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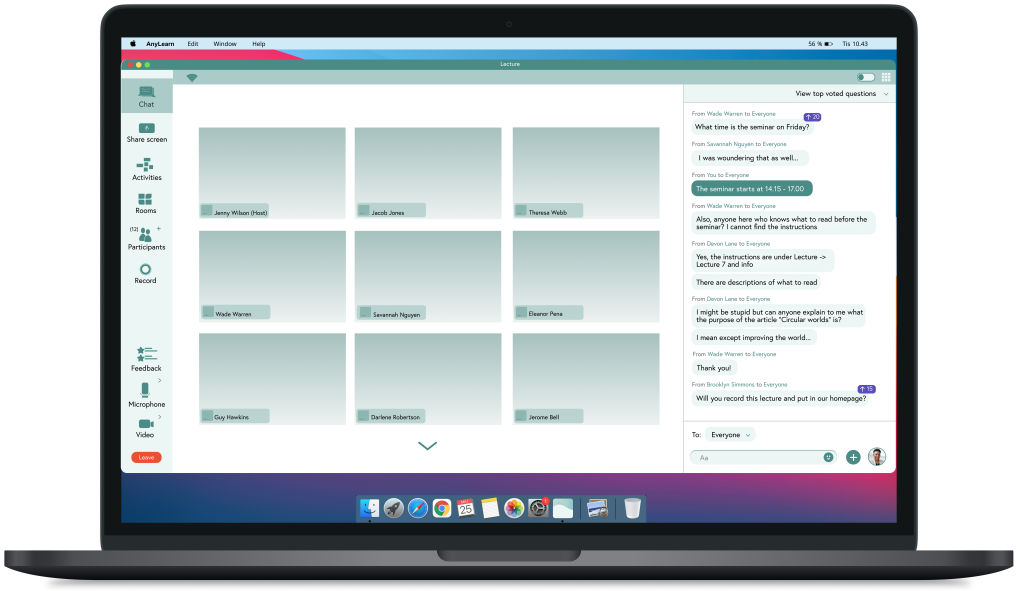

Enhancing the experience of remote lectures

Development of a new digital software to meet the needs of educators and students in higher education

Master's thesis in Industrial Design Engineering

MOA HANSSON
THEA WIDDGÅRD

DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE (IMS)

CHALMERS UNIVERSITY OF TECHNOLOGY
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Enhancing the experience of remote lectures
A development of a new digital software to meet the needs of educators and students in higher education

Moa Hansson
Thea Widdgård

Department of Industrial and Materials science
Chalmers University of Technology SE-412 96
Göteborg Sweden, 2021
Telephone + 46 (0)31-772 1000

Cover: [Hero shot of the final concept.]

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Abstract

The pandemic Covid-19 has forced many high-level educational institutions to shift from traditional to remote lectures. Current software used for remote live lectures in higher education are primarily designed to facilitate business meetings. However, literature examining students' and educators' experiences using the software suggests that there is a need for a more adapted design. This paper examines the needs of educators and students and proposes an initial concept of a software designed with consideration of the findings. Furthermore, theories within the areas of cognitive ergonomics, user experience design, interaction design and design for usability have been applied. The concept is based on user studies consisting of 2 surveys, 10 interviews and 4 usability tests. The final concept improves the quality of communication, interaction and collaboration of remote live lectures and provides users with an enhanced user experience compared to the current solutions.

Keywords: Online live lectures; Higher education; Cognitive ergonomics; User experience design; Interaction design; Design for Usability

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Gothenburg, June 2021

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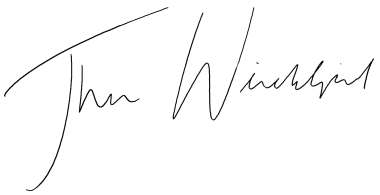

Thea Widdgård

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1. Introduction

The need for innovation and design within the area of online education seems important to follow the development of a more digitalized world. Ferrer et al. (2020) states that while part of the students thrives when studying in an online environment other feel less motivated and engaged. Furthermore, Lange & Costley (2020) highlight the importance of how a media is used and assert that online instructors should be aware of the effects. They claim that visual and auditory media can be either very efficient or limiting depending on its delivery. In collaboration with the company Invencon, this study is to investigate how a new design may facilitate the needs for remote lectures to be adapted towards high level education.

In this study the experience of remote live lectures from the perspective of both students and educators in higher education is investigated. The study questions what requirements there are, from both perspectives, on a design for qualitative online live lectures. Furthermore, it is explored how a digital software for online live lectures can be designed with consideration to the theories of cognitive ergonomics, user experience design, interaction design and design for usability.

1.1 Background

In parallel with the advances of information and communication technologies the interest of online education has grown due to it becoming a more feasible option. The incentives for universities to offer online education are the decreased need for physical infrastructure, access for more students and that the technology is easily implemented (Palvia et al., 2018). A catalyst for this transition is the pandemic Covid-19, which has forced many parts of higher education to change into online practices.

The rapid change from traditional to distance learning due to the pandemic Covid-19 has generated several studies exploring the perceived differences between traditional face to face classes and online education. Mouchantaf (2020) investigated higher education at Notre Dame University in Lebanon. The study compares teachers' opinions regarding online vs traditional face to face education. The results showed that teachers in general were pleased with their experience of educating online. However, the educators expressed dissatisfaction towards less students attending lectures, technical complications using platforms and a lack of institutional

guidance and help. Furthermore, the study showed that educators, in a face-to-face setting, more easily can control and interact with students than online. Educators also expressed a difficulty in keeping the attention of students for a longer period during online classes.

Another study made by Serhan (2020) at Arizona State University explored students' experiences of having their education executed via the videoconferencing tool Zoom due to the pandemic Covid-19. The study showed that a majority of students' attitude towards remote lectures was negative and that they preferred traditional education. Furthermore, a majority experienced that online lectures had a negative impact on the learning and the engagement in class and that interaction with the instructor decreased. It appears the students experienced both advantages and disadvantages when studying in an online environment compared to attending face-to face classes. The main advantages identified in the study were that online education allows for a greater flexibility due to the ability to choose where to study, adapting one's schedule and not having to appear on camera and show their face. Furthermore, the students appreciated written communication via chats, not having to speak openly and that the platform encouraged the use of digital resources instead of physical literature. The disadvantages of remote lectures were considered to be distractions, decreased interaction, less feedback and quality education and technical difficulties. The students experienced that it was hard not to be distracted by the surrounding environment and that it was difficult to stay focused. Furthermore, the students experienced a lack of connection between the lecturers and classmates and that the quality of interaction was poorer compared to face-to-face communication. Finally, the students experienced a loss in motivation, that the quality of the education decreased and that technical issues made remote lectures less favourable than face to face (Serhan, 2020).

1.2 Scope

This project aims to investigate the experience of online live lectures at high level education from the perspectives of both the educators and the students. The purpose is to understand the educators and students' needs through extensive user studies in relation to design theories with the intention to design a concept of a new software. Further, the software will be designed using theories of Cognitive ergonomics, User experience design, Interaction design and design for Usability.

Research questions:

1. *What are the requirements of a digital software for online live lectures?*

2. *How can a digital software for online live lectures be designed?*

1.3 Limitations

The study aims at exploring the experience of a general lecture and excludes subjects that require practical elements like, for example, laboratory work. The user study conducted in the thesis will be performed solely in a Swedish context. However, the literature review will include data from international studies. The study is limited to voluntary participants which may affect the diversity, experience and engagement. All user studies will be performed with the help of digital tools due to the restrictions of the pandemic Covid-19. This may affect the user studies since the participants might be less comfortable in an online context. Furthermore, the quality of communication may be reduced due to technical issues.

1.4 Project process

The objective of the study is to practice a design process which starts with exploring the needs of the target group and ends in a deliverable that meets their demands. The design process applied to this project, see figure 1 below, is inspired from the double diamond design process model. The double diamond model is according to the Design council (2021) a way to clearly visualize how the design process explores an issue by utilizing both divergent and convergent thinking. It represents four phases in the design process: discover, define, develop and deliver. The first phase, discover, means to understand and explore the issue by collecting information from the users. The second one, define, is about analysing the data to find insights and to define a problem. The next phase, develop, is to find a wide range of ideas and solutions for the problem. Lastly, the delivery is to test the concepts and develop it into a final concept. Important to remember is that the process is iterative and not linear.

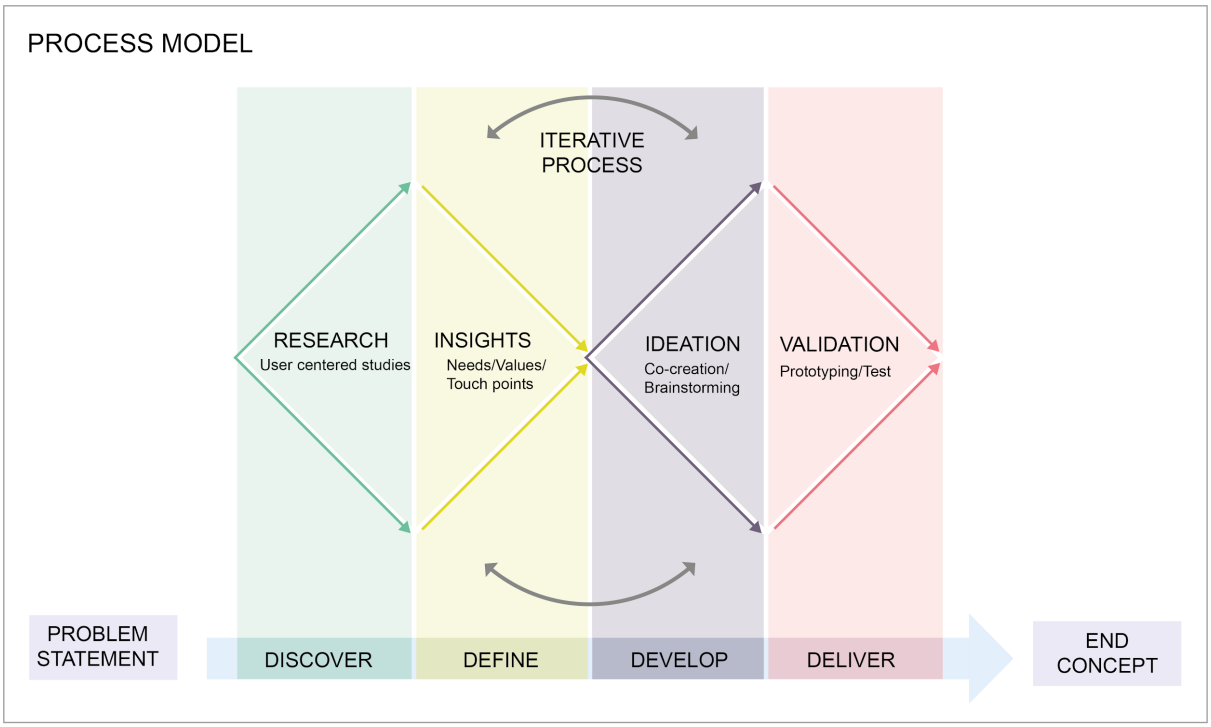


Figure 1. The double diamond design process model

2. Theoretical frame of reference

The theoretical frame of reference is based on four theories in order to develop a design that is truly user centred. It includes cognitive ergonomics, user experience design, interaction design and design for usability. The four theories were chosen in this project due to the interplay between them, see figure 2 below, and how they complement each other. The theories have methods and tools to understand the human brain complimented with how to design for certain experiences as well as evaluation methods to improve a design even more. Further, the selection aims at providing general understanding of the complex interaction between users and systems.

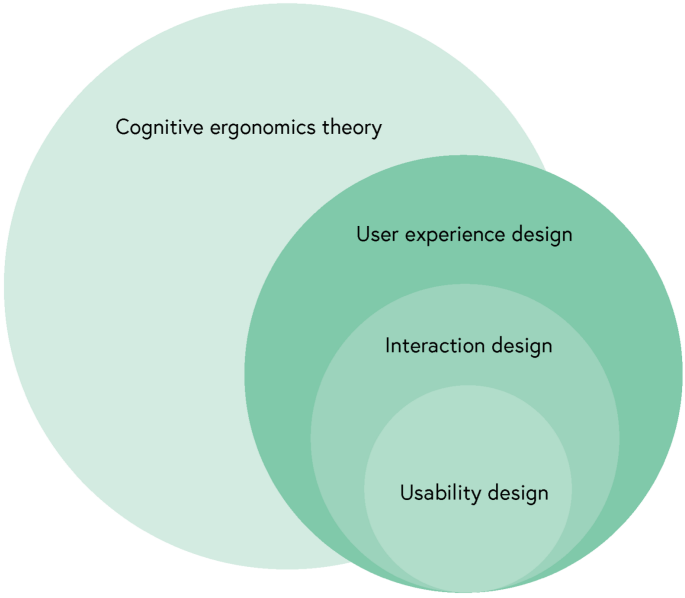


Figure 2. How the theories are used in correlation to each other in this project

Theories of cognitive ergonomics explores the cognitive interplay between a person and a system (Hollnagel, 1997). Cognitive ergonomics are used in this project as the foundation for understanding the interaction between humans and systems as it regards the human brain. It is about understanding human abilities, limitations and characteristics which in turn is very relevant to the design of tools and systems (Hollnagel, 1997). Furthermore, user experience design regards creating solutions that provide users with meaningful experiences (Interaction design foundation, 2020). It is an umbrella term that includes both interaction design, which focuses on the interplay between the user and product (Norman, 2013) and design for usability, that concerns how efficiently a solution allows a user to reach its goals (Organization for Standardization, 2018). In this chapter each theory and the most useful information for this project will be presented.

2.1 Cognitive ergonomics

Cognitive ergonomics concerns the quality of work and describes how the mind affects work and how work affects the mind (Hollnagel, 1997). Work is performed by the mind or with the mind. Cognitive ergonomics centres around the way people think, not how they act. The purpose of cognitive ergonomics is to understand the characteristics of the interplay between operator and machine/computer (joint cognitive system) to improve the design of a system. In this section perception, attention, vigilance, emotions, mental models and Wickens multiple resource theory are explored. The subjects were chosen because of their relevance regarding activities and events occurring during lectures, see chapter 1.1.

2.1.1 Perception

Perception is described by Zimbardo & Gerring (2002) as the process which enables the brain to comprehend and sense events and objects in the surroundings. It includes sensing, understanding and labelling of objects and the process determining how to react to them. Perception can be divided into three stages. The first one is sensation which refers to the process where physical energy transforms into neural codes that enables the brain to extract information about what a person is experiencing or seeing. The second stage is perceptual organization where a perception of an external stimuli is developed and a representation of an object is formed in the brain. The perceptual organisation allows people to understand objects by combining information from stimuli presented in the moment with the data from past representations and experiences. Past perceptions and representations therefore enable people to make sense of the surroundings and stimuli in the present. The final stage is identification and recognition which refers to attaching meaning to a perceptive stimulus. For example, Zimbardo & Gerring (2002) describes how identification and recognition enables a circular shape to have a meaning and be perceived as a ball, clock or coins or perceive people as male or female. Furthermore, in order to identify and recognise an object, knowing what it is and how to respond to it requires further cognitive processes such as memory, values and attitudes.

2.1.2 Attention

Lamme (2003) describes attention as a selection process in which different stimuli are processed more quickly and successfully then others and thereby have a greater chance of being memorized or generating a behavioural response. Further, Wickens & Carswell (2012) claim

that attention can be divided into three modes: selective attention, focused attention and divided attention. Selective attention decides what in the environment to process while focused attention represents the effort put into processing that specific stimuli whilst avoiding surrounding distractions. Finally, divided attention is the ability to process several stimuli in an environment simultaneously (Wickens & Carswell, 2012).

2.1.3 Vigilance

Vigilance is the ability to stay focused and attentive on stimuli for a longer period of time (Warm, Parasuraman & Matthews, 2008). Vigilance and sustained attention have become more important as automation technologies have developed and changed what the role of a worker looks like. Having sustained attention is crucial in professions where for example surveillance and monitoring occurs. Being able to keep sustained attention over a longer period of time is considered hard and decreased attention is referred to as vigilance decrement. Vigilance decrement starts after about 15 minutes of watching or monitoring and it can start as soon as after five minutes if the task is demanding (Warm et al., 2008). In a study by Rosengrant, Hearrington & O'Brien (2021) the ability of students in higher education to have sustained attention were explored using an eye tracking device. The results disproved the common belief that the vigilance decrease for students starts after ten to fifteen minutes. Instead the results supported theories that suggest that well-structured lectures with student-student and student-educator interactions can be proved effective for maintaining students' attention for the entire lecture (Rosengrant et al., 2021). Further, a study made by Young, Robertson & Alberts (2009) concludes that in order to maintain student attention during lectures it is beneficial to have presentations that vary in its structure. For example, discussion groups were positive for maintaining attention. However, not only variations in the form of interaction were effective but any type of variation in presentation or media proved useful.

2.1.4 Emotions

According to Norman (2013) emotions are an important part when designing and states that:

"Cognition attempts to make sense of the world: emotion assigns value"

In line with Norman (2013), Brave and Nass (2002) claims that emotions play a critical part in every computer-related activity and that everything from sending an email, playing games or

searching a website is affected by emotions. It is almost impossible for someone to think or act without engaging consciously or unconsciously with the emotional systems. Emotion is defined using two aspects. The first aspect regards the fact that emotions are reactions to events that are relevant to an individual's goals, needs and concerns. Further, the second aspect relates to the understanding that emotions encompasses and influences behavioural, affective, physiological and cognitive abilities. Feeling fear, for example, is a reaction to being in a threatening situation or seeing something that seems threatening to a person's well-being. The reaction will result in physiological and cognitive preparation as well as putting the person in a heavily negative affective state. However, feeling joy is a reaction to fulfilling goals and will result in a positive approach-oriented state (Brave and Nass, 2002).

