identified programs are for example Zoom, Teams and Discord. The advantages of these substitutes is that schools often do not have to add any new expense to use them, since the programs are usually included in some kind of package which they already pay for. Meanwhile, a big disadvantage is that the main purpose of the program is not to be a queuing-application which results in different instructions on how to use them for every course. Our application however, is niche to be only a queuing system, therefore it offers many advantages which will be worth paying for.

To conclude, there are a threat from substitutes since the schools often already use them for the same purpose as our queuing-application. However, the advantages TopQ is offering reduces that threat.

Threat of New Entrants

The threat of new entrants depends on the barriers to entry on the market [9]. High barriers reduce the threat while low barriers make it bigger [9].

The market in which TopQ operate has low barriers to entry. If you have knowledge in programming, all you need is a web-platform and programming- tools and languages to develop a system to fulfil the same need as ours. This indicates that if our application experiences high growth, there is a great risk for new entrants to show up on the market.

Internal Competition

The level of internal competition primarily depends on the number of current competitors on the market and the differences among them [9].

The internal competition was identified through the survey in the feasibility study. It can be stated that there are currently not many direct competitors in the market, but instead several substitutes were identified (see the heading *Subsitutes*). One other application that

could be identified as a direct competitor was Camedin which is a web-based application with the primary use of being a queuing-system for students and teachers[10]. However, Camedin offers a somewhat unappealing and simple design and lacks the feature that students can describe what assistance they need giving the teacher a possibility to help several students at a time.

Based on the reasoning above, the internal competition is rather low.

A.4 Competitor Analysis

The competitors to the queuing system are the systems currently used by tutors and students for the same purposes as our application. As previously described, these were identified through the survey done in the pre-study (Appendix B).

Camedin

Camedin is a web-based queuing application designed for educational purposes where students put themselves in queues and tutors assist them in order. They describe themselves as *"an ongoing project [...] which can improve student-student, student-teacher, and teacher-teacher interactions"* [10]. Camedin offers a trial version with one free course containing one lab session for each account, otherwise, the prices are 1.5 USD /course/lab session, around 12.5 SEK [11]. According to their tutorial page, Camedin requires login through a Google account for the manager and assistant, while the students access the lab sessions through a link and password.

Some of the advantages of Camedin is that the system's primary purpose is to be a queuing system and that the student's place in the queue is visible. However, Camedin lacks the ability to describe the kind of assistance the students need and offers a somewhat unappealing and easy design.

Discord

Discord is a voice, video, and text communication service mainly used to meet and talk to friends and communities. The system was originally designed for communication while playing online games but is today used for several other things, including queuing for educational purposes [12].

A disadvantage of Discord is that the system is not mainly used as a queuing system and therefore provides several other inapplicable features. On the other hand, Discord provides the ability to tag messages, call, and video chat directly through the system while at the same time allowing students to share their screens [13].

Microsoft Teams

Microsoft Teams is a web-application used for team collaboration that runs across mobile devices and desktops. The application provides chat, meeting, call and collaborate functions and prices vary between $20.00 user/month, around 165 SEK, to free of charge [14].

While Microsoft Teams is a well-known application, and often used for queuing purposes based on the survey done in the pre-study (Appendix B), it features various other inapplicable features.

Zoom

Zoom is a cloud platform for video, voice, and content sharing that runs across mobile devices and desktops [15]. The price varies from $240 /year/license, around 2000 SEK, to free of charge which offers group meetings up to 40 minutes [16]. Zoom during lab sessions and lessons often use breakout rooms which splits the participants into different breakout sessions where the students use the "Ask for Help" button to receive help. The host will consequently get a notification and is able to join the student's breakout room [17].

While Zoom is a simple video, voice, and content sharing application it lacks the functionality to place students who need assistance in a queue. Consequently, the tutors are unable to assist the students in a correct order.