A main advantage of emotions is that they are able to capture, direct and focus the attention of a person. It is objects and situations that are perceived as important for fulfilling needs and goals of a person that determine where the focus is directed. The more important the situation or object is perceived the greater focus a person will have. Moods are more general feelings that are not directed towards something special. Mood is relevant to a person's attention as users often focus on stimuli that enable them to sustain a current positive mood or to hinder a negative mood. This way, by predicting the user's mood in a certain situation a system could for example avoid users entering a negative mood by presenting alternative stimuli that will put a person in a more desired mood (Brave and Nass, 2002).

Furthermore, emotions do also affect a person's memory and how good situations or experiences are remembered. For example, negative experiences that cause a lot of feelings are often more easily remembered than positive experiences. Mood does also affect performance as even the lowest positive affective state will increase a person's ability to be flexible and efficient which in turn has a positive effect on problem solving and thinking (Brave and Nass, 2002).

2.1.5 Mental models

When designing user interfaces, it is useful for designers to tap into the users' mental model to create intuitive user experiences (Interaction Design Foundation, 2020). Mental models represent users' understanding of a system and regulate the user's experience interacting with, for example, a software (Potesnak, 1989). According to Potesnak (1989) users develop mental

models of a system when learning it and using it. During this process the mind of the user generates representations for what the system is capable of, for example why an action causes a response and what responses actions cause. Because people are continuously processing information the mental models can change over time. It is also important to consider that a users' mental models not necessarily are in line with what the designer intended. In order to make it easier for users to build mental models, principles of user interface design can be applied when designing a new software. One of these principles is consistency, which implies that software or systems should correlate with the users' mental model and already existing understanding of similar systems. Further, the simplicity of a software and its completeness can have an effect on how easy it is for users to build mental models of a system.

2.1.6 Wickens multiple resource theory

Wickens multiple resource theory and four-dimensional model can be used as a design tool and to predict if multitasking activities will create an overload of mental workload (Wickens, 2008). The theory describes how people encode, process and respond to different stimuli. It also explains why some tasks can be performed at the same time and others not. This makes the model a useful tool when designing to avoid mental workload overload. The four-dimensional model is a tool that can assist in determining and predicting how performance levels are affected when multitasking. The four dimensions, see figure 3, considered in the model are processing stages and codes, visual channels and perceptual modalities (Wickens, 2002).

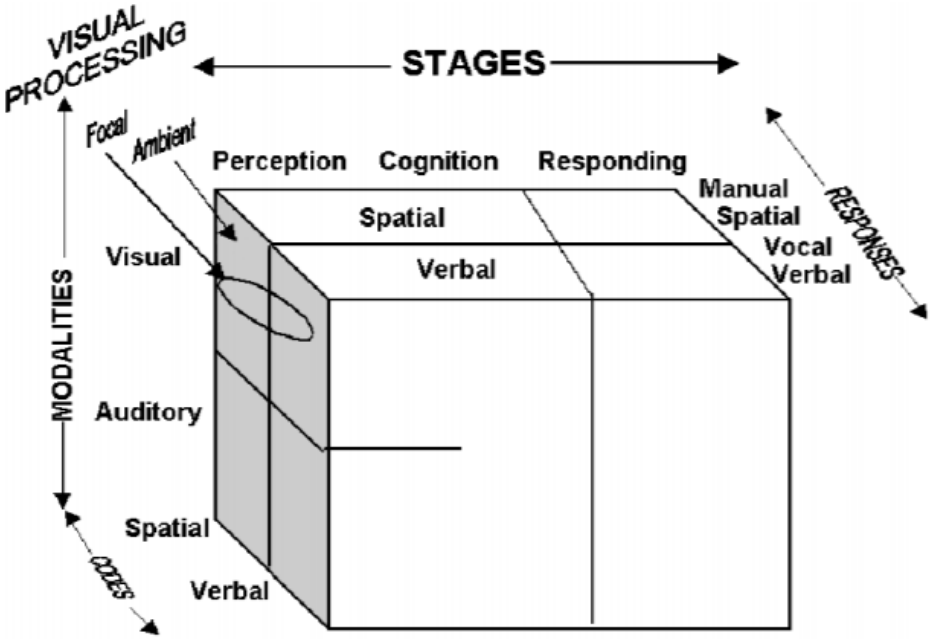


Figure 3. The four dimensional for predicting mental workload (Wickens, 2008).

The model shows that the stages of perception and cognition use the same resources but are functionally separate from the resources used for selecting and acting on responses. Further when viewing perceptual modalities, the model shows that it is easier to divide attention between visual and auditory stimuli then staying attentive to two visual stimuli or two auditory stimuli simultaneously. This is a good example of when intramodal time sharing is more difficult then cross modal time sharing of resources. Moving on to visual channels, the process of focal and ambient visual processing is using different resources. Focal vision enables pattern recognition and processing of details like text or small objects while ambient vision enables processing of environment and sensing of orientation. Because the two processes use different resources it is possible for people to, for example, walk down the hall and read a book at the same time. Furthermore, the dimension of processing codes spatial and verbal shows that the two processes are using different resources. This separation can explain, for example, why people are able to respond manually and vocally at the same time. This however assumes that a manual response is spatial, for example a movement. By taking the model and how the resources are distributed into account, it is possible to predict the performance of a person performing multiple tasks (Wickens, 2002).

2.2 User experience design

User experience design (UX design) is a process where the focus is to create products that provide users with relevant and meaningful experiences (Interaction design foundation, 2020). UX design is an umbrella term for several aspects of design such as design for usability and interaction design. Design for usability measures how well and efficiently a user in a specific context is able to reach a determined goal when using the product. Interaction design concerns the process of designing usable and pleasurable software interfaces. What sets UX design apart from these terms is that it considers the entire process related to a product. The process takes into account the designed experience of acquiring and using a product as well as its design, functionalities, branding and usability. Furthermore, there are no single definition for a good user experience. The user experience is usually high if the needs of the individual in the specific context are considered (Interaction design foundation, 2020).

To consider the whole spectrum of experiences surrounding a solution, UX designers consider the why, what and how levels when designing a product (Interaction design foundation, 2020).

The first question asked is why, which identifies the motivation for using the product and the values the consumer relates to owning or using the specific solution. What considers the functionality of the product, what activities the user can execute using the solution. Finally, the how determines the appropriate design of the functions. By considering all three aspects and using the why as a foundation for designing the product, designers are able to create products that enable the user to have meaningful experiences when using it (Interaction Design Foundation, 2020).

2.3 Interaction design

Interaction design has many definitions, however in this project the explanation given by The Interaction Design Foundation (2020) is used:

"It is the design of the interaction between users and products".

In addition to the definition, Norman (2013) states that interactions are remembered by human's dependent on the experience of a design. It can be related to positive or negative emotions. In order to interact with a product, it is crucial to understand how to use it. The journey to discover how it works, what it does and can do is called discoverability (Norman, 2013). The discoverability of a design can be controlled by designing for five psychological concepts: affordances, signifiers, constraints, mappings and feedback. Beyond those, there is a sixth principle called the conceptual model that is important to truly understand.

Affordances

Affordances is a term that describes the relationship between a person and a physical object. Affordances is the designation factor of how an object possibly can be used considering the properties of an object and capabilities of an agent. Affordances means what actions are possible to perform.

Signifiers

Signifiers is a term that describes an indicator in some form that is perceivable and communicates to a person how to appropriately behave. It communicates where an action can or should take place. Signifiers may be intentional or accidental. It provides users with clues of what things mean and how to use them which is crucial for humans in order to interpret and

interact with the constantly changing world around us. A good design provides intentional signifiers to its users.

Mappings

The relation between the elements of two fixed things is described by the term mapping. Natural mapping is about utilizing spatial analogies in a way that offers the user immediate understanding. Some natural mapping originates from biological or cultural aspects. It is important to consider different cultures and that some “natural” mapping only is true to one particular culture. Principles of perception is another factor controlling the natural mapping which allows for patterning or grouping. For example, controls that are related should be grouped together. Mapping is a very important part to consider when designing layouts for displays. An understanding of people's behaviour needs to be addressed and a good design should be thoroughly planned, thought through and cared for.

Constraints

There exist natural constraints, called knowledge in the world, that are natural things (for example, gravity) that limit physical actions. Furthermore, there are cultural constraints and conventions, named knowledge in the head, which also restrict actions. If constraints are used correctly it is a powerful tool to limit the possible actions. There are four kinds of constraints: physical, cultural, semantic and logical.

Feedback

Feedback is when the results of an action are communicated. Humans are equipped with many feedback mechanisms such as visual, haptic, auditory and the vestibular and proprioceptive systems. When designing for feedback it is important that it is immediate and informative. Feedback designed poorly may be distracting, irritating and annoying instead of helpful. Another important aspect is the amount of feedback, too much feedback can be very annoying and excessive feedback can even be dangerous. It is important to prioritize the feedback and have gradients of feedback that is dependent on the need to catch the attention of the user.

Conceptual model

A very simplified explanation of how something functions is a conceptual model. An example is the folders icons on a computer screen, this makes the user think that there are documents in a folder inside a computer, however, that is not the case. This is only how it is visualized

towards the user in order to make a computer easy to use. The conceptual models can be found both in technical manuals but also in people's minds, in the form of mental models.

2.4 Usability design

The International Organization for Standardization (2018) defines usability as:

"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"

Satisfaction is how the user's needs and expectations are met by the cognitive, physical and emotional responses that develop during interaction with a system, product or service. Effectiveness is how complete and accurate specific goals are reached by the user and efficiency is resources such as time, human efforts, costs and materials that are used in relation to the results accomplished.

User characteristics have a large effect on usability, one product may be usable for one person, however, not for another (Jordan, 2002). Therefore, it is important to have a specific target group and design for usability for those specific users. Experience, domain knowledge, age and gender, cultural background and disability are main characteristics that play a part on how usable a product is.

There are five components of usability according to Jordan (2002). The five components are guessability, learnability, experienced user performance, system potential and re-usability.

Guessability of a task concerns how much resources it costs the user to perform a task for the first time. It is an important element in products that mostly are used one time, for example, fire extinguishers. It is the first impression of a product's usability and may affect the user's choice of what to buy. The guessability is not as important when something is supposed to be used repeatedly and an initial training or demonstration is given.

Learnability is how much it costs the user to perform a task with certain competence at some specific level, excluding the challenges of first time use. It is important for tasks that have a short training time or should be self-taught. Recognition-based interfaces, for example

graphical or menu-based interfaces tend to be learnable since they do not need memory yet prompt the users with visual cues.

Experienced user performance (EUP) is when the user has used a product to perform a task many times before and the performance is relatively unchanged. This is the most important component when there is time for training and the end goal is for the user to perform at a high level, for example driving a car.

System potential describes the maximum level of performance that can be performed with a product, the highest level of the EUP. Many times the full system potential is never reached, for example it is rare that a car is driven at full speed even though it has the potential.

Re-usability describes a possible decrement in how the performance of using a design is affected after a long period of time. For example, it may happen if the user has forgotten how to use a product or service.

3. Methodology

This chapter presents the study's methodology in chronological order. It incorporates the overall research approach as well as the methods and tools for the user research, analysis, idea generation and evaluation.

3.1 Research through design

The overall research methodology used in this study is Research through design (RtD), which is a method where design activities play a big part in generating knowledge (Stappers & Giaccardi, 2020). According to Zimmerman & Forlizzi (2014) new knowledge is created by suggesting enhanced solutions in a design format to improve a current state. The process is iterative and demands an in-depth understanding of the user's needs. It is a methodology that uses the design practice processes but with the intention of generating new knowledge. The documentation of RtD is thorough and possible for other researchers to replicate, however, the outcome is not expected to reach the same or even a similar end result. The main focus of RtD is to create new, valuable knowledge by utilizing the design practice (Zimmerman & Forlizzi, 2014).

3.2 Justification of methodology

In figure 4, the workflow is illustrated and the different methods used in the study presented as well as categorised into the different phases of the thesis work. The methods used in this project follows the principles of the process model presented in chapter 1.4, the double diamond. The first step, the data collection, is divergent and relates to the discovery phase which is about understanding the issue. The second step is convergent and the affinity diagrams are used to define the data and turn it into insights which are presented as a requirements list, two personas and two customer journeys. To develop one concept, the process firstly goes divergent again in the form of creating a large variety of ideas with different ideation methods. Finally, affinity diagrams and prototyping methods followed by usability tests are convergent forming one evaluated concept. In parallel with the main process, a market analysis followed by an HTA of functions were concluded in a benchmark. This provided valuable insights of how the products on the current market are designed.

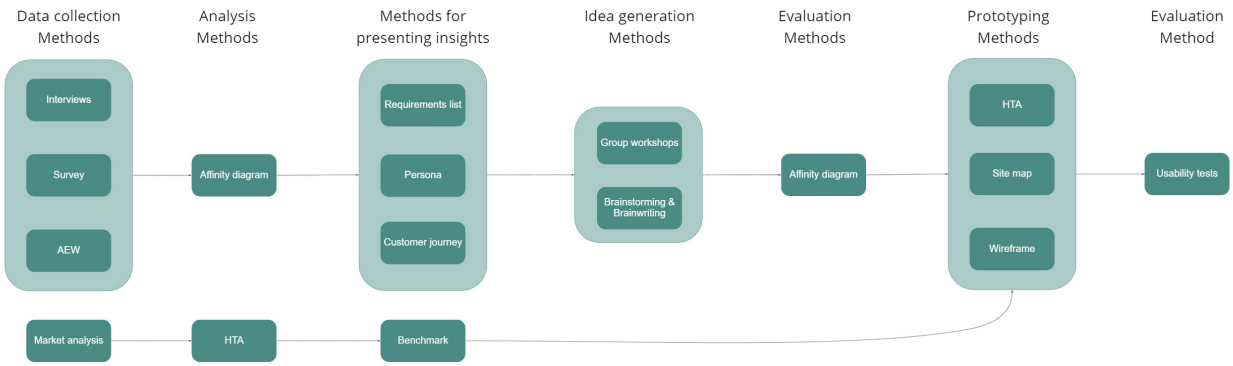


Figure 4. How and where in the development process the methods were used.

3.3 Market analysis

A market analysis is a systematic analysis of customer categories, the competitors on the market as well as the market potential (Johannesson, Persson & Petterson, 2013).

A market analysis was conducted in order to explore possible competitors and for identifying market opportunities. Five of the most commonly used software for video conferencing were explored and their target groups and main functions were listed. The market analysis provided data for the benchmark.

3.4 Benchmark

Benchmark is a method to compare, evaluate and learn from the currently dominating companies on the market (Thylefors, 2015). It is performed without any restrictions of geographical location nor kind of business.

The benchmark in this project was performed in order to explore the design and functionality of current applications and software used for online live lectures. The benchmark investigates five of the leading video conferencing software on the market and their market offering, functionality and target group. The purpose of the benchmark is to assemble the best aspects of each software to create a theoretical conceptual software that can be used as a reference in the development phase.

3.5 Heuristic task analysis

Heuristic Task analysis, HTA, is a method to describe and structure how a task is performed (Osvalder et al., 2015). It showcases what actions, in detail, that a user does to reach a specific target.

A first HTA was used in the benchmark to illustrate the most commonly used functions from the five software explored in the benchmark. Another HTA was used when planning the design of the interface of the prototype, see Appendix 1. The HTA describes the different actions the users can take inside the digital prototype. The HTA functioned as a guide for prototyping the interface of the software. However, as the prototyping was an iterative process the final actions are not the same as the original HTA.

3.6 Pilot test

The purpose of pilot tests is to test interview questions and see if they make sense or feel relevant to the research conducted. These types of tests can be done with friends or colleagues or with a person who is part of the intended target group. The pilot tests may result in necessary changes being made to the questions used (Rowley, 2012).

In this study pilot tests were performed when preparing for sending out surveys, preparing interviews and workshops. The pilot tests were conducted with one person from each target group, educators and students, that respectively reviewed the prepared questions. Each person took notes and suggested modifications to questions that thereafter were changed. The pilot tests were performed to test if the questions were relevant and unambiguous.

3.7 Survey

Surveys are a subjective, indirect method to collect a large amount of data during a short period of time (Osvalder et al., 2015). Two different surveys were conducted, Survey 1 (see Appendix 2) with the educators as the target group and Survey 2 (see Appendix 3) with the students.

Survey 1 was distributed by email to educators at Chalmers University of Technology as well as a few educators at Halmstads University. Survey 2 was spread via two private Facebook accounts and in two Facebook groups named “Teknikkvinnor” and “DEI123”.

The surveys focused on exploring how the experience of online lectures differentiates from the experience of traditional physical lectures and what works better or worse in an online context.

3.8 Interviews

Interviews are a method for collecting data of how and what people think. It allows for in depth insights of a person's values, experiences, opinions, dreams and showcases how a person reason (Osvalder et al., 2015).

Interviews with five students and five educators were performed in the digital software Zoom. Three persons were present at each interview: one interviewee, one interviewer and one note taker.