A.5 SWOT-analysis

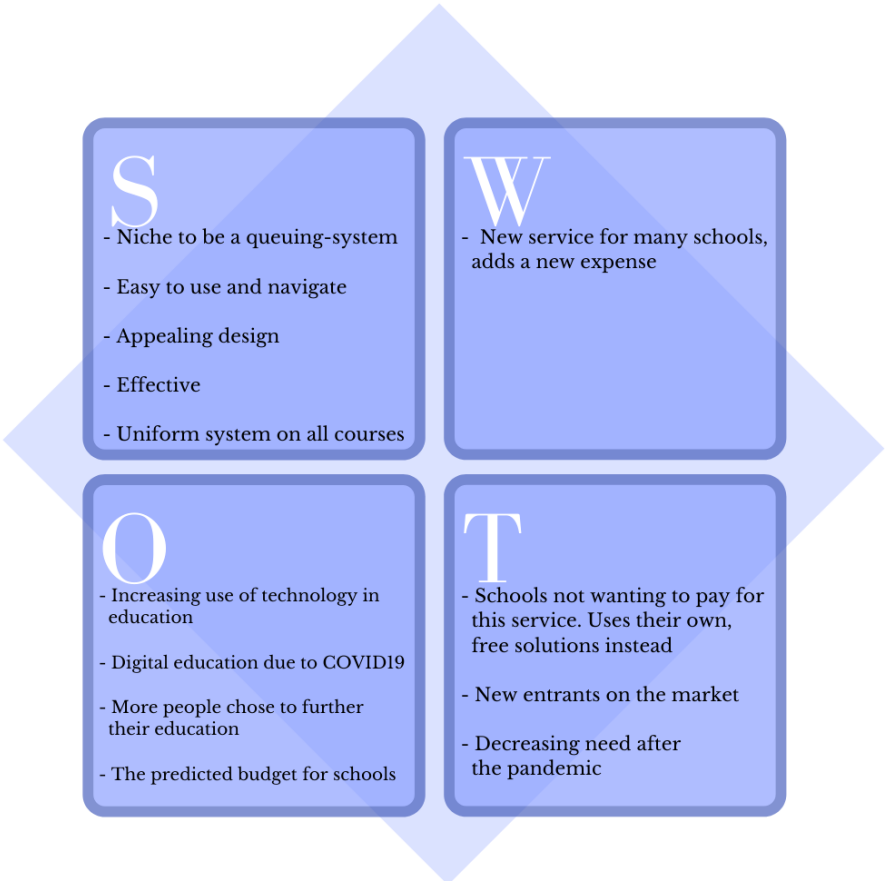

Figure 33: Illustration of the SWOT-analysis

Strengths

The identified strengths are that the application is designed and niche to be used for one purpose, as a queuing system. It gives the schools and universities the possibility to have one single, uniform, tool for this purpose, and the instructions on how to use it will be the same for all courses. Additionally, the application will fulfill the need of being easy to use and navigate and at the same time deliver an appealing design.

Weaknesses

Using our application will add an additional expense for the schools. Currently, most of the teachers are using a tool which the school already pays for, and then come up with their own solution for it to fulfil the need of a queuing system. As a result, the fact that our application will not be free for schools to use can be identified as a weakness.

Opportunities

The identified opportunities are the increasing use of technology for educational purposes, especially during the current global pandemic. Additionally, an increasing number of people in Sweden chose to further their education which indicates that there will be a continued need for our solution. Furthermore, in the government's budget-proposal it seems like the economy of schools and universities is only getting better in the next few years which hopefully result in a possibility to invest in our application.

Threats

Regarding threats, the identified ones were that schools would not be willing to invest in this new service and instead use their own, free solutions. Low barriers to entry make the possibility of new entrants on the market a threat. Furthermore, a decreasing need for digital tools after the pandemic can also be seen as a threat. However, as discussed in A.3.1 PEST-analysis, there is a need for this kind of system in physical education too.

A.6 Marketing strategy

A.6.1 Market Goals

In order to make sure the goals are clear and reachable the research team uses the SMART-approach. SMART is an acronym that stands for Specific, Measurable, Achievable, Relevant, and Time bound [18]. Based on the NABC- and external analysis, and with respect to the fact that the aim is to create a navigable and desirable queuing application, the following goal is defined:

> *TopQ aims to, within two years, possess 10% of the market share for queuing systems used in Swedish schools and universities.*

A.6.2 Customer Segment

The research team use customer segmentation to target the right customers for TopQ. A common strategy for B2B marketing is by segmenting them through *firmographics, tiering, needs, customer sophistication* and *behavioural factors*. *Firmographics* can be used the same way as B2C marketers use the factor demographics while the *behavioural factors* looks at the way the current customers use your product or solution. The segmentation through *tiering* is based on how well the customer matches the offer's market goals while the factor needs are based on what customers are looking for. In terms of the *customer sophistication* factor, the question is not whether the customer needs the service but rather why they need your service, in other words, what distinguishes it from the competitors they already use. [19]

Based on the NABC- and external analysis previously presented, the *needs* factor can be used to segment the customers due to the fact that there is an increasing need for effective solutions during online lessons and lab-sessions. In addition, the survey done in the pre-study (Appendix B) shows that schools and universities currently use systems for this purpose, hence the factor *customer sophistication* can be applied. As a firmographic factor, TopQ will be limited to Sweden. Thus, the customer segment can be seen as Swedish schools and universities.

This customer segment represent the buyers and is therefore the most important one for the offer. However, it is important to keep in mind that TopQ is created primarily for students and tutors due to the increasing need for a uniform web-based application. Thus, the customer segment for TopQ can be summed up to:

- The buyers - Swedish schools and universities
- The users - Swedish students and tutors

A.6.3 Customer Offer

TopQ will offer schools and universities a uniform web-based application for the purpose of queuing to receive help on lessons and lab-sessions. Moreover, the service aims to optimize usability through appropriate navigation structures and proven aesthetic design principles. Consequently, TopQ will offer students and tutors a queuing application designed to be navigable and desirable.