The interviews were semi-structured with a mixture of open and closed questions. The reason for having the interviews semi-structured was because it allowed for the interviewees to steer the conversation and elaborate on their experiences further. The questions aimed at exploring the interviewees experiences of online lectures. The student interviews focused on exploring the experiences of attending lectures online while the educator interviews explored the experience of planning and conducting classes online. The purpose of the interviews was to find more qualitative data which was supported by the semi-structured format.

3.9 Activity and Emotional Walkthrough

The Activity and Emotional Walkthrough (AEW) was specially designed for the format of the conducted interviews. The intention with the walkthrough was to collect information of the activities and emotions the users generally do/feel during online lectures. It was inspired by the methods Heuristic Task analysis (see 3.5) and the theory of Cognitive ergonomics concerning emotions (see 2.1.4). To map the activities performed during online lectures the interviewee subjects were asked to describe activities performed just before a lecture, during a lecture and just after a lecture. Similarly, to understand the users’ attitudes and emotions, the interviewees

were asked to elaborate on what emotions that were felt throughout that timespan. To support the interviewees when talking about experienced emotions a menu of well recognized emoji's were used. The activities and experienced emotions were mapped out over a timeline that reached from the time just before a lecture to the time just after a lecture is completed, see Appendix 4. The mapping was performed in real time using the software Figma to visualize the experience. The actions in Figma was performed by the project group at the same time as the interviewee described their experience. The communication was held via Zoom.

In this project, the data for the AEW was collected during interviews with five educators and five students. The interviews were performed in both Swedish and English, depending on which language was preferred and most comfortable for the interviewee. The walkthrough was around 15 minutes and performed in the end of the interviews.

3.10 Persona

Personas are based on research work and presented as characters that represent the users that will use the solution that is developed. Using personas can aid in creating a greater understanding of users' experiences, needs, goals and behaviours. It can also be useful for assessing the solutions developed with regards to characteristics of a user (Dam & Siang, 2021).

The personas created in this study were based on the findings from the user study including data from interviews, the AEW and surveys. The reason for making the personas was to better describe the situation and experience of students and educators participating in or having online lectures. The personas describe the experience of one general student and one educator, thus, representing the target groups for this study.

3.11 Customer Journey

A customer journey is a tool used to map out and identify touch points between users and the deliverer of a service. It is commonly portrayed with a scenario (Johannesson, Persson & Pettersson, 2013).

The customer journeys in this project are based on the results from the conducted survey, interviews, the AEW and the two personas. Two separate customer journeys were created, one

for the educators and one for the students. The customer journey describes the course of events happening during online lectures, starting from just before a lecture starts to just after a lecture ends. Further, the journey is visualized using a series of illustrations complimented with markings of touch points which indicates where the main challenges or possibilities to make a change are. To make it easier to understand, the touchpoints are separated into three different categories: points of pain, points of delight and opportunities. The points of pain represent what and where the user finds things hard or dissatisfying. Points of delight represent activities or experiences that the user is positive towards. Finally, opportunities represent aspects where a solution could make a big change in the user's experiences.

Furthermore, the results regarding experienced emotions from the AEM is visualized in the customer journey. The emotions are numbered and placed on a timeline and the cause of each emotion is described. The reason for visualizing both activities and emotions is to enable understanding of how activities influence what emotions are experienced during a lecture. By drawing parallels between activities and emotions opportunities for change or innovation can be made visible.

3.12 Affinity diagram

Affinity diagram is a method for grouping or categorising data gathered from, for example, user research or generated in brainstorming activities. The method can be used in several parts of a design process and the categorisation allows for creating an overview and deeper understanding of relations within the data (Dam & Siang, 2020).

The analysis of the findings from the user studies was performed with support of several affinity diagrams that indicated the main problems and insights by providing an in-depth understanding of how the users experience and emotions were connected to remote lectures. The analysis was based on all the data and information collected from two surveys, ten interviews and ten AEW’s.

3.13 Requirements list

Requirements list is a tool to create limitations and a framework which can be used in the development phase to evaluate solutions against. It specifies what the solution should do. The requirements list can be updated and complemented over time (Karlsson et al., 2015).

The requirements are specified from the findings in the performed user studies. Each requirement is weighted from 1-5, where the requirements marked a 5 are the most important to ensure are fulfilled in the end concept and the ones marked 1 only desirable. The weighing was based on the findings from the extensive user studies and the results from the analysis. The requirements that target the most prominent problems identified in the user study were weighted the highest. These are also the requirements that are judged by the project group to have the greatest positive influence on the user experience.

The requirements list was used as a foundation for the ideation and evaluation. It provided guidance during the idea generation process as well as criteria' and measurements to validate ideas and concepts with. Finally, it was used to evaluate the final concept.

3.14 Brainstorming

Brainstorming is an idea generation method that is performed in a group that is ideating a large variation of ideas around one defined problem. It is of importance to have an open and positive environment to allow for free minded ideas to materialize (Osvalder et al., 2015). Below, two different brainstorming sessions are presented.

Brainstorming 1: Customer journey opportunities

This ideation method is a great tool to ideate solutions for all steps in the customer's journey. The overview it provides makes it easier to cover all aspects and minimises the risks of missing an important step of the customer's journey. Two separate ideations of the opportunities were made, one for the educators and one for the students. Each point was complimented with a question to easier ideate solutions.

Brainstorming 2: Project group

The second brainstorming was visually performed by the project group in the program Mural and simultaneously the communication was held in Zoom. It was structured as a brainstorming session where 18 stated problems, based on the requirements list, were ideated upon. For each problem, a brainstorming session during 3 minutes was held. During the brainstorming, the ideas considered the best, based on the expertise knowledge the project group developed due to extensive user studies, were marked out and further used in the study.

3.15 Group workshops

A workshop is a work session where a group of people are creatively collaborating together to reach a goal. The goal could for example be to create new solutions and ideas to problems together. A workshop is typically a creative but structured meeting that is planned and held by a host (Hamilton, 2016).

Two workshops were held in order to broaden the ideas generated as solutions to the problem areas defined in the user study. During the workshop the idea generation method brainstorming was used. Both workshops were held online in Zoom and the website Mural was used to facilitate the idea generation. In Mural, six problem areas and their related questions were described. The six problem areas were chosen based on the most prominent issues from the user studies. During the workshop the group had approximately five minutes to write and discuss ideas and solutions for each problem area. After each brainstorming session the group voted on which ideas were the prominent ones and discussed the top ideas together.

Each workshop was one-hour long. The first workshop was held together with the company Invencon where seven persons participated. The participants were selected randomly and had all different backgrounds and varied experience performing brainstorming activities. The second workshop was held with two students and two educators from Chalmers. The participants in workshop number two were chosen in order to represent the two user groups intended to use the final software. The data collected during the workshops was saved in a Mural document.

3.16 UX Sitemap

A UX sitemap is used to document the Information architecture (IA) of a product design. It is useful for defining the hierarchy within an interface and its navigation. The sitemap represents the core structure of a product and is useful for structuring ideas and thoughts in a concrete manner. Furthermore, creating a sitemap forces a designer to assess the logic behind the structure and to consider if names given to components in the interface will make sense to the end user. A sitemap can be used when prototyping and making wireframes (Allen & Chudley, 2012).

In this study a sitemap was created using the digital collaboration tool Miro. The purpose of the sitemap was to structure the navigation and information of the interface and create a basis for supporting the work with prototyping wireframes. In this project the sitemap was mainly used for visualizing the initial structure of the prototype interface.

3.17 Prototyping & Wireframes

Prototyping is a quick, simple and cheap way for designers to explore, test and develop ideas. The output of prototyping can also be useful when conducting usability tests. Prototyping digital interfaces can be done both using physical tools like pen and paper but also with digital tools (Allen & Chudley, 2012). Wireframes are diagrams of an interface that allow a designer to create a framework of a design for a website or application. Low fidelity wireframes are useful for exploring the content of an interface and its navigation and interactions without considering aspects like fonts or colour palettes. Wireframes are a tool that encourages collaboration on, testing, learning and improving of a design. Furthermore, mid-high fidelity is when the wireframes are made with, for example, the intended fonts and colour palettes (Allen & Chudley, 2012).

In this study wireframes were used for the process of prototyping the final concept. The information the wireframes were based on came from the sitemap and the HTA that visualized the different components and the overall structure of the interface.

The first wireframes created were on paper where the content, navigation and interaction were explored. The wireframes were sketched and edited simultaneously as the project group discussed its structure and logic. When the main components of the interface were discussed

and sketched the wireframes were created digitally. The programme used for creating the digital wireframes was Figma. Figma was useful as it allowed the project members to work together in the same wireframe document. The digital wireframes were iteratively developed until a version good enough for user tests was created. Finally, the prototype was made interactive by using the prototyping function in Figma. The prototyping tool made it possible to interact and navigate throughout the prototype in a more realistic way.

3.18 Usability tests

Usability tests are when a user is observed when performing tasks using the developed product or design. It can be used as a method for repeated tests of a product in its formative setting in order to identify design errors. By repeating the process, designers can validate if the fixes were successful. Usability tests can also establish what users like and what works the best for them (Barnum, 2020). According to Nielsen & Landauer (1993) an optimal amount of user tests are together with 3 to 5 users if it should be cost beneficial. With only four user tests it is claimed that around 75 percent of the usability problems are found. Furthermore, it is stated that after the fifth user test it is a waste of time to conduct the same type of test since the user will repeat the same actions as the ones before (Nielsen & Landauer, 1993).

In this project, four usability tests were conducted in order to test and evaluate the interactive prototype created in Figma. Two of the tests were together with students and two with educators. All tests except one were performed in a live setting and the final one in a digital format using Zoom and a link to the prototype in Figma. The tests were adapted after which user group it was tested by since the prototype is different for the students and the educators. The test was prepared with tasks asked to follow in order to evaluate if the users could find and understand the new features in the prototype. Full overview of the tasks can be viewed for educators in Appendix 5 or for students in Appendix 6. During the test, the participants were asked to comment on their experience.

After the tests the discovered usability errors were concluded in a table together with suggested solutions as well as if it was considered necessary or only desired to update the issue.

4. Market analysis

There are a great number of software available for video conferencing in online education on the market today. In this market analysis five of the most common software used for online live lectures were explored and the target groups and markets identified and most common features listed. The explored software was Zoom, Microsoft Teams, Google Meet, Cisco Webex meetings and Blackboard.

Target group

All five solutions had several target groups and offered services and solutions to a number of industries like businesses, healthcare, finance and education, see Appendix 8. The only software that had higher education as its primary target group was Blackboard, however it also provides businesses with services (Blackboard, 2021).

Functions

When viewing the functions within the videoconferencing tools there were several similarities. It was, for example, screen sharing, recording of meetings, chat function, breakout rooms, reactions and emotions, polls and raising hands, see Appendix 8. The correlation between the software indicates that there is a will to use attributes that the average user knows and has previous experience of. An explanation for this could be that designers aim at matching the mental model of users in order to create an intuitive experience (Interaction Design foundation, 2020).

4.1 Benchmark

The market analysis of Zoom, Microsoft Teams, Google Meet, Cisco Webex meetings and Blackboard is the foundation for the benchmark. The benchmark is a hybrid of the companies' solutions in order to represent the best possible solution on the market today. It presents a gap in the market to target, the most important functions and usability features as well as how to relate to the current market in order to be competitive. The benchmark will be used as a reference when designing concepts.

Target group and market

The five companies target different groups of users. As stated, only BlackBoard targets high level education as the primary group, however it does still offer services for businesses

(Blackboard, 2021). The market analysis therefore indicates that there is a lack of software that is specifically adapted towards the needs of educational institutions, educators and students. Therefore, the study will focus on this specific area of the market and create a more niched product that is adapted for educational services only. By adapting the software to the specific needs of education the hope is that it will stand out on the market and become leading within the market of video conferencing for educational institutions.

Functions and usability

The benchmark includes the most common features identified in the explored software. The functions that will be incorporated into the benchmark are basic functions that facilitate communication, visual features, collaboration and documentation, see figure 5 below. These are features that many of the software in the market analysis had in common which implies that the functions are relevant to users' perception and mental model of software within the market of video conferencing. In order to utilize and match users' current understandings of similar software these functions will be included in the benchmark. This strategy is pointed out by Potesnak (1989) who describes consistency as a user interface design principle that often is applied when designing interfaces that match user's current mental models of similar systems.

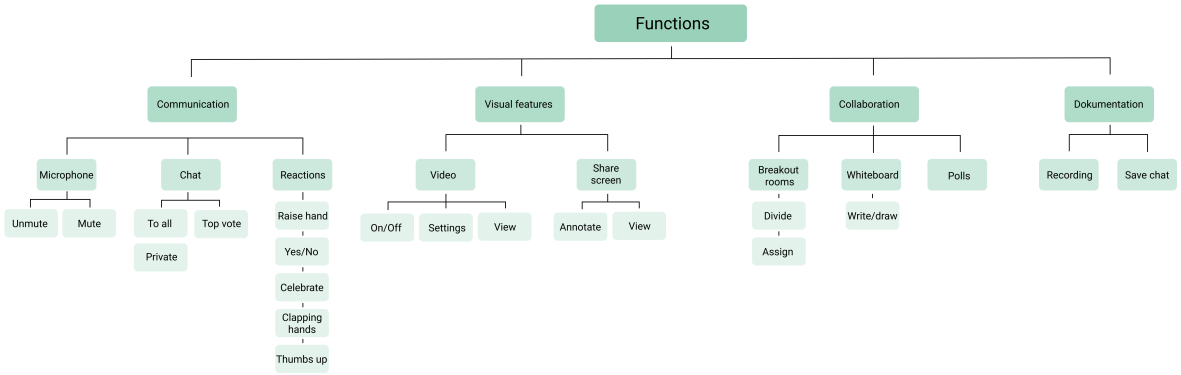


Figure 5. HTA of the main functions

5. Results

In this chapter the results of the study are presented. First the insights from the user study is presented by summarising the insights from educators respectively students. The insights are also presented using personas and customer journeys. Thereafter a requirement list is presented. Furthermore, the results from the concept development phase including the idea generation, prototyping and usability tests are presented along with an evaluation of how the prototype meets the defined requirements.

5.1 Results of User Study analysis

The user study consisted of two surveys, ten interviews and ten AEW with both students and educators. The results were analysed using Affinity diagrams and the categorised insights are summarized and presented in this chapter.

5.1.1 Educators

Below the insights regarding the educators experience of online lectures are summarized and presented (see figure 6 below).

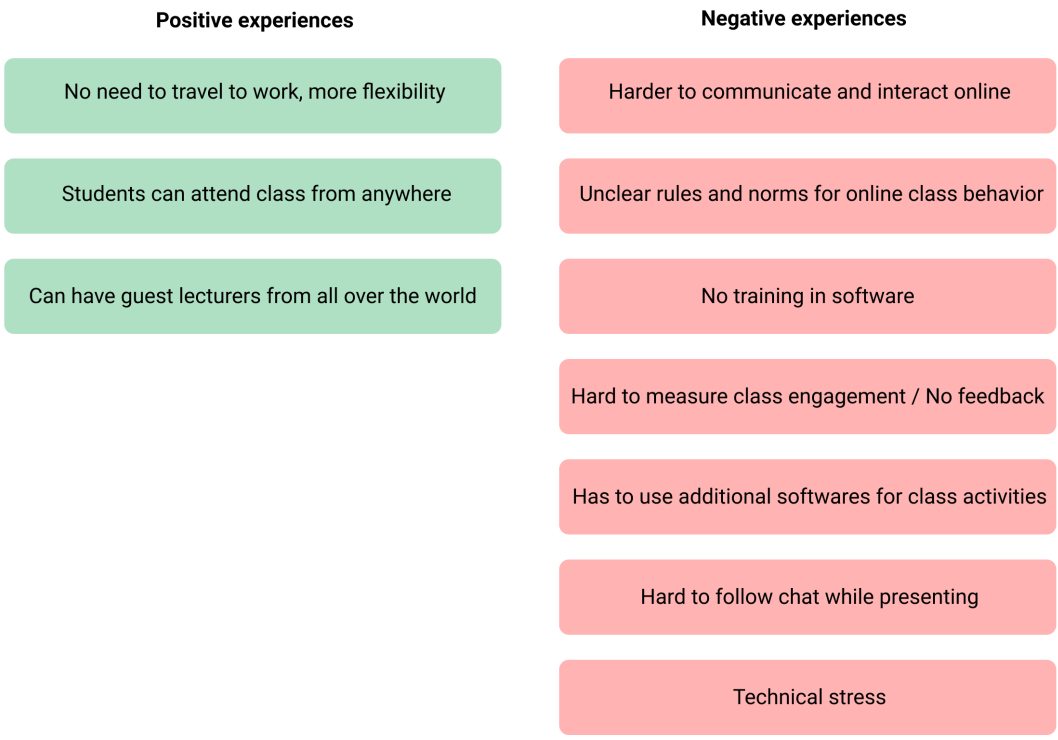


Figure 6. Educators positive and negative experiences from teaching online.

Flexibility of online education

Most educators were positive towards the flexibility that online teaching allows for. Many appreciated not having to travel to work and that it reduced some stress in their everyday lives. Overall the educators thought that a mix between physical and online lectures would be the preferred teaching style in the future. Further positive aspects were the flexibility in inviting guest lecturers from all over the world and that more students were able to attend lectures online. Other than flexibility the educators pointed out that larger classes were easier to teach online.

Norms, rules and culture

Many educators experienced it as hard to establish norms and rules during online lectures. The lack of a collective understanding in how to behave causes according to some educators a confusion among students that attend several lectures a day which all have individual rules. As there is no standardisation there is no obvious way a student should behave during a lecture regarding how to use their video or ask questions. Some tutors believed that the lack of rules

contributed to students being less engaged and considerate during the lectures. Some educators also expressed a concern regarding the safety and integrity of recording and posting lectures online.

Experience, technical stress and preparation

Most educators expressed a lack of support or training in the software used for online teaching at respective universities. The tutors learned the software while working with it or by asking colleagues for help. Most educators did not experience the learning process as hard; however, the inexperience in performing lectures online and in using the software created a nervous feeling during the lectures. The feeling was described as a "technical stress" which originated from the distrust in the technology and lack of experience using the software. Furthermore, some educators expressed a need to change the planning of lectures when moving into an online format. Online lectures required other strategies for teaching and some educators claimed that new pedagogical methods were needed.

Usability and functionality

Overall the educators thought the software used for online lectures was fairly easy to navigate and understand. However, some functions were more appreciated while others were considered less good or did not work as desired.

A function that was appreciated were breakout rooms that allow for dividing a class into smaller groups for discussions. Many educators expressed how this function made it easier to quickly generate group discussions compared to in a physical classroom. However, some teachers discovered how students during breakout sessions ignored their classmates and refused to participate in discussions. The educators thought that this might depend on them not being able to monitor the breakout rooms. Furthermore, some educators expressed a wish to be able to move from room to room in an easy way.

Another function that most teachers used regularly was sharing their screen in order to show, for example, a PowerPoint or other media. Further, many lecturers expressed that they liked the chat function as more students seemed comfortable asking questions that way. However, a big downside was that the teachers were not able to view the chat while they were sharing their own screen. This led to some questions being missed or viewed only at the end of a lecture. To solve this problem some educators had assistants that kept an eye on the chat during the lectures.

Other educators that were able to see the chat while lecturing claimed that seeing the questions while talking could be distracting.

Communication, interaction and feedback

A common opinion among the educators was that high quality communication and interaction are harder to achieve online than in a physical classroom. The educators expressed that it was harder to get students engaged during lectures and that most communication was carried out through the chat function. Furthermore, the educators experienced it harder and almost impossible to determine if the students were following or understanding the lectures. This issue had, according to the teachers, a lot to do with the students not having their cameras on which prevented the tutors from being able to interpret their body language. However, some educators suggested that even if the students would have their cameras on it would still be hard to read their body language as the video square is too small or that if the class is too big it will still be impossible to see one individuals body language. The lack of feedback and natural communication with the students makes it harder for educators to connect with the students. Furthermore, as the social interaction online is dysfunctional many educators experience a feeling of loneliness and that they are talking to a “black hole”.

5.1.2 Students

In this part the summarized insights regarding the students experience of online lectures are presented. The students' positive and negative experiences are presented in figure 7 below.

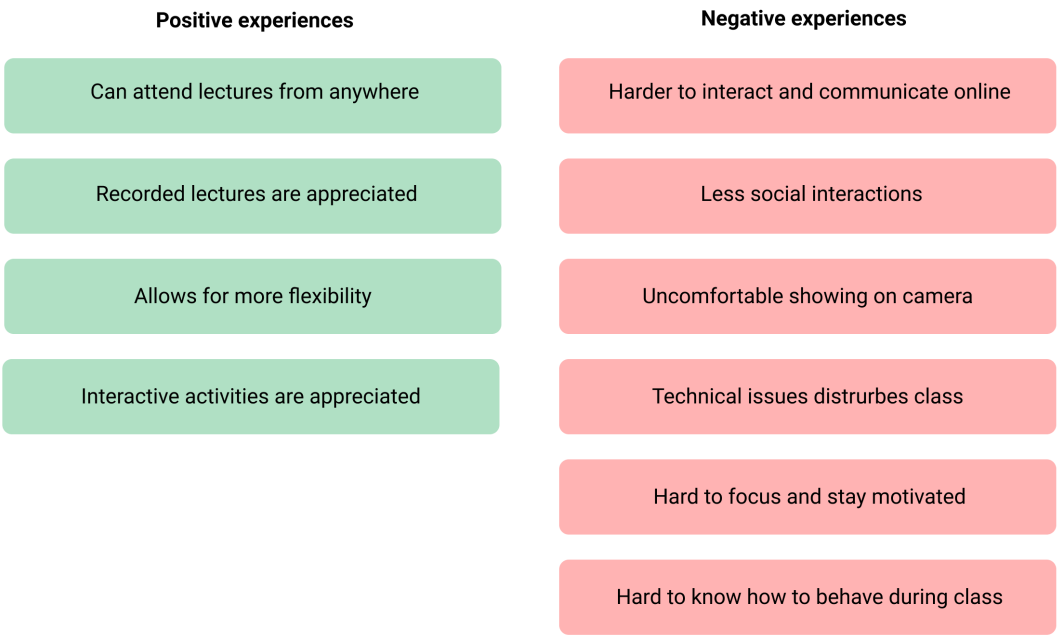


Figure 7: Students positive and negative experiences from attending online lectures.

Flexibility

An aspect of having lectures online that was widely appreciated among students is the flexibility it allows for. Many students were positive towards not having to travel to school and being able to attend lectures from anywhere. Most students liked if there were recorded lectures available as it made it possible to watch lectures several times and at any time of the day. Further, some students described how online lectures made mornings less stressful and made planning and time management easier. However, the students suggested that it would be preferred to have a mix between online lectures and physical lectures. Some thought that interactive lectures should be held in person while other types of lectures are better suited for the online format.

Hard to focus and stay motivated

Many students experienced it hard to stay focused and motivated during online lectures. The explanations were that there are more distractions at home than in a physical classroom. It also depended on the length of the lecture since many students claimed that it was harder to focus for a longer period of time. Further, the level of focus and motivation could be affected depending on the lecturer's teaching style or if the subject was something the students were interested in.

Lack of social interactions

The main reason why students preferred traditional physical lectures over online lectures was because of the lack of social interaction in the online context. Many students felt lonely at home and missed their classmates and the natural social interactions that occur in between classes or over lunch. The social interaction online was experienced as less natural and many students feel less connected to their peers and their educators.

Communication

Most students experience it as harder to communicate and interact with classmates and teachers online. Communication online, both verbal and written, feels less natural and often contributes to misunderstandings. Another aspect affecting the quality of communication is the lack of body language that plays a big role in how people interpret each other. Some expressed that it is uncomfortable to speak into the microphone and some students claimed that it was stressful and that they felt judged by their peers if the question was formulated in a weird way. The chat was most students preferred way of communication as it was experienced as easier than talking, it is less likely to interrupt someone speaking and it feels more anonymous. Also the equipment and technical issues have a great impact on the quality of communication during online lectures.

Interactive activities

Interactive activities were very appreciated by students as it often allowed for social interactions. Group discussions, games and quizzes were described as fun and motivating activities during lectures. However, many students believe the online format is limiting and that interacting with peers or teachers online is much harder and less natural then in a physical classroom.

Norms and rules

Many students claimed that it was hard to know how to behave during lectures and that most tutors had different rules for class behaviour. Because there is no obvious way to behave, students sometimes feel confused regarding what rules apply to lectures.

Camera

The comfortability of having the camera on during lectures online varies between students. Some experience it as uncomfortable knowing that people can watch and judge their appearance or behaviour. Others believe that having the camera turned on contributes to a nicer atmosphere

in class and that it makes it easier to focus knowing that classmates and the educator are watching.

5.1.3 Personas

The personas portray one educator (see figure 8 below) and one student (see figure 9 below), both are based on the answers from the surveys, interviews and AEW's. They are a balanced mixture between all the data collected from the pre-study to describe the most general educator and student in one story each. The personas are developed to facilitate a deeper understanding of the issues and emotions of an educator respective a student's experience during online lectures.

Educator: Simon Ljung
Age: 53 years

Simon has many years of experience working as an researcher and educator within Service and Sustainable Management at Chalmers University of Technology. He works half time with his research projects and half time with educating students at both a bachelor's and master's level.

The pandemic Covid-19 had consequences in Sweden during the spring of 2020 and all high level education was conducted from distance. For Simon the experience of the transition from traditional lectures in a classroom to online lectures in Zoom has been challenging. He expresses that the flexibility it has provided him with is the positive element, he does not need to travel and therefore he has more time for his family. However, to have the office at home can be challenging if the children are at home at the same time as he is working. Fortunately, he lives in a large house with the possibility to work in a separate room.

In the beginning he did not have good enough equipment to perform quality lectures however, soon his workplace provided him with tools such as headphones, a microphone, a computer, extra screen and a tablet. Nevertheless, Simon has struggled to learn Zoom and did not receive any training on how to use the software. This results in him being stressed over the technology and exhausted after a lecture, even if everything went well.

Simon thinks that the hardest thing with online lectures is the lack of interaction. The students usually don't have their cameras or microphones on so it is like talking into a black hole. This makes him feel lonely and the lack of feedback makes it hard to determine if the students have understood or not. Simon feels as his skills to educate are not compatible with the online format.

Figure 8. Persona of an educator

Student: Allison Lundberg
Age: 24 years

Allison is studying her 3rd year of Media and Communication Science at Jönköpings University. She is living in a one room student apartment close to campus. Her only income is student loans. Before the pandemic Covid-19, she usually spent very little time at home, most of the time she was in school studying or hanging out with her friends.

The transition from traditional lectures in a classroom to online education has been hard for Allison. She does not have a good place in her apartment to study, there is no room for a desktop so she needs to sit at the dinner table, on the sofa or the bed. She thinks it is harder to focus at home since there are a lot of distractions. To prevent herself from doing other shores or activities, she tries to put everything away before a lecture starts.

Allison was always comfortable to ask questions in a traditional setting, however, in the online format she thinks it is more challenging. She cannot afford any good equipment and therefore technical issues and the risk of not being able to ask questions without disturbance is too high. She also thinks it is uncomfortable knowing that her question might be stupid and is being recorded. Because of this, like many other students, she prefers to ask questions in the chat. Most of the students don't have their cameras on during online lectures and Allison thinks that it depends on them not being comfortable showing off their home, feeling insecure that someone else is watching them, pure laziness or so they can do other stuff at the time as being in class.

Allison misses the social part of the traditional education the most. She finds it lonely to sit at home by herself. It is great with the flexibility but she would still prefer to be in school and meet her classmates. In the future she wishes for a mix between traditional and online education.

Figure 9. Persona of a student

5.1.4 Customer journey

The two Customer journeys are telling a visual story of how the educators and students act in the context of online lectures. The journeys illustrate the activities that are usually performed in relation to an online lecture. It considers preparations, actions before, during, directly after and later as well as emotions. It pinpoints where the touchpoints are and insights of where there are possibilities to make changes. There are three different touch points in the customer journeys (see figure 10 & 11), points of pain (orange), points of delight (pink) and opportunities (blue). The points of pain mark where the user feels negative towards an activity or situation. Meanwhile, the points of delight mark the opposite. The opportunities are points where there is a great chance to make a change and will be reflected over in the ideation phase.

The purple field displays emotions felt during the different stages of before, during and after. Both positive and negative feelings are mapped out and explained underneath the 'explanation' to the right. The emotions were collected during the EAW's and with this in mind, it does not represent all emotions that the users may feel, however, work as a guideline.

5.1.4.1 Customer journey of an educator

The educator customer journey is presented in figure 10 below, and provides an illustration of the general educator's experience of educating online live lectures and some of the emotions connected to the different stages. The journey shows that educators experience a lot of conflicting emotions during online lectures. During the interviews and AEW's the interviewees expressed their feelings in relation to different situations and activities. Considering the time before a lecture the emotions of confusion and frustration were expressed in relation to understanding how to navigate and use the software. Furthermore, it was considered hard to know what equipment was needed and a lack of support from the employer. Nevertheless, emotions such as excitement and motivation were also expressed towards shifting from traditional education to online education. Moving to the section just before class, the positive emotions are related to the situation of meeting the students and the timesaving opportunity to choose where to work. On the other hand, the negative emotions are related to technical stress and worrying if everything will go as planned during the lecture. In the section during class, the positive emotions are related to things working well and the lecture not being interrupted by technical issues. However, there is an overwhelming amount of negative emotion due to the harsh environment of educating online. It is hard to talk and interact if no one has the camera on and there is a lack of feedback which creates an uncertainty if the students are listening and understanding or need further explanation. After class it usually feels good but often exhausting since there is a need to be focused and alert at all times.

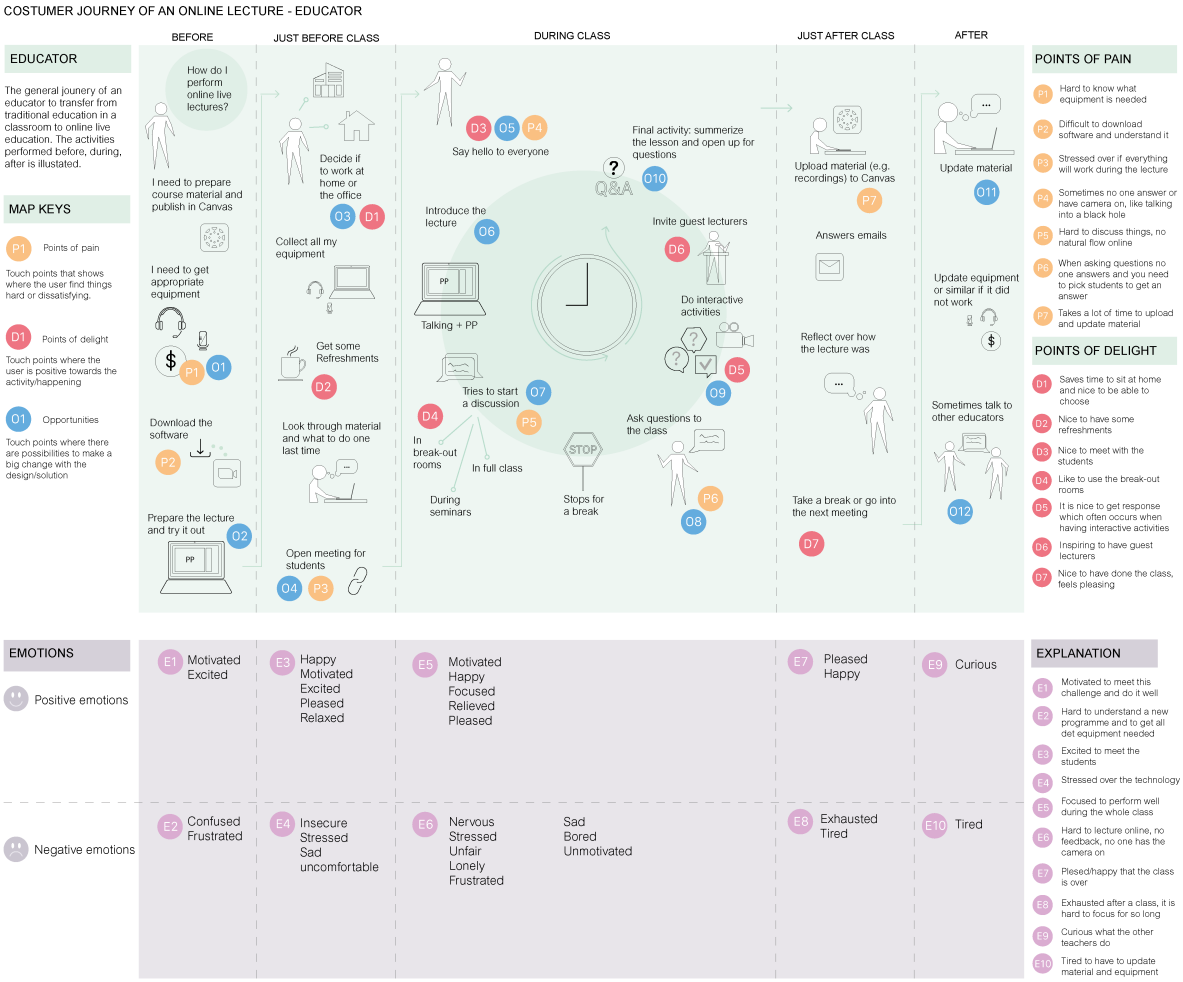


Figure 10. Educator customer journey

5.1.4.2 Customer journey of a student

The student customer journey, see figure 11 below, is an overview of a typical student's experience of studying at distance and participating in online live lectures. In line with the educators, the general students experience a lot of conflicting emotions during an online live lecture. The majority is negative emotions which is an indicator that there is room for improvement. The time before a class is described as motivating, most students feel excited and happy to enter a new lecture. However, searching for meeting links or equipment is seen as very frustrating. The journey shows that students experience eleven negative emotions during a live lecture and only three positive emotions. The negativity is due to the subject or lecture not being interesting, the difficulty to ask questions or technical issues affecting the quality. The few positive emotions are related to interactive and fun activities. The reason for the emotions felt after class is that the student often feels insecure due to lack of social interaction

and confirmations talking to other students about the tasks or lecture. The digital format demands more independent work and more individual responsibilities.

The yellow field is a diagram of a student's focus during the different stages. The yellow line illustrates how a student's focus changes over time during a remote lecture. It is usually high in the beginning of a lecture but decreases with time. When it is time for a break, the focus is really low. However, after a break it is higher again but towards the end of class, it is at the lowest point. The orange line in the yellow field shows how the focus of the students may be improved if interactive activities are included in the lecture. It is stated to be easier to focus and become motivated if it is possible to participate actively during a lecture.