A.6.4 Positioning Map

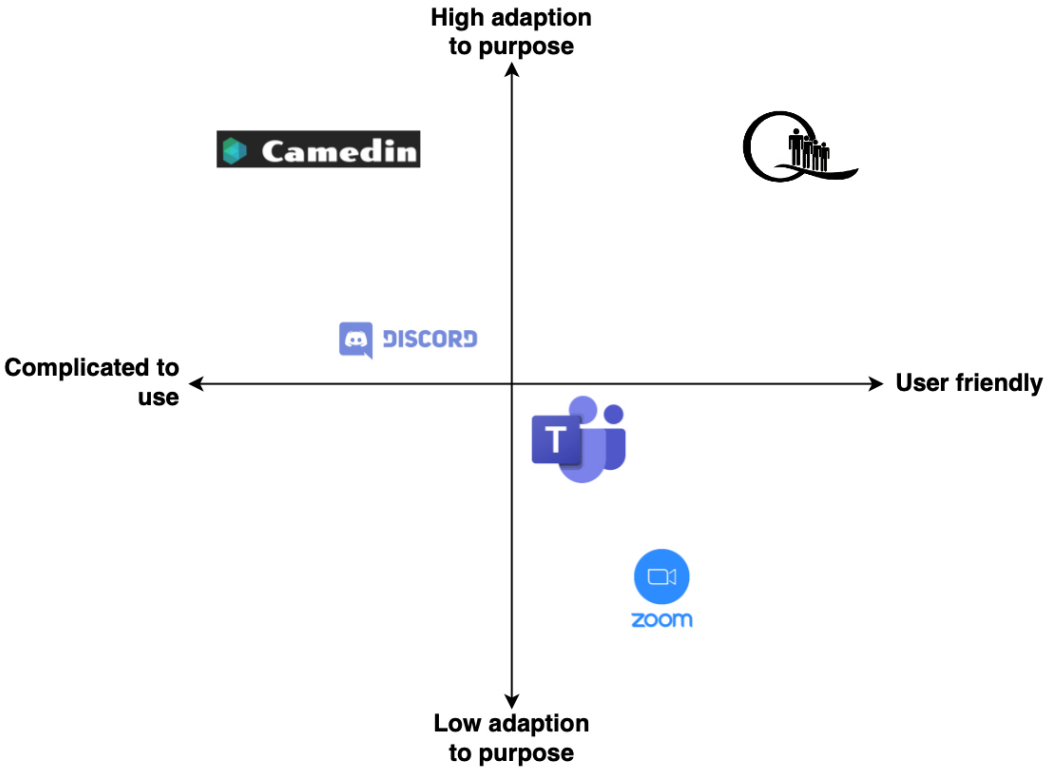

Figure 34: Positioning map of TopQ compared to competitors

The positioning map shows TopQ compared to the competitors listed in A.4 Competitor analysis. As seen, the axis *user friendly* and *adaption to purpose* have been chosen. This since the purpose of the web application, as previously described, is to offer a universal and usable system that can be used in several courses.

As seen in the Figure 34, TopQ is placed in the upper right corner and is thus able to differentiate its offering from its competitors. The other competitors in the positioning map are placed accordingly to the analysis presented in A.4 Competitor analysis.

A.7 Marketing Mix

In this section, the four Ps model is used to develop a marketing mix. The model introduces the following four main areas that the marketing mix will be centred around: product, price, place, and promotion [20].

A.7.1 Product

TopQ is a web-based queuing application specifically created to be used during student/tutor sessions. The application is supposed to be used for every course that requires a queuing system, thus creating value for students and tutors that do not have to spend time learning multiple systems in different courses. TopQ is developed with appropriate navigation structures and proven design principles to ensure high system usability. The high system usability adds value for both students and tutors as it simplifies the way lab/tutor sessions are held and lets the users focus on learning. The following figures illustrate a prototype of the landing page and the room page of TopQ:

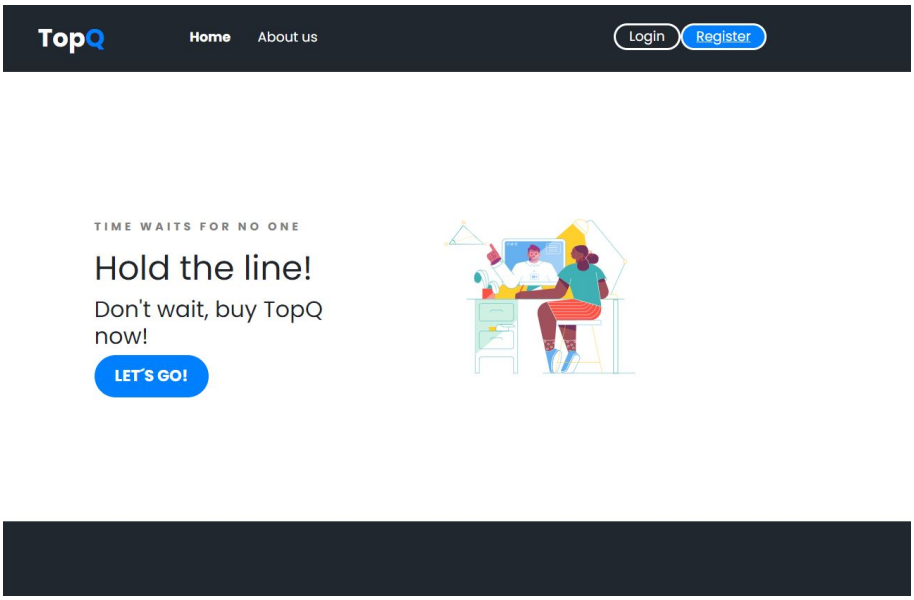

Figure 35: Prototype of TopQ's landing page.

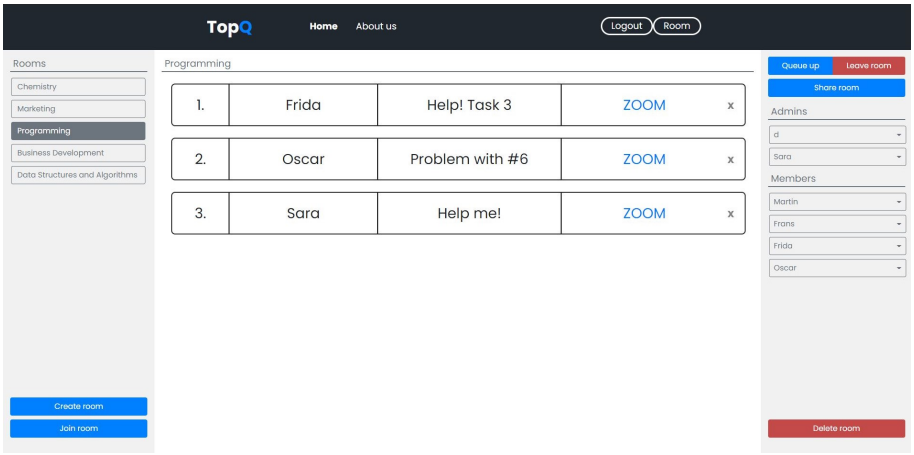

Figure 36: Prototype of TopQ's room page.

A.7.2 Price

The main objective of TopQ is not to be profitable. As the market goal specifies our goal is to possess 10 percent of the market share for queuing systems used in Swedish schools and universities in two years. To reach this goal, it is important to have a competitive pricing strategy. This means that the price should be set as low as possible, preferably lower than TopQ's competitors. This pricing strategy ensures that TopQ is a competitive alternative when it comes to pricing and makes it possible for TopQ to gain market shares quickly.

Students do not have to pay to use TopQ, they are able to join course rooms and use the queuing-related features without paying. Teachers and university employees should be able to create new rooms and use a set of admin features. To separate students from teachers, there will be two types of accounts on TopQ. Student accounts with limited features will be free, and teacher accounts with upgraded features will be payed for monthly. The teacher accounts are called premium accounts, and they are bought as bundles by universities. The pricing for the premium-account bundles is presented in the following figure:

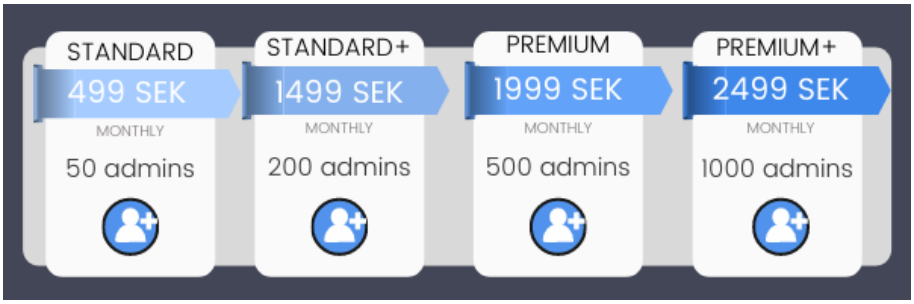

Figure 37: TopQ premium account bundles with pricing.

A.7.3 Place

All interaction with TopQ will be made through the web application. Communication with students, tutors, TopQ, and payment related interactions will be handled through the same web page. TopQ will be released on the Swedish market, with Swedish schools and universities as its primary costumers.

A.7.4 Promotion

The relevant costumer segment is primarily Swedish schools and universities. To reach these organizations, business to business marketing should be applied. The marketing will be done through direct contact with universities. The research team will look at which universities are likely to benefit from TopQ and then contact these universities directly in order to promote TopQ. Since TopQ is not the only solution for queue handling available it is important to promote our application in a way that make organizations understand the value TopQ provides that other services do not. In other words, it is important to focus on what differentiates our product from the competitors.

Since TopQ is meant to be implemented throughout entire organizations, individual sales are likely to result in a high number of users. Under the assumption that TopQ becomes an appreciated application, it is expected that promotion through word-of-mouth will further increase TopQ's growth once a few sales have been made.

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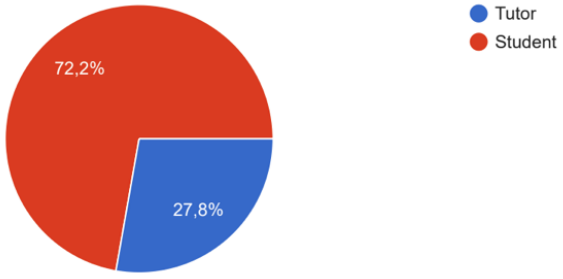
B | Survey Conducted in the Pre-Study

This appendix contains a summary of the survey conducted in the pre-study, with the aim of examining the need for an web application used for queuing. The survey was conducted anonymously online using Google forms and contained 10 questions regarding students' and tutors' current situation and the need for improvement.

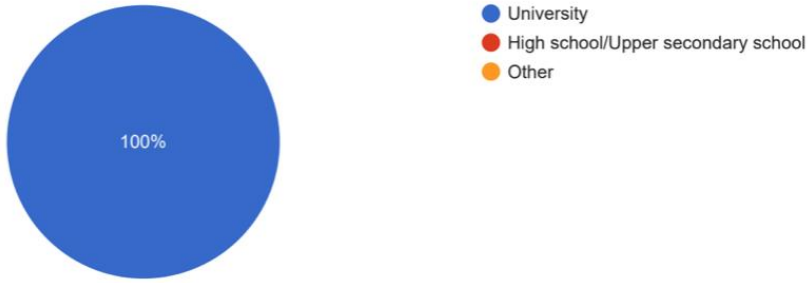
Are you a tutor or a student?

42 svar



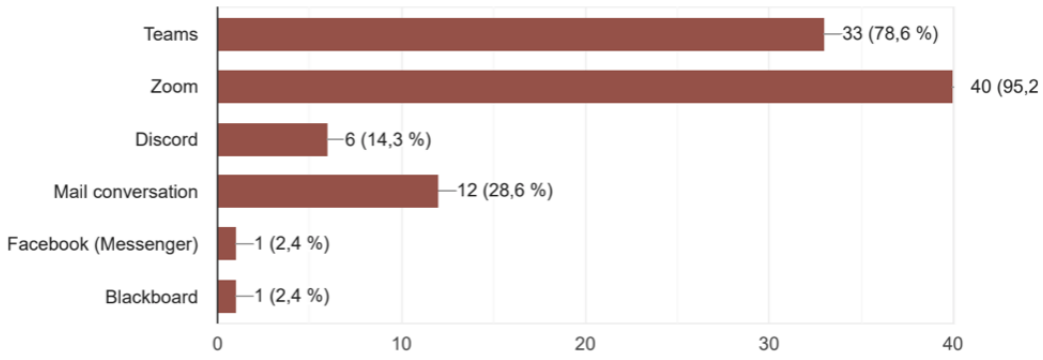
What level of study are you in?