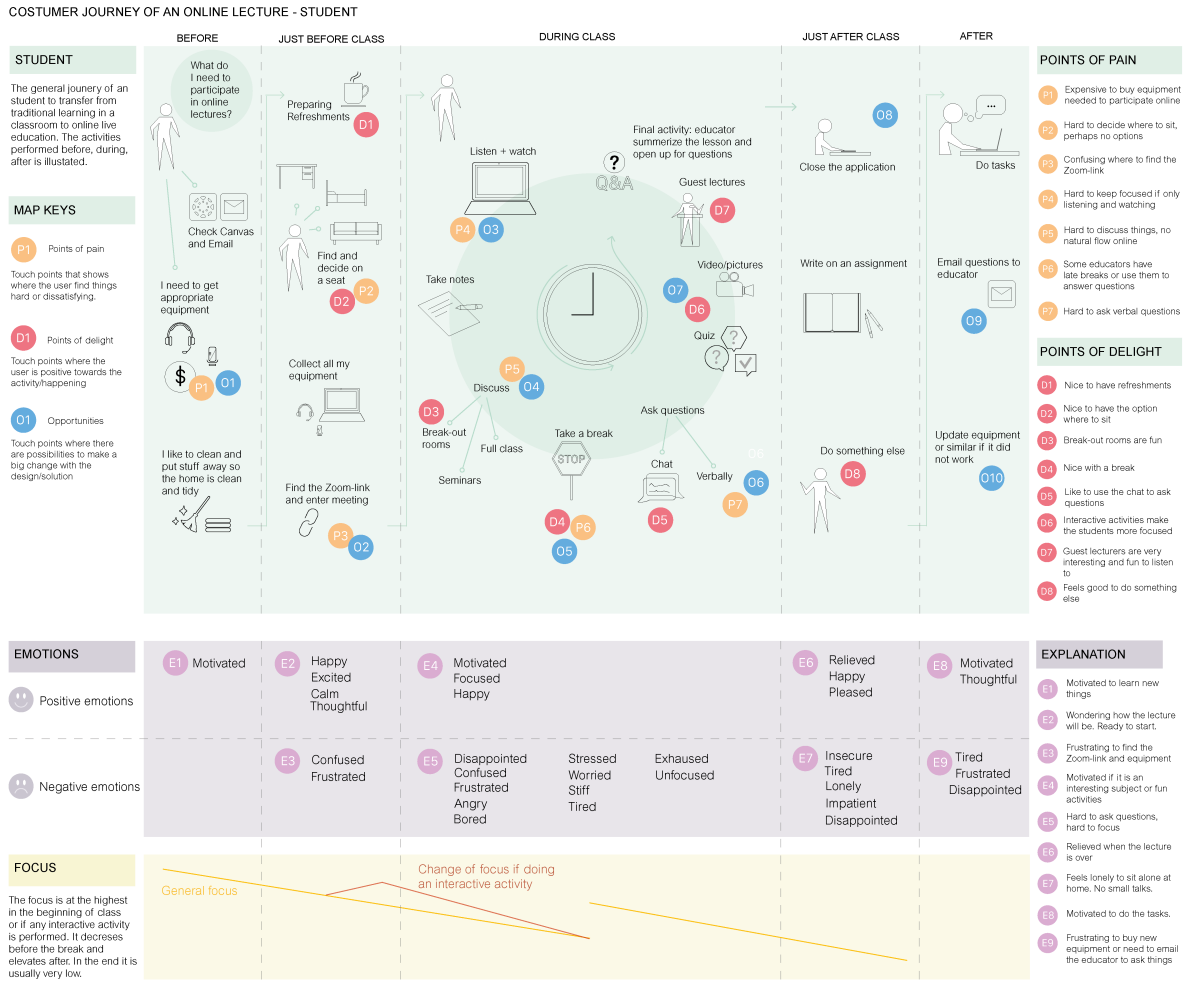


Figure 11. Student customer journey.

5.1.5 Requirements list

The requirements list includes all the important aspects to consider during the concept development phase, see table 1. The list contains fifteen requirements that will be used for further development of ideas and as validation of ideas. The motivation explains attributes that are related to the stated requirement. The weighing of the requirements is important for the evaluation of solutions in order to prioritize what design is most suitable. The weighing was based on the findings from the extensive user studies and the results from the analysis. The list is presented from top to bottom with the most prioritized requirements at the top.

Table 1. Requirement's list

Number	Requirements	Motivation	Weighing (1-5)
1.	Provide sufficient interaction and usability	The software should have an intuitive interface that is easy to use and interact with	5
2.	Adapted for educational purposes	The software is designed with the purpose to enable high quality education and meet the specific needs of educators and students in higher education	5
3.	It should be possible to divide a class into smaller groups	The software should provide opportunity to divide class in order to enhance collaboration and student interaction.	5
4.	Facilitate interactive activities	Interactive activities can increase student engagement, motivation and attention.	5
5.	Facilitate more social interaction among users	Provide opportunities for creating a sense of community and belonging. Social interactions can increase positive emotions and motivation.	5
6.	Facilitate communication between all users	Software should provide multiple ways to communicate.	5
7.	Provide feedback	The software should provide users with feedback during interaction with the different functions.	5
8.	Facilitate tools to visually	Visual communication can be	5

	perform presentations, exercises and collaboration	important to enhance understanding and learning.	
9.	Enable easy establishment of norms and rules for class behaviour and culture	The software should provide opportunities to clarify rules for class behaviour and culture.	4
10.	The interface and functions should consider Wickens multiple resource theory (Wickens, 2008).	Prevent high mental workload by consciously designing for human ability and resources.	4
11.	The design should consider users' current mental models.	Considering users' mental models when designing the software can make it easier for users to manoeuvre it (Potesnak, 1989).	4
12.	Prevent technical stress	Decrease stress related to equipment and software.	3
13.	Provide opportunities to give and receive feedback	Receiving feedback on lecture content and structure will help educators improve the lectures. Allowing students to impact lectures may increase engagement.	3
14.	Provide training of software	Educators and students should receive training and support in using the software.	1

5.2 Concept development

This chapter presents the stages performed to develop initial ideas into a final concept. The first part is the ideation phase, followed by an analysis of the ideas. The analysis presents selected ideas to be developed into a concept. For further development, HTA diagrams and a UX sitemap were used to illustrate the structure of the digital concept. The diagrams and sitemap were used as guidelines in the design and development of wireframes during the prototyping stage. The interactive prototype was tested during four usability tests, divided equally between students and educators.

5.2.1 Ideation

The ideation was performed during four activities: brainstorming of customer journey opportunities, project group brainstorming and brainwriting along with two separate group

brainstorming workshops. The results of the brainstorming regarding the identified customer journey opportunities are available for educators in Appendix 9, and students in Appendix 10. Furthermore, the results from the two group workshops are available in Appendix 11. Finally, the project group brainstorming results are concluded in Appendix 12. A summary of all ideas and solutions from the ideation methods are presented in this section.

The ideation phase was iterative and a wide range of ideas was created, see an example of one workshop ideation session performed in Figure 12 below. The session provided ideas of how to solve four problems that were found during the user studies. One problem is the absence of a developed and pronounced culture in a digital format considering rules and norms and how to deal with the lack of visual feedback since the cameras often are turned off. Furthermore, how to prevent loneliness was discussed and the common problem of feeling stressed over technical issues. The ideas provided possible solutions for how to improve communication, collaboration and social aspects. Furthermore, the cognitive theories of perception, attention, vigilance, emotions and mental models were considered during the entire ideation process. This also applies to the theories of usability and interaction. Additionally, to meet the complexity of software development, ideation on a more detailed level was conducted. It considered the functionality of different features.

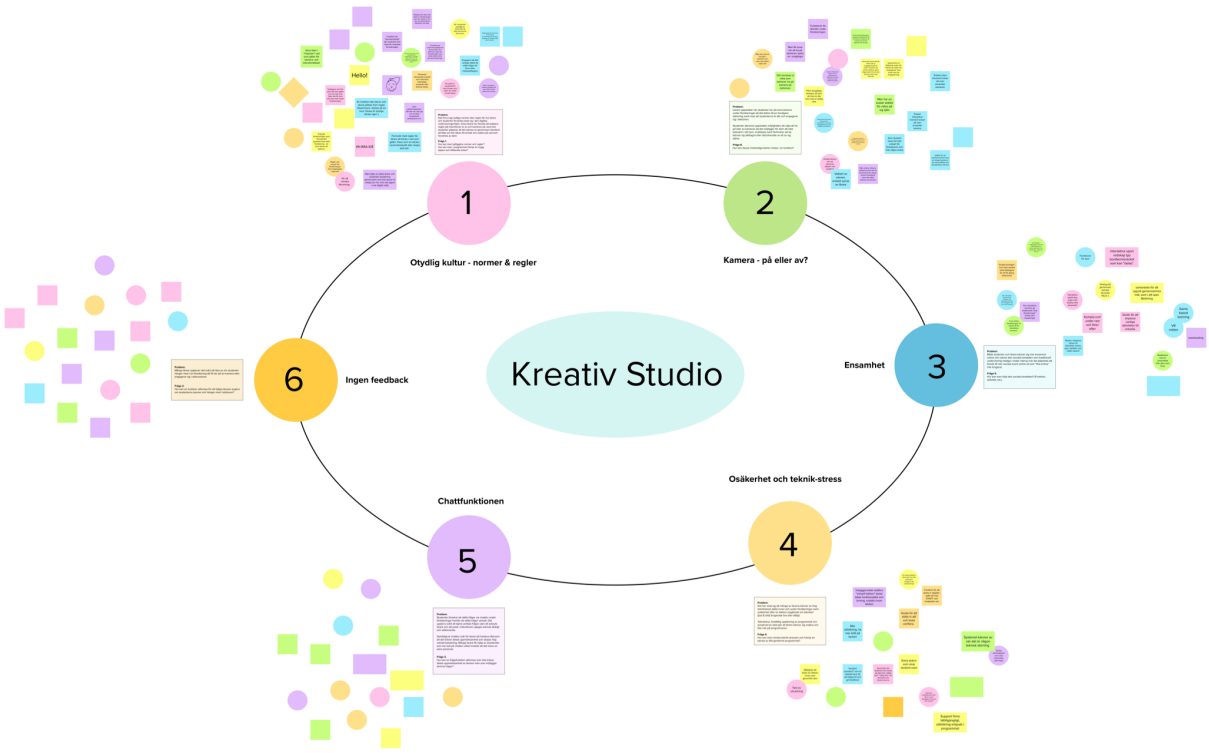


Figure 12. Worksheet from Kreativ Studio workshop in Mural

5.2.2 Selection of ideas

A summary of selected ideas and solutions from the ideation methods are presented in this chapter. The ideas were selected from a collection of all generated ideas from the ideation phase, see figure 13, for full version see Appendix 13. The selection was based on how well the ideas fulfilled the requirements and needs of the users. The ideas to develop further were chosen based on qualitative judgements and on how well the idea fulfilled the requirements listed in chapter 5.1.5.

Figure 13. Process picture from the analysis of ideas

Furthermore, the benchmark was considered when choosing what functions to include in the concept and what ideas to develop further. This to take advantage of users' mental models and previous understanding of similar software. To create a concept that can easily be understood by users, the functions that were perceived in the user study as well working or necessary were incorporated into the new concept. However, some functions which were proven inadequate in the user study were either developed further or excluded from the concept.

The ideas selected to move forward into the prototyping stage are presented below in Table 2, which is an overview of the ideas mainly concerning the educator's experience. Table 3 shows the ideas relevant to the students' experience. In order to visualize the ideas in the prototype the ideas were turned into functions fulfilling the idea.

Table 2. The selected ideas for the user experience of the educators.

Educators		
Solutions improving interaction, communication and social aspects		Function fulfilling the idea
1.	Allow educators to easily incorporate interactive activities in lecture that will increase motivation and social connections between students and educators. The interactive features include: Collaboration board, Breakout rooms, Quizzes and Polls, Chat forum.	Collaboration board, Breakout rooms, Quizzes and Polls, Chat forum.
2.	Allow educators to receive feedback on lecture content and structure.	Feedback feature. Enable to send out quick questions.
3.	Rooms: Provide educators with better overview of rooms and opportunities to easily navigate between rooms.	Room overview feature
4.	Upvoting functionality in chat allows educators to estimate what questions most students have in common.	Upvoted questions visibility function
Solutions facilitating information and control		
4.	Ability to decide rules before a lecture allows educators to clarify behavioural rules for specific lectures and activities.	Rule establishing feature
5.	A homepage with all lecture related information gathered in one place. Allow educators to plan and prepare lectures, activities, create links and material.	All links in one place. Opportunity to plan lectures within the program. All communication in one place.
6.	Automatic training in the software. A feature that allows educators to be guided in how to use the software when learning it.	Training and guidance feature
Solutions preventing technical stress		
7.	A feature that allows educators and students to monitor if the equipment is working and that indicates where the problem lies if there are any disturbances.	Technical control panel. Messages that tell the user if something is not working properly

Table 3. The selected ideas for the user experience of the students.

Students		
Solutions improving interaction, communication and social aspects		Functions fulfilling the idea
1.	Students choose to only be visible on video for the teacher.	Video visibility feature
2.	Collaboration board inside the programme for students to collaborate easily.	Collaboration board
3.	Provide students with opportunities to ask for help from inside breakout rooms.	Help request function
4.	Upvoting functionality in the chat function that allows students to upvote questions they agree with.	Upvoting functionality
Solutions facilitating information and control		
5.	Rules for how to behave during lectures are made visible for students.	Accessible rules feature
6.	A homepage with all lecture related information gathered in one place. Allow students to easily access lecture information and enter meetings.	All links gathered in one place. No need to have chats in other media to talk to classmates.
7.	Training in the software is provided. The feature allows educators and students to be guided in how to use the software when first learning it.	Training and guidance feature. Tips and trix during usage.
Solutions preventing technical stress		
8.	A feature that allows educators and students to monitor if the equipment is working and that indicates where the problem lies if there are any disturbances.	Technical control panel. Messages that tell the user if something is not working properly.

5.2.3 Prototyping

To visualize the ideas a prototype of the software was developed. The prototyping was performed in different stages: planning a structure using HTA diagrams and a sitemap, sketching wireframes and finally designing digital wireframes. The prototype was continuously evaluated by the project group and finally user tests were performed with both educators and students. This chapter presents the different stages of prototyping in a more detailed manner.

5.2.3.1 Building prototype structure and connections

To prepare for designing wireframes of the prototype the content and interactions were structured using HTA diagrams and a sitemap. By structuring the content using HTA diagrams the possible connections could thereafter be visualized using a sitemap. The HTA diagrams present an overall structure of the content in the student and educator homepage as well as the content in the video conferencing tool. The overall structure of the content in the video conferencing tool is visible in figure 14.

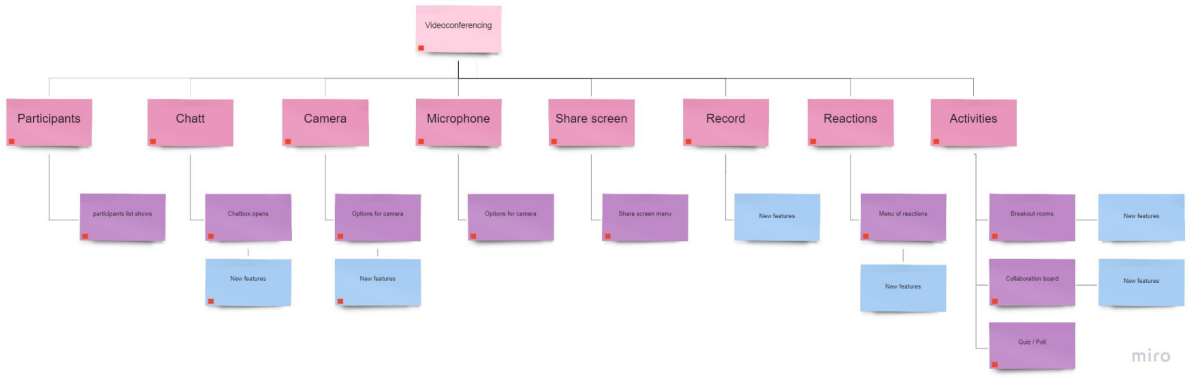


Figure 14. HTA diagram showing the overall structure of the video conferencing tool.

Using the HTA diagrams as a base for the structure of the prototype, a sitemap was created to further work on the possible interactions and navigation of the prototype. By creating the sitemap thoughts and ideas of the structure were concretized and the connections between pages of the prototype were created, see figure 15.