42 svar



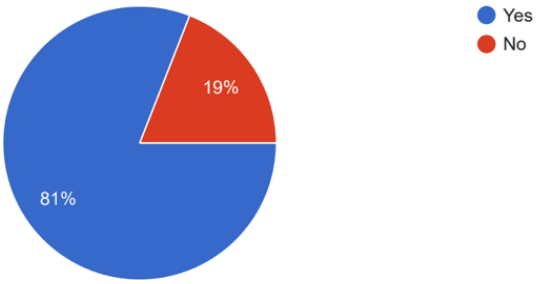
What program du you use for distance lessons/lab-sessions?

42 svar



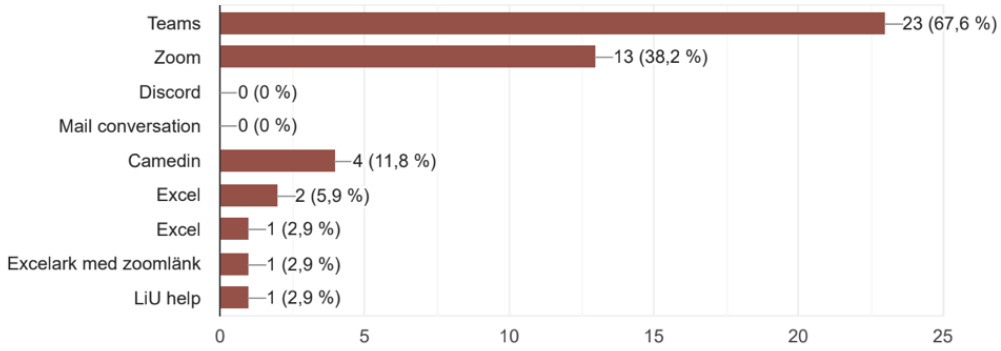
Does the tutor use any type of queuing system if the students need help or want to submit?

42 svar



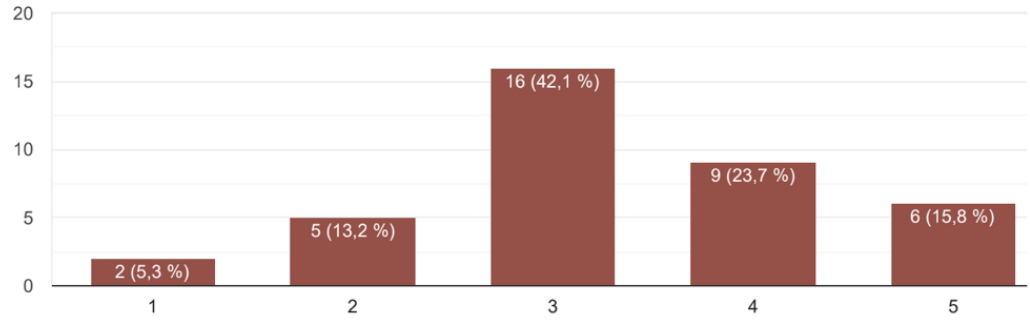
If yes, what program are used for the queue system?

34 svar



What is your general experience of the queue system?

38 svar



Please motivate your answer on the previous question.

42 responses

Good

Our tutor used an excelsheet on google drive for everyone to put their name in the queue, worked out pretty fine

It works, they often mark which one they are helping atm, thus you can see how many is left until your turn

Teams good, camedin bad

They dont really have a system, we just write comments in Teams and they help us in the cronological order of the comments. It works but would be more convenient with a systematic solution.

Not using queuing system atm

Aldrig strulat. Lätt att komma in i "rummet"

Answering pace

Excel - funkar sisådär, kan skriva upp sig tidigt och skriva över varandra. Teams - funkar hyfsat!

I don't use any queue system.

Have not been any problems so far

I havnt experince so much of queue system in my education so thats why i gav it a 3 of 1-5 scale

It works well and everybody understands how to use it

The system we use is most often clear and easy to maintain. Teams can reorder posts in the queue list if modified which can be confusing.

Jag har aldrig använt ett kösystem

Works ok

Osäker på om de faktiskt använder kösystem eller ej

I mean it’s a queueing system. You get in line and you get help

Don’t really use the queue system

Lite få ibland men genomskinligt och bra

I don´t use a queue system... (which I stated above).

The system is seldom needed as my classes are of max. 40 people

:)

You just write your name in the team chat and after a while the teacher calls you. It works okey. Not the best, not the worst. I guess it could be hard for the teacher to keep track of 180 students.

Students reply in a thread to say that we need help, and the tutor helps the student according to the order of the replies. As a student we don't know how long it will take until we receive help but otherwise it works fine.

Tydligt, enkelt att se vem som är före en själv

Duger för ändamålet, inte perfekt men alla vet hur det fungerar och man får feedback då och då.

I dont really know how to system works but sometimes the queuing takes a long time.

Don’t know the queue order until it’s my turn.

We have a channel in teams were we write if We need help

There is no queuesystem

It varies on what system is used. Some are better than others.

Man vet inte hur lång väntetiden är

Bad

Eftersom meddelanden i Teams hamnar i kronologisk ordning (om ingen kommenterar) så skapas en kanal specifikt för att fungera som en kölista, där jag kan checka av studenter via att tumma upp deras meddelanden. På det viset ser även grupper som väntar på hjälp vilken plats de är på i kön. I Team:et finns även privata gruppspecifika kanaler för alla grupper som jag smidigt kan hoppa mellan. Tror många kuser använder detta typ av system på IDA just nu!