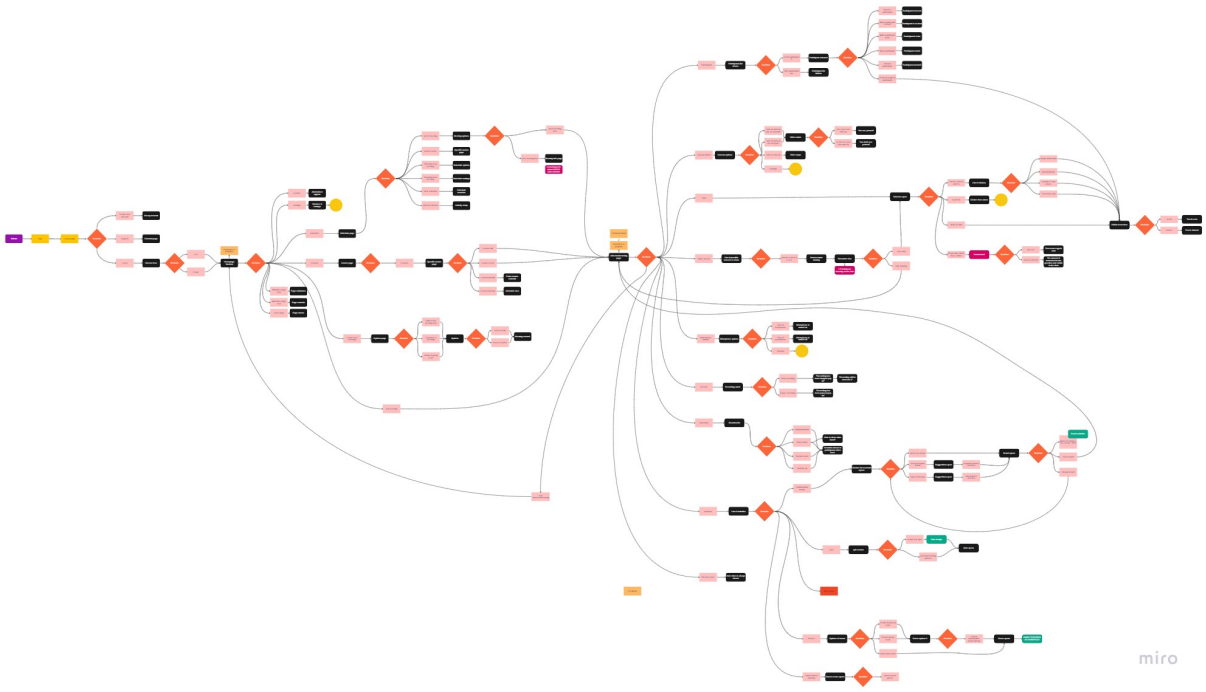


Figure 15. Sitemap used for visualizing the connections and interactions in the prototype.

5.2.3.2 Designing wireframes

The HTA diagrams and the sitemap were used as a base for the development of the wireframes. The first wireframes were created using pen and paper and the project group sketched wireframes to visually explore the structure on each page of the software. The sketches were developed iteratively and when the structure on all pages had been explored the project group started designing digital wireframes.

The digital wireframes were developed iteratively and both possible structures and visual expressions using for example different fonts and colours were explored. The focus however, was to visualize the ideas generated in the previous phase of the project. During the development of the digital wireframes theories of cognitive ergonomics and usability were considered in order for the prototype to meet the cognitive needs of the users as well as provide high usability and excellent user experience. Finally, the digital prototype was made interactive to facilitate usability tests. The interactivity made it possible to navigate through the concept in a realistic manner.

6. Final concept

The interactive prototype is a holistic design that includes both how the educators and students may use and be able to navigate within the concept. It is a complete solution that offers a homepage that facilitates the needs of planning lectures, communicating with other users and access to the integrated video conferencing tool, see figure 16. It is built with two separate homepages, one exclusive for the educators and one exclusive for the students. From each homepage it is possible to access the video conferencing tool. The prototype of the video conferencing tool has three different ways of usage, depending on if it is used by the educator, the student attending a lecture or a student hosting a meeting on their own. Of course, the educators may have a personal meeting as well but this was not prototyped since the video conferencing tool will have the same functionality and design as the students. The prototype is a visual tool to express and test how the application looks but there are hidden actions and functionality. The experience and possible actions of the prototype for both the educators and students will be presented more thoroughly below.

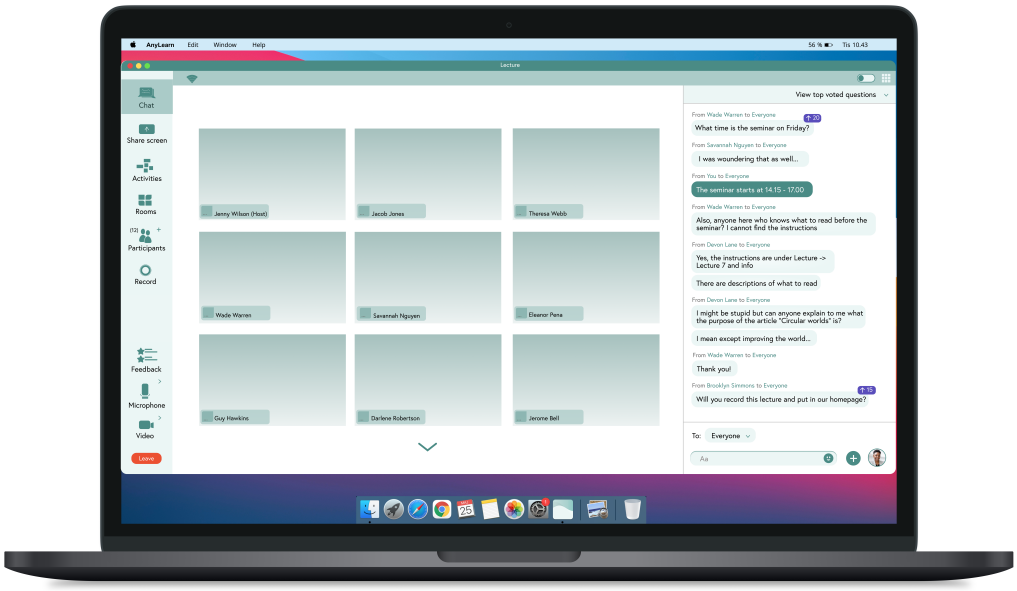


Figure 16. Final concept

Target group for the prototyped software

The target group of the prototype are university level educational institutions that want to perform high quality online lectures. The concept's functionalities are specifically adapted after the needs of students and educators that attend or perform online lectures in higher education.

When compared to the market competitors it is unique for a software to be adapted solely for educational purposes, see benchmark in chapter 4.1. Adapting the software to the needs of a single market is what defines the unique selling point of this concept.

6.1 The educator interface

This part of the chapter describes what the educator interacts with in the software, the educator homepages and videoconferencing view. It differs from the student interface as functionalities are adapted after the educator needs found in the user study.

Educator's homepages

The educator homepages offer a range of different functionalities to meet the needs of educators that teach using online lectures, see the functionalities and navigation of educator homepages in figure 17 below.

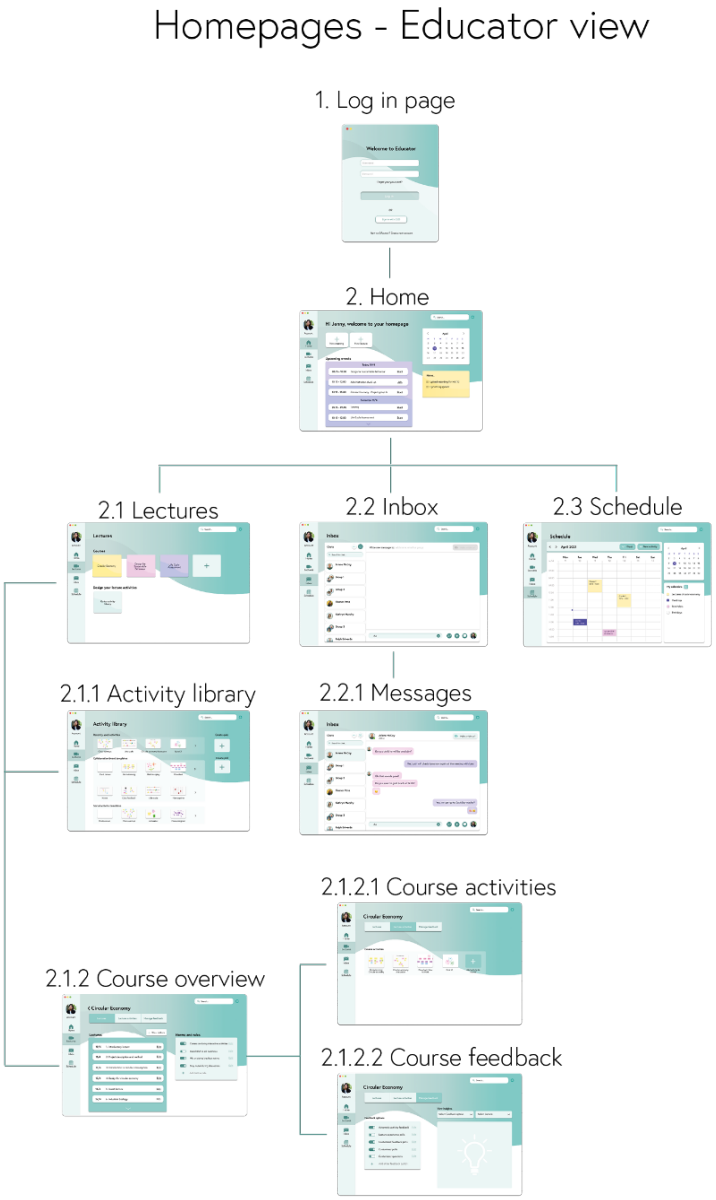


Figure 17. Wireframe structure of the educator homepage.

The first homepage, offers educators easy access to upcoming meetings and lectures and the possibility to directly start or plan new meetings or lectures, see figure 18.

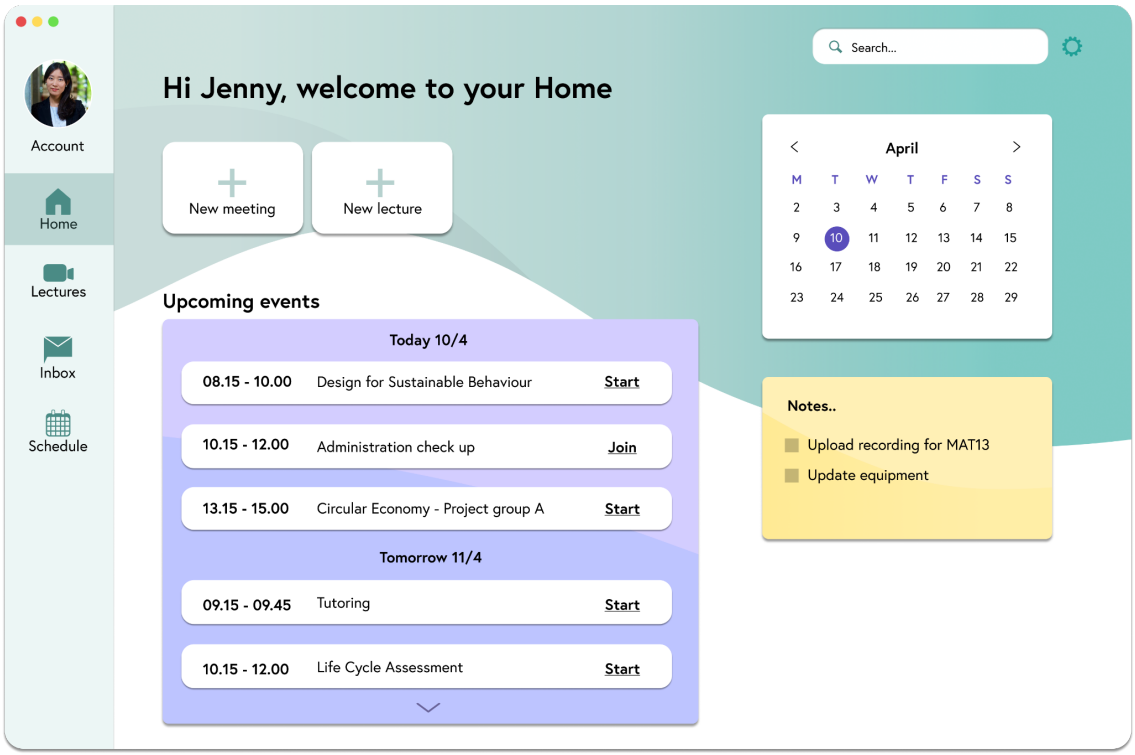


Figure 18. Educator Home

Furthermore, the educator homepages allow the educator to manage and plan lectures and lecture activities. The lecture activities are gathered in an activity library where collaboration boards, quizzes and polls can be prepared and assigned to specific courses or lectures, see figure 19. The educator can also through the course pages easily regulate what rules that apply for online class behaviour in a course, see figure 20. The information about course rules will thereafter be available in the student homepages and displayed when a student joins a lecture. Further the course pages provide educators with the opportunity to manage and regulate lecture feedback. Prepared feedback questions will thereafter be accessible for educators during lectures and can for example be used to evaluate students' experience of a specific activity. Also, the homepages give the educator access to an inbox where it is possible to communicate with other educators or students individually or in groups. It is also possible to start meetings directly in a chat. Finally, the educators are able to view and manage a schedule in the homepages where meetings can be accessed and new meetings planned.

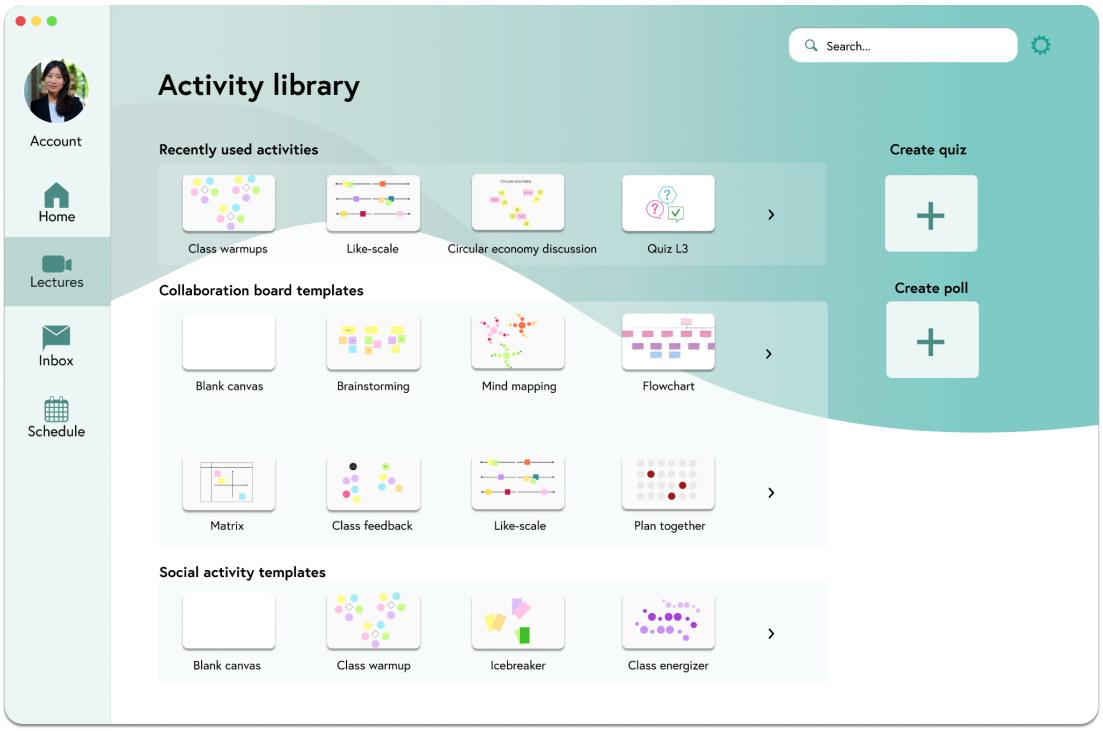


Figure 19. Educator activity library.

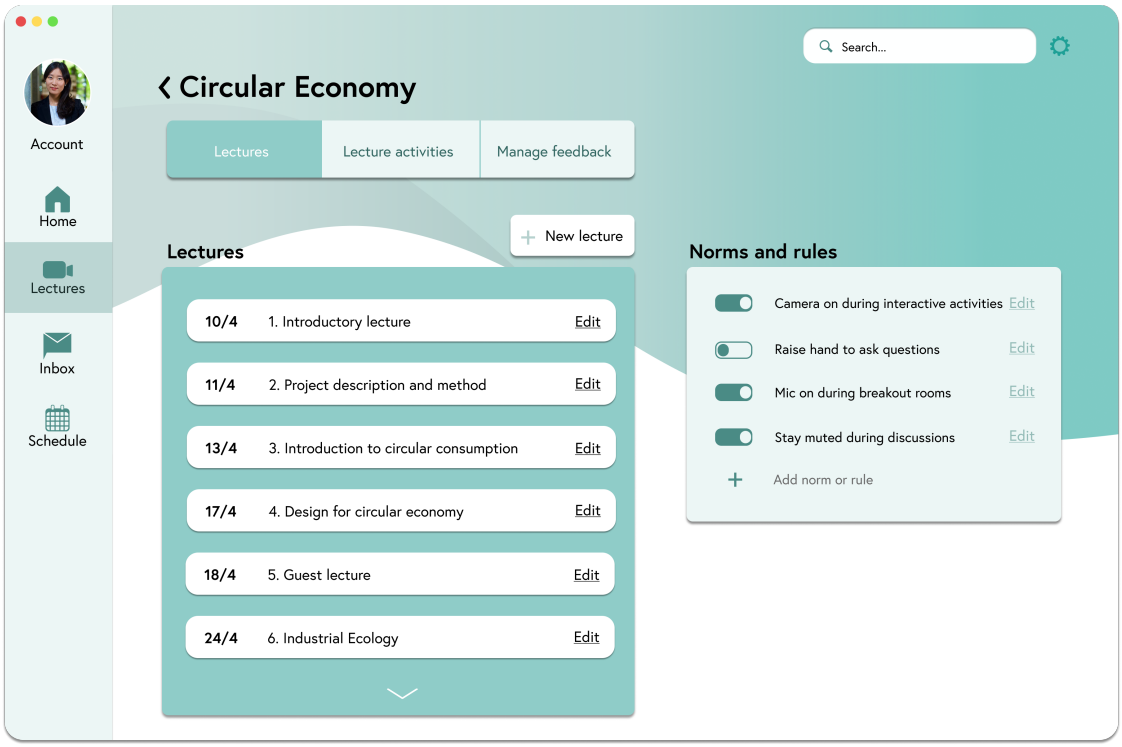


Figure 20: Educator course pages

Educator video conferencing view

The video conferencing view for the educator, see content and structure in figure 21, is more complex than the view a student has during a lecture. Except for standard functionalities like sharing screen, recording, participants and chat, other further developed or new functions are incorporated into the prototype. A new function is top voted questions that allow the educator to estimate what questions are common among several students, see figure 22. This function was developed to make it easier for educators to follow the chat while presenting. By only viewing top voted questions the educator can determine what questions most of the student have in common without having to scroll through the entire chat. Further, the activities' function allows easy access to the interactive tools: collaboration board, quiz and poll, however, in the prototype only the collaboration board is visualized, see figure 23. The collaboration board is a version of the typical whiteboard found in similar software, see chapter 4.1, however it is a further developed version in which predesigned templates can be used. The educators can either choose templates from the activity library, see figure 19 or prepare collaboration boards under lecture activities in the course homepage or simply open a new collaboration board from inside the video conferencing tool.

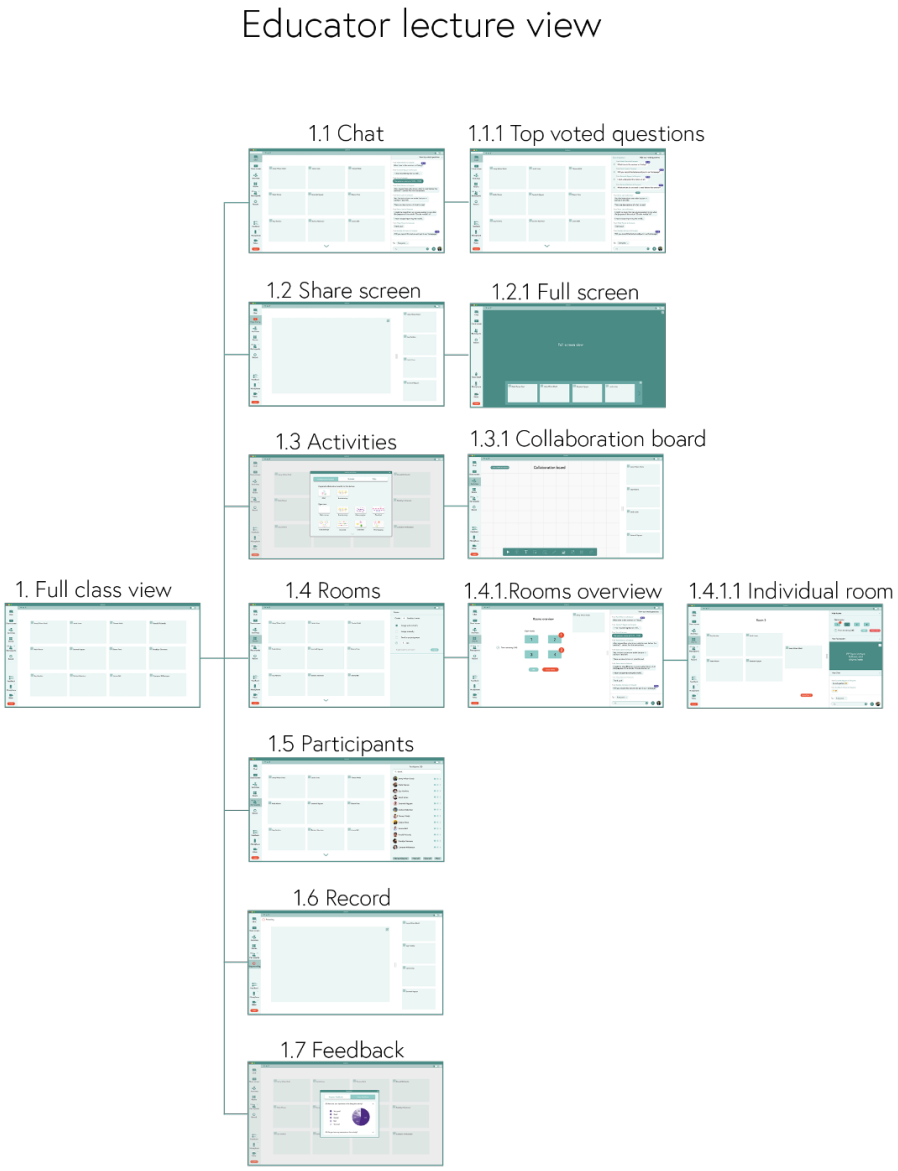


Figure 21. Wireframe structure of educator video conferencing view during lecture.

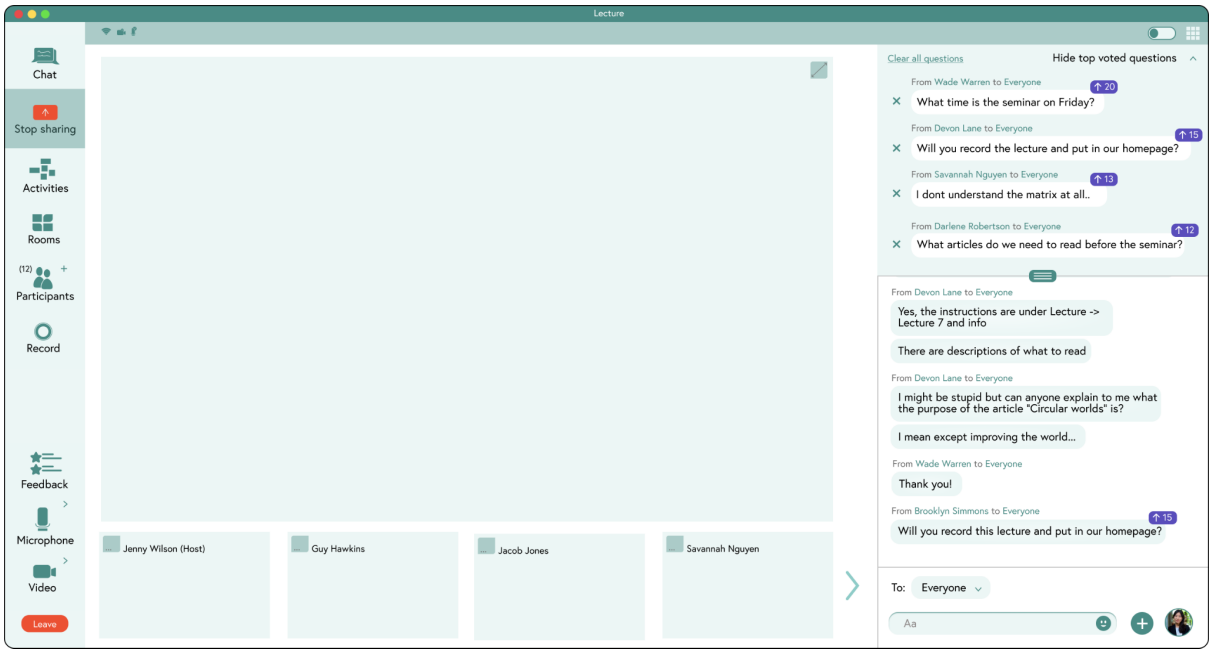


Figure 22. Shows top voted questions in the right corner above the regular chat

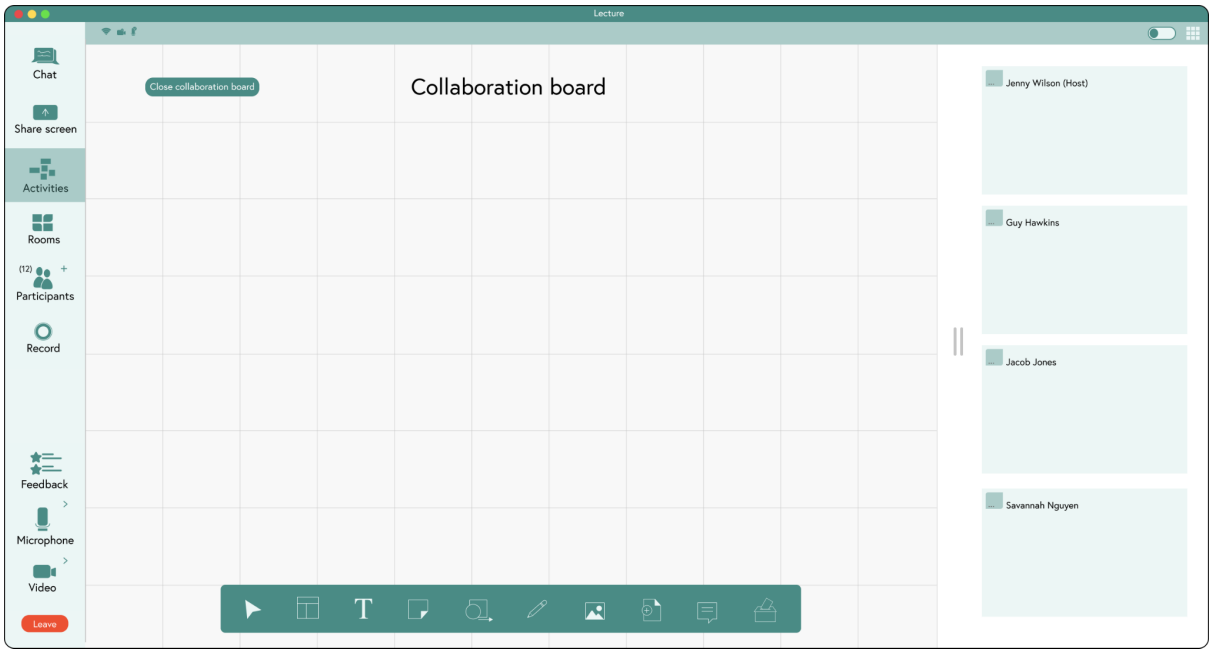


Figure 23. Collaboration board

When creating rooms, a new feature is the overview of all open rooms, view figure 24, and a function allowing students to request help from the educator when inside a room. When a room has requested help from a teacher there will be a notification visible in the *room overview* that notifies the educator of the request by making a red dot appear by the room, see figure 24. The number in the red dot represents the group's placement in line for help. Further, the overview interface also allows educators to easily navigate between rooms by clicking the room icons.

When visiting a room, the educator is still able to access an overview of remaining rooms and also view the chat and shared screen, see figure 25.

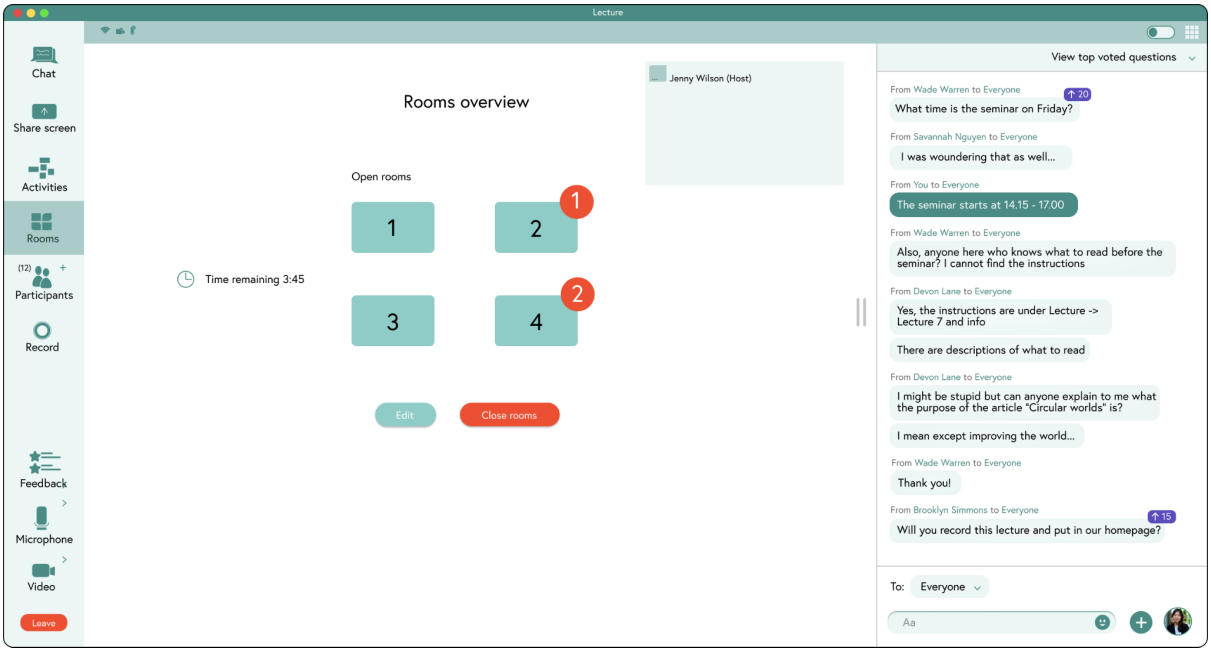


Figure 24. Room overview

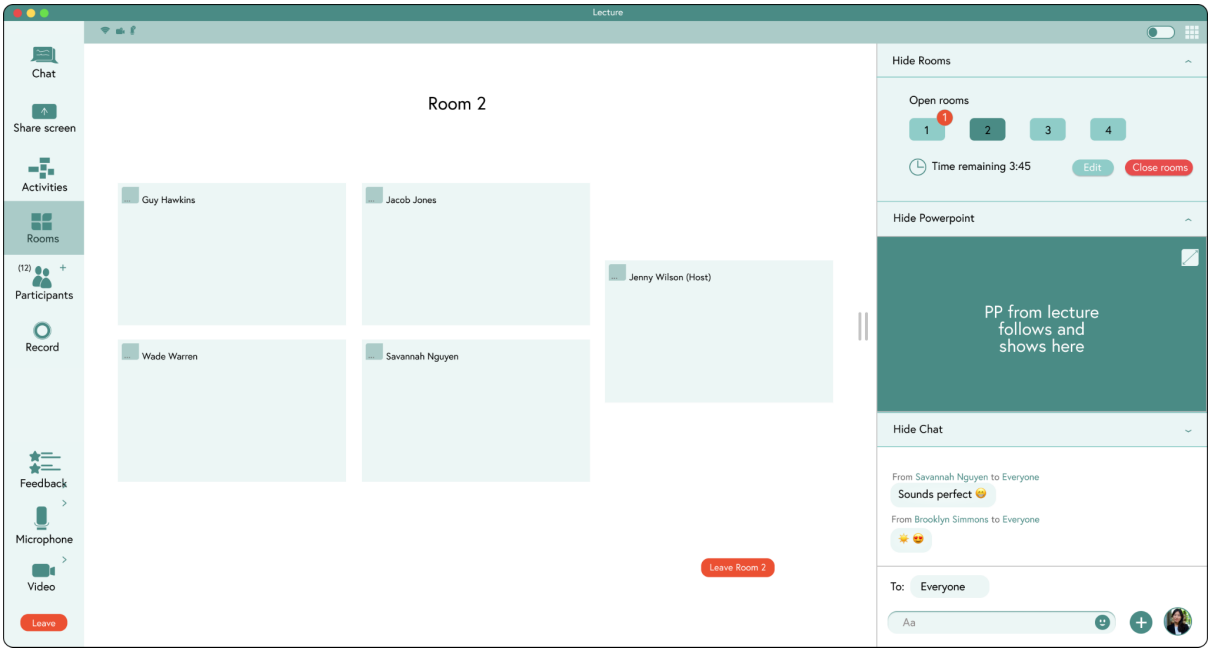
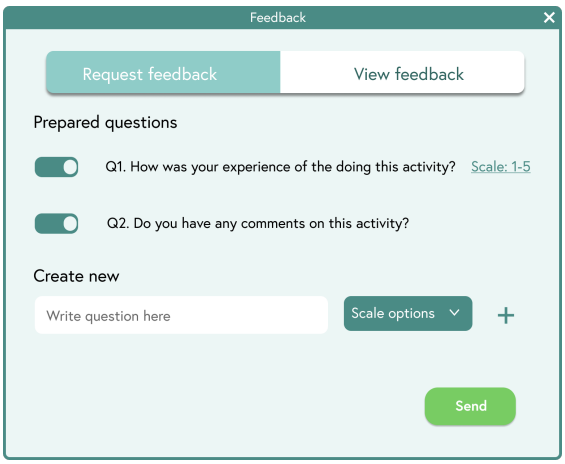


Figure 25. View of educator when visiting a room. Room overview, shared screen and chat are available on the right side.

Another new feature is the feedback function that allows educators to request feedback from students during the lecture. The feedback questions can be prepared before a lecture in the educator homepages or directly during a lecture, see figure 26. When feedback is requested

from the teacher a pop up window is displayed for the students where feedback questions can be answered. The feedback insights is thereafter accessible to the teacher directly through the feedback function in the video conferencing view, see figure 27, or in the homepages.