The queuing is often unclear and sometimes people enter the queue long before the actual class starts

Never had any issues but the contact with teacher is less frequent

They just write a post, then you have to Vimmerby if you need help and they like the comment when they have started to help a new student. It works but it can be a bit confusing sometimes

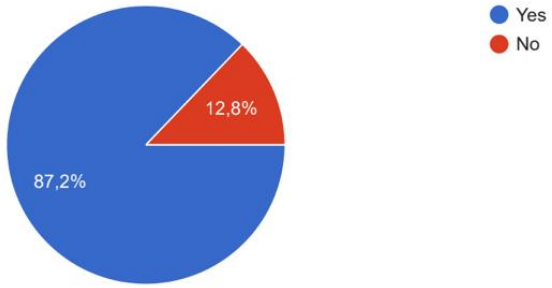
Not very stable

They take each person in the right order.

Inkonsekvent hur kön funkar mellan olika föreläsningar. Först till kvarn -system innan lektion börjar gör det väldigt orättvist.

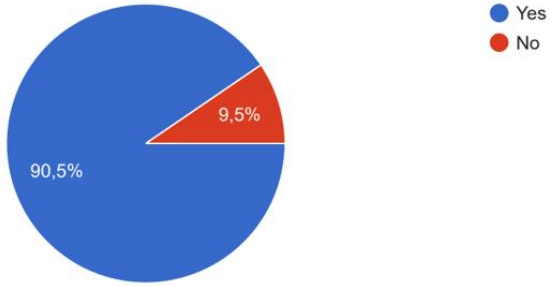
Would it make it easier for your education experice to have a single uniform application for all of your lectures?

39 svar



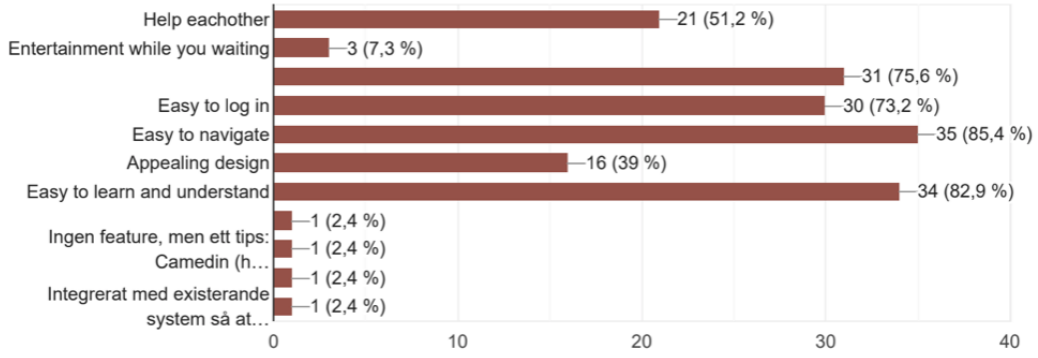
Are you interested in a better queuing application that will help students and tutors during lessons and lab-sessions?

42 svar



What features would you request in a queuing application?

41 svar



C | Usability Evaluation - Retrospective Probing Methodology

This appendix contains the outcome for the retrospective probing methodology part in the usability evaluations.

What is your overall impression of the queuing system?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *Simple application, nice graphic design, few but good buttons that make you understand where to click. Good system with the queue, easy to understand.*

Test user 2 (tutor): *It seems smooth. Some features like sharing rooms and managing other admins were a bit hard to grasp. Also confusing that I could queue-up as a tutor. Otherwise, a clear system.*

Test user 3: *Very good. Smooth and fast.*

Test user 4: *It was easy and smooth to navigate. I think I could have understood and done it without you giving me the tasks. Clear and easy!*

Test user 5: *Good! It is clear and I liked that I can see the people in front of me in the queue.*

Test user 6 (tutor): *Pretty intuitive. Some things you learn gradually as always. It would be nice with another design to see which ticket is mine more clearly. Also students should only be able to have one ticket at a time.*

Test user 7: *Very easy to navigate. Nice and simple colours and a funny name! Easy to use! No unnecessary functionality that makes it complicated.*

Test user 8: *Pretty easy but it could have been better! Confusing with Rooms-button in the navbar and not that intuitive how to queue-up. The label "description" is unclear as well as the link.*

Test user 9 (tutor): *Pretty clean! Only a few buttons which is nice. All the functionality I can think of is there.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Feels professional and clean with clear and distinct colors. It is clear that what you click on is a different color. Easy to find what to do.*

Test user 2: *I give 5 out of 5.*

Test user 3 (tutor): *Very clear and the use of color elements shows what the action does. Easy to use. Like the question marks for admin, could be one to explain the rooms as well.*

Test user 4: *Simple and easy to learn.*

Test user 5 (tutor): *Intuitive and gives a clear overview of what students need help with. Would have been nice with sound plucking if the list is empty and someone joins the queue so you can work with other things at the same time.*

Test user 6: *Simple system to use.*

Test user 7: *Very easy to use and uncluttered, without unnecessary buttons and design.*

Test user 8 (tutor): *Intuitive and clean.*

Test user 9: *Good and a clear placement of buttons. The "General Terms" button in the registry could be larger.*

What do you like the most about the queuing system?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *I liked most of it!*

Test user 2 (tutor): *All needed functions are there, no unnecessary functions which I like. Simpel and does the job.*

Test user 3: *Easier than Teams. A bit unclear when the rooms open, can I queue 24/7?*

Test user 4:*: I liked that you could see and jump between your rooms. Also liked that you could see other people in the queue and what they needed help with.*

Test user 5: *Easy to jump between rooms.*

Test user 6 (tutor): *It is a nice queuing-system. It includes all information I need as a tutor to help the students.I like that you encourage students to describe their problem and not just type "help".*

Test user 7: *: It was simple.*

Test user 8: *I did not like the first picture on the landing-page. Otherwise it was good! I liked that you could be in several rooms at the same time and also that you could see your place in the line very clearly.*

Test user 9 (tutor): *I liked that you could describe the problem*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Good that you can change what you need help with. Clean and clear design.*

Test user 2: *That it was clear.*

Test user 3 (tutor): *It is good that modals appear so you need to confirm what is being done.*

Test user 4: *Good that you can see your place in the queue.*

Test user 5 (tutor): *Good overview and fits the purpose, unlike Zoom and Teams. Encourages to describe the problems which is good.*

Test user 6: *Good that everything is on the same page.*

Test user 7: *Clean design and good with few buttons on the room side.*

Test user 8 (tutor): *I like the colors and that it is the same color on the buttons as on the logo.*

Test user 9: *Liked that it was easy to manage and change their queue.*

What do you dislike the most about the queuing system?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *Weird with a single-number room-ID. The join room button should be on top of the page. Weird that the queue-up- and share room-buttons are next to each other. Confusing with a Rooms button in the navbar.*

Test user 2 (tutor): *How do I queue-up? And manage other members? Also I want more feedback when I am about to do something "dangerous".*

Test user 3: *Nothing.*

Test user 4: *I did not really understand the label description on the queue-up modal. A bit unclear.*

Test user 5: *That you need to have your own Zoom-link.*

Test user 6 (tutor):*Nothing really. Some interface stuff you need to look at. And I would like a different design on my ticket than the others to make it more clear.*

Test user 7: *Nothing really. Maybe an average waiting time if I have to come up with something.*

Test user 8: *I answered that in the previous questions.*

Test user 9 (tutor): *Nothing really. Maybe you should be able to regret removing a ticket. And you should not be able to demote yourself as admin.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Nothing really.*

Test user 2: *A little unclear with a blue delete button in the "delete-ticket-modal".*

Test user 3 (tutor): *Could be clearer with admin functions and what happens if you "demote" or "promote" someone. The student should also be able to share a room and would have been flexible if the supervisor could send notices to everyone in the room.*

Test user 4: *Positive with time in the queue-list, but you could add the day as well.*

Test user 5 (tutor): *Would have been good if it was built into the school systems (Lisam) but can be difficult to implement if many different schools use it.*

Test user 6: *Somewhat unclear with "Join room" at first login*

Test user 7: *My own queue ticket was a little higher than the rest, could have been with uniform*

Test user 8 (tutor): *The logo is not completely consistent with the rest as it seems that we now have two different logos*

Test user 9: *That you could not press enter to e.g. Sign in.*

Did it feel natural to navigate the queuing system?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *OK. I think the queue-up button should be more in focus, it is the most important one.*

Test user 2 (tutor): *The log in-flow felt natural. So did the queueing system once I had the chance to look at it. I liked the three-part view.*

Test user 3: *Yes, very natural!*

Test user 4: *Very! I quickly understood what to do.*

Test user 5: *Yes.*

Test user 6 (tutor): *Yes, partly! Not totally intuitive with the cross to remove students from the queue. Do they really disappear from the server?*

Test user 7: *Yes.*

Test user 8: *Yes. Perhaps the queue-up button should be a bit bigger to make it more clear.*

Test user 9 (tutor): *Yes.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *I think so, you did not really have to think so much.*

Test user 2: *Yes, super natural!*

Test user 3 (tutor): *Yes it did, above all that you can change the description on your queue ticket.*

Test user 4: *Yes, it was simple and easy to know where to press first.*

Test user 5 (tutor): *Yes, I think so, especially good color coding. Natural to navigate and use it for the first time.*

Test user 6: *Yes, but the Room-ID was a bit unclear*

Test user 7: *Yes*

Test user 8 (tutor): *Yes, felt clear*

Test user 9: *Yes*

How would you rate the website's navigability from one to five where one is not at all navigable and five is very navigable?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *3*

Test user 2 (tutor): *4*

Test user 3: *4*

Test user 4: *5*

Test user 5: *4*

Test user 6 (tutor): *5*

Test user 7: *5*

Test user 8: *4*

Test user 9 (tutor): *5*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *5*

Test user 2: *5*

Test user 3 (tutor): *5*

Test user 4: *4*

Test user 5 (tutor): *5*

Test user 6: *4*

Test user 7: *5*

Test user 8 (tutor): *5*

Test user 9: *4*

Did anything feel difficult to find?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *Yes, Join Room was hard to find.*

Test user 2 (tutor): *To queue-up and understand the admin-actions.*

Test user 3: *Information about the creators.*

Test user 4: *The buttons were clear so, no!*

Test user 5: *The join room-button. And also confusing with the Rooms-button in the navbar.*

Test user 6 (tutor): *Did not quite understand the admin-functionality.*

Test user 7: *No.*

Test user 8: *Join-room and Queue-up.*

Test user 9 (tutor): *Not really. The Rooms-button in the navbar should only be visible on the home-page.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Not really.*

Test user 2: *No.*

Test user 3 (tutor): *"Share room" was a bit difficult to find, not sure if it should be on the left or right. However, do not know where I think it would be best placed.*

Test user 4: *Not really.*

Test user 5 (tutor): *"Leave room" for the first time but I do not know why. Really think it fits well there so you do not accidentally press it.*

Test user 6: *Difficult to find the "Join room" the first time you log in, could have been a bigger button.*

Test user 7: *No.*

Test user 8 (tutor): *Not really.*

Test user 9: *No.*

If you could change anything to make the site more navigable what would you change?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *Move some buttons as I said before.*

Test user 2 (tutor): *Change the word queue-up. And change the arrow to a gear on the drop-down menu for admins.*

Test user 3: *Nothing.*

Test user 4: *Change the word "description". And maybe not have queue-up and share room next to each other.*

Test user 5: *Move the join room-button.*

Test user 6 (tutor): *A little more information in the navbar, a profile to see who is signed in and more pages to go to.*

Test user 7: *The Buy TopQ button on the landing-page is a bit confusing for the students. Maybe everyone should not see other students' problems, only the admins.*

Test user 8: *Answered in previous questions.*

Test user 9 (tutor): *I thought it was pretty good!*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *I do not know.*

Test user 2: *The approve button in "delete-ticket-modal" should be red.*

Test user 3 (tutor): *Modal with all members instead of directly in the right column.*

Test user 4: *Nothing.*

Test user 5 (tutor): *Could have a modal with all members and a toggle bar / side bar so you can hide the right and left panels.*

Test user 6: *Larger "Join room" button when you are not in a room.*

Test user 7: *Maybe less focus on "Buy TopQ" on the start page but at the same time clear with login and register in the navbar.*

Test user 8 (tutor): *Change "Room" to "Rooms".*

Test user 9: *Changed so that the "Join room" and "Queue up" buttons are not the same.*

What is your overall impression of the website's graphical design?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *I think it is nice. Perhaps make the queue-tickets a bit smaller and broaden the navbar a little bit.*

Test user 2 (tutor): *I really liked the landing page. Nice colours and all buttons where you expect them to be. In the queuing-system it felt like the middle-panel was not in line with the rest of the design.*

Test user 3: *Very nice landing-page! Simple and clean. Appreciate the animations on the quick-links.*

Test user 4: *Very clean. I liked the pictures on the landing-page, looked serious but still funny. It was not much more to ask for.*

Test user 5: *I liked the pictures! I did not like that the tickets changed size depending on the length of the description.*

Test user 6 (tutor): *Professional and trustworthy! You get feedback when you put the mouse on buttons and I really like that as well as the rounded corners on buttons. A few small problems in the interface but otherwise nice!*

Test user 7: *Good. Easy, clear colours. Nothing unnecessary, I liked the blue and red buttons to make it more clear.*

Test user 8: *Nice! Simple, it does not have to be so advanced.*

Test user 9 (tutor): *It looks and feels modern! Maybe consider colour blindness.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Very good, feels like the relevant stuff are in color and that the page feels serious.*

Test user 2: *I give it 4.5 out of 5.*

Test user 3 (tutor): *Very good design, feels like a lot of time was spent on it.*

Test user 4: *A bit boring but if it had been more color it might have been harder to find things.*

Test user 5 (tutor): *Clean and very aesthetically pleasing. Good with rounded edges and that it is uniform.*

Test user 6: *Good, fun with animations on the home page.*

Test user 7: *Very good.*

Test user 8 (tutor): *Nice and clean.*

Test user 9: *Nice and uniform with good colors on the buttons.*

Was the design in line with your expectations?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1:*Absolutely!*

Test user 2 (tutor): *Not sure what I expected. Simple and the design highlighted the important things. I liked that!*

Test user 3: *Yes.*

Test user 4: *Yes.*

Test user 5: *Yes.*

Test user 6 (tutor): *Absolutely! Even better actually. Applications for schools are often way more boring.*

Test user 7: *I had high expectations, and yes, it is good!*

Test user 8: *Yes.*

Test user 9 (tutor): *Yes.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Yes I think so.*

Test user 2: *Yes.*

Test user 3 (tutor): *Yes absolutely, I like the three-column-system, it feels intuitive.*

Test user 4: *Yes.*

Test user 5 (tutor): *Yes, even better.*

Test user 6: *Yes, but the footer and navbar could have been smaller.*

Test user 7: *Yes.*

Test user 8 (tutor): *Yes, in line with my expectations.*

Test user 9: *Yes.*

How would you rate the website's design from one to five where one is very bad and five is very good?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *4*

Test user 2 (tutor): *The landing page is a 5. But the middle-part makes the queuing-page a 3. In total I would say 4.*

Test user 3: *5*

Test user 4: *4*

Test user 5:*: 3*

Test user 6 (tutor): *4.*

Test user 7: *: 4.*

Test user 8: *3.*

Test user 9 (tutor): *5*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *5.*

Test user 2: *5*

Test user 3 (tutor): *4*

Test user 4: *3*

Test user 5 (tutor): *4*

Test user 6: *4*

Test user 7: *5*

Test user 8 (tutor): *4*

Test user 9: *5*

Did anything feel unappealing to you?

USABILITY EVALUATION AFTER ITERATION 1

Test user 1: *The queue-tickets were too big.*

Test user 2 (tutor): *No, not really! The colours are matte and that is really nice.*

Test user 3: *Did not like the Buy TopQ-page.*

Test user 4: *No.*

Test user 5:*: I did not like the footer. The colours and the animations. Also want more information about the product on the landing-page.*

Test user 6 (tutor): *Some problems with the interface. And also the tickets are quite big, I would have liked smaller tickets so that you can see more at a time to get a better overview as a tutor.*

Test user 7: *If I have to say something, the picture of four students on the landing-page is not that including. Everyone looks very "white".*

Test user 8: *The first picture on the landing-page.*

Test user 9 (tutor): *Did not like the dark colours. Also it should be easier to find more information.*

USABILITY EVALUATION AFTER ITERATION 2

Test user 1: *Not really.*

Test user 2: *No.*

Test user 3 (tutor): *No, but would have been fun with more animations and movement.*

Test user 4: *Fits the purpose but maybe a little boring, would have liked more color.*

Test user 5 (tutor): *The "Help student" link could have been better as it is not so appealing now, could have been a button or arrow.*

Test user 6: *No.*

Test user 7: *My own queue ticket should be the same height as the rest.*

Test user 8 (tutor): *The logo is not super nice.*

Test user 9: *No.*