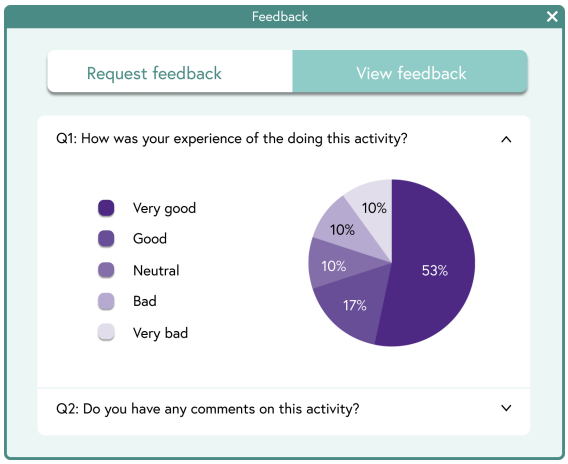


Figure 26 (left). Educator view of requesting feedback during lecture
Figure 27 (right). Educator view of feedback insight

General functionalities that apply in the video conferencing tool for both educators and students are the feedback that is given regarding if there are technical issues. For example, in case of if the microphone is not working the software will give the user feedback via a pop-up window, see figure 28, that will be shown for a few seconds. This notifies the educator of the problem so that it can be dealt with.

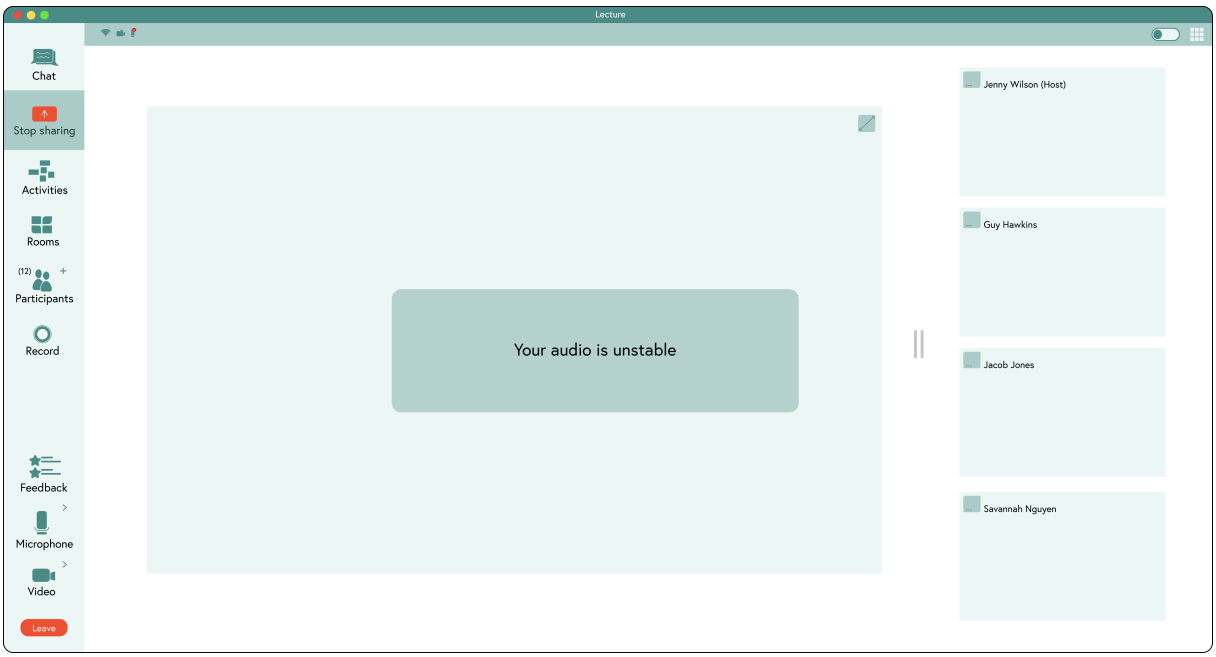


Figure 28. Pop-up window giving the educator feedback on sound quality

6.2 The student interface

This part of the chapter presents the interface in the software that is dedicated towards the student needs, the student homepages and videoconferencing view.

Student's homepages

The homepages of a student have less functionalities than the educator homepages. The student homepages give the student access to lecture information, groups, inbox, and schedule, see figure 29. From the home, the student has easy access to upcoming meetings and to groups, see figure 30. However, meetings can also be initiated through messages in the inbox or in the schedule view. The home also allows the student to easily create new groups or personal meetings. The homepages are designed to prevent confusion and high mental workload by assisting the users with easy access to upcoming lectures and thereby preventing search after links by having them all collected. Furthermore, it facilitates one application for the users to communicate by different means instead of the users needing to connect with, for example, group members through private applications.

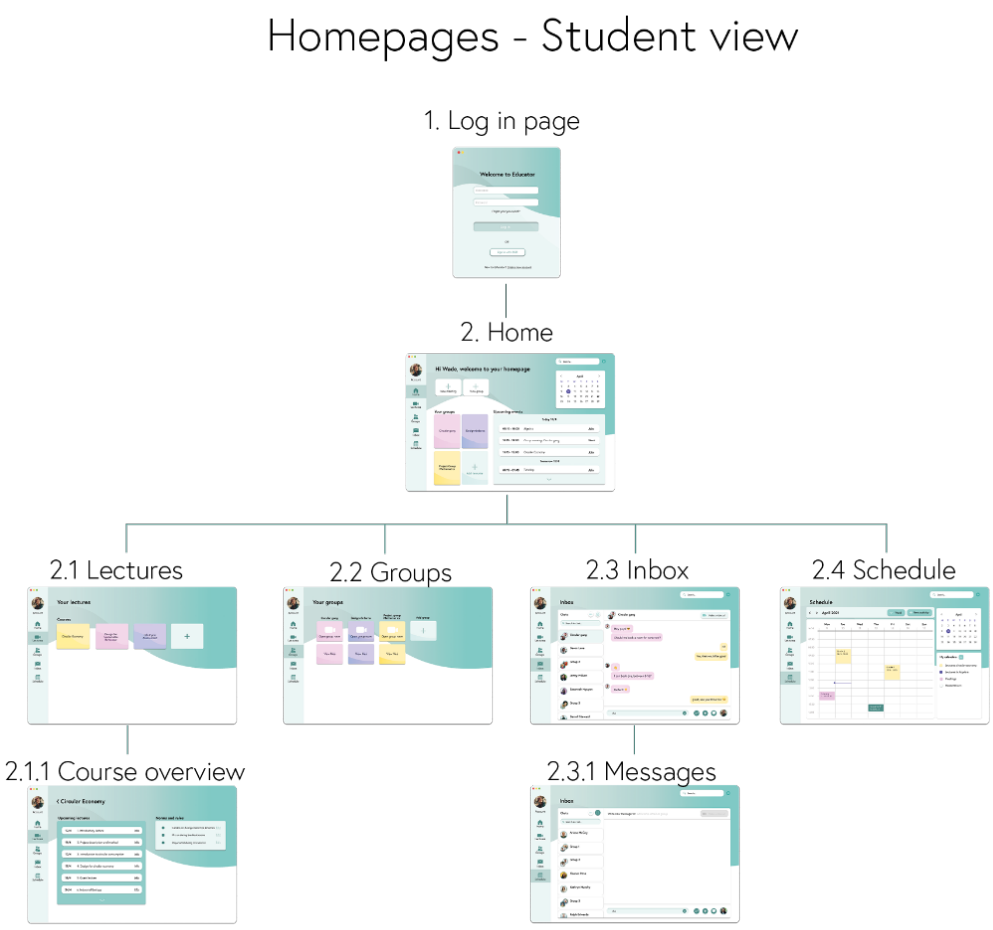


Figure 29. Wireframe structure of student homepages

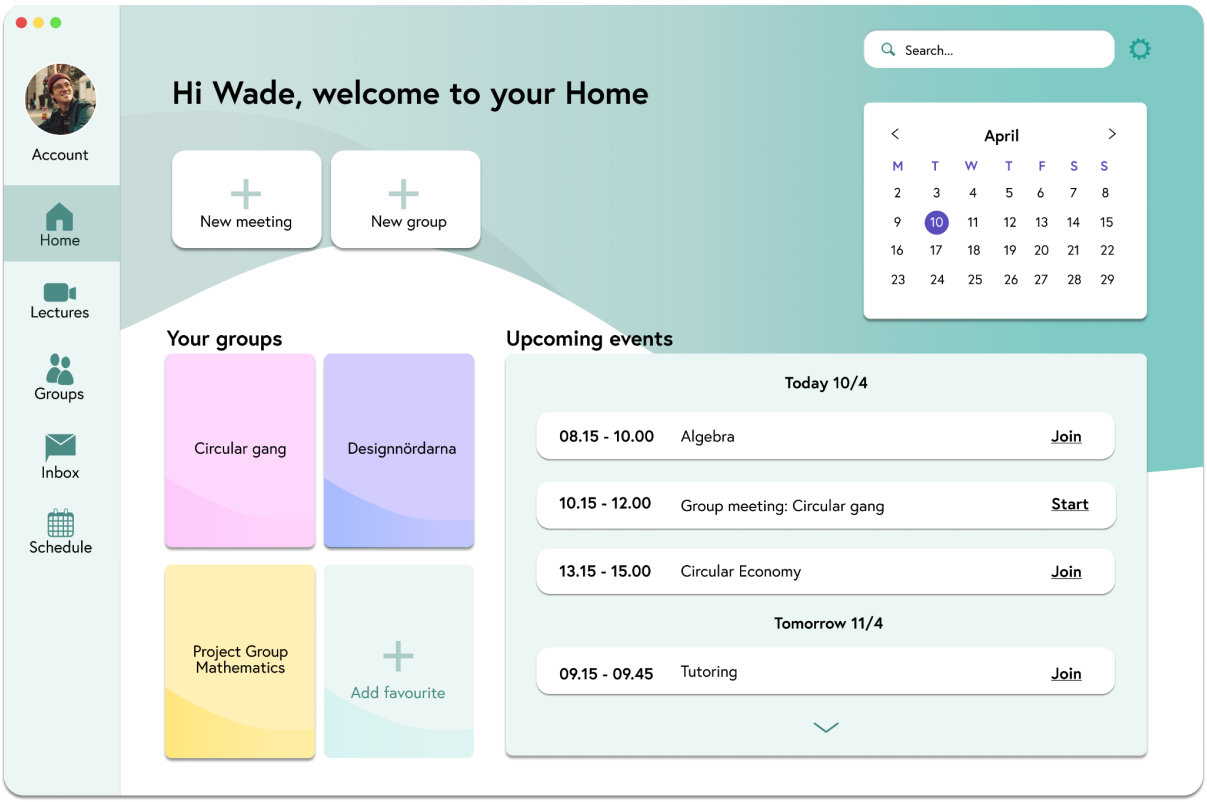


Figure 30. Student Homepage with easy access to upcoming meetings and groups

Student video conferencing view attending online lectures

The video conferencing view for students during a lecture has less functions than the educator view. Only the host, the educator, can access and manage activities and rooms. The student, however, still has access to basic functions like chat, share screen, participants, record and raise hand, see figure 31 below. A further developed function in the student lecture view is the ability to upvote questions in the chat. Another new functionality is the pop-up window containing lecture rules that opens when the student joins a lecture. Also, the room feature allows students in a room to request help from teachers as well as view both chat and the shared screen from inside the room. An additional view, see figure 32 below, is how the students' rooms are designed during usage of a collaboration board inside the room. It makes it possible for the students to only use the application instead of navigating between different browsers which makes it easier to collaborate and stay focused.

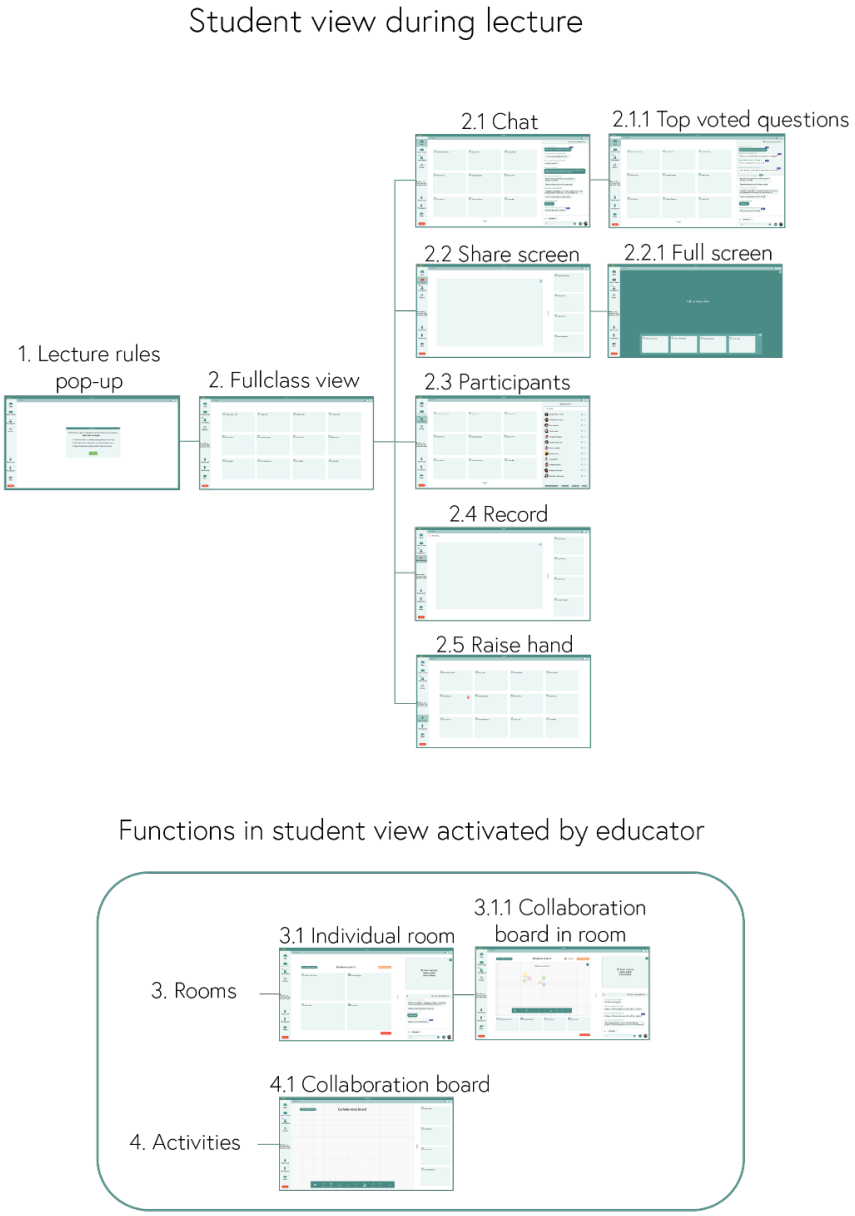


Figure 31. Wireframe structure of student view during a lecture

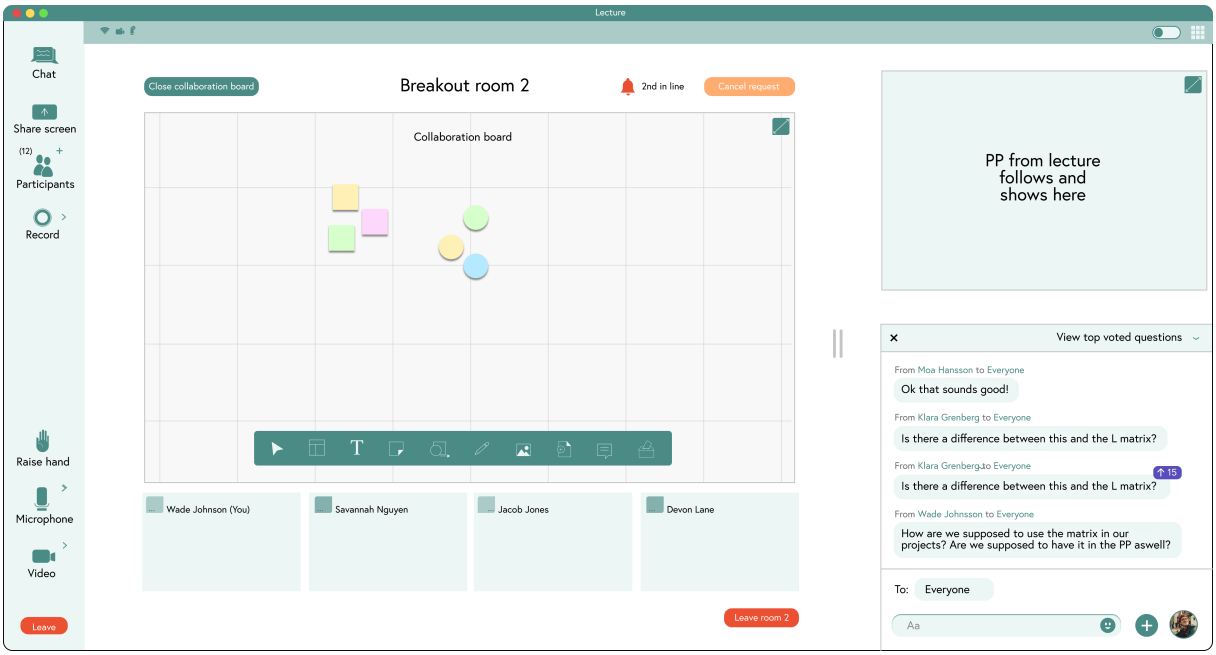


Figure 32. Window layout during rooms working with a collaboration board.

Student video conferencing view as host

When the students themselves host personal meetings, with for example project groups, the video conferencing view offers more functionalities than if they are attending an online lecture hosted by an educator, see figure 33. In this view the students still have access to the basic functions: chat, share screen, participants, record and raise hand. However, in a private meeting the students can now access activities such as collaboration boards, quizzes and polls. Furthermore, it is possible to use the room functionality to divide the participants into smaller groups if desired.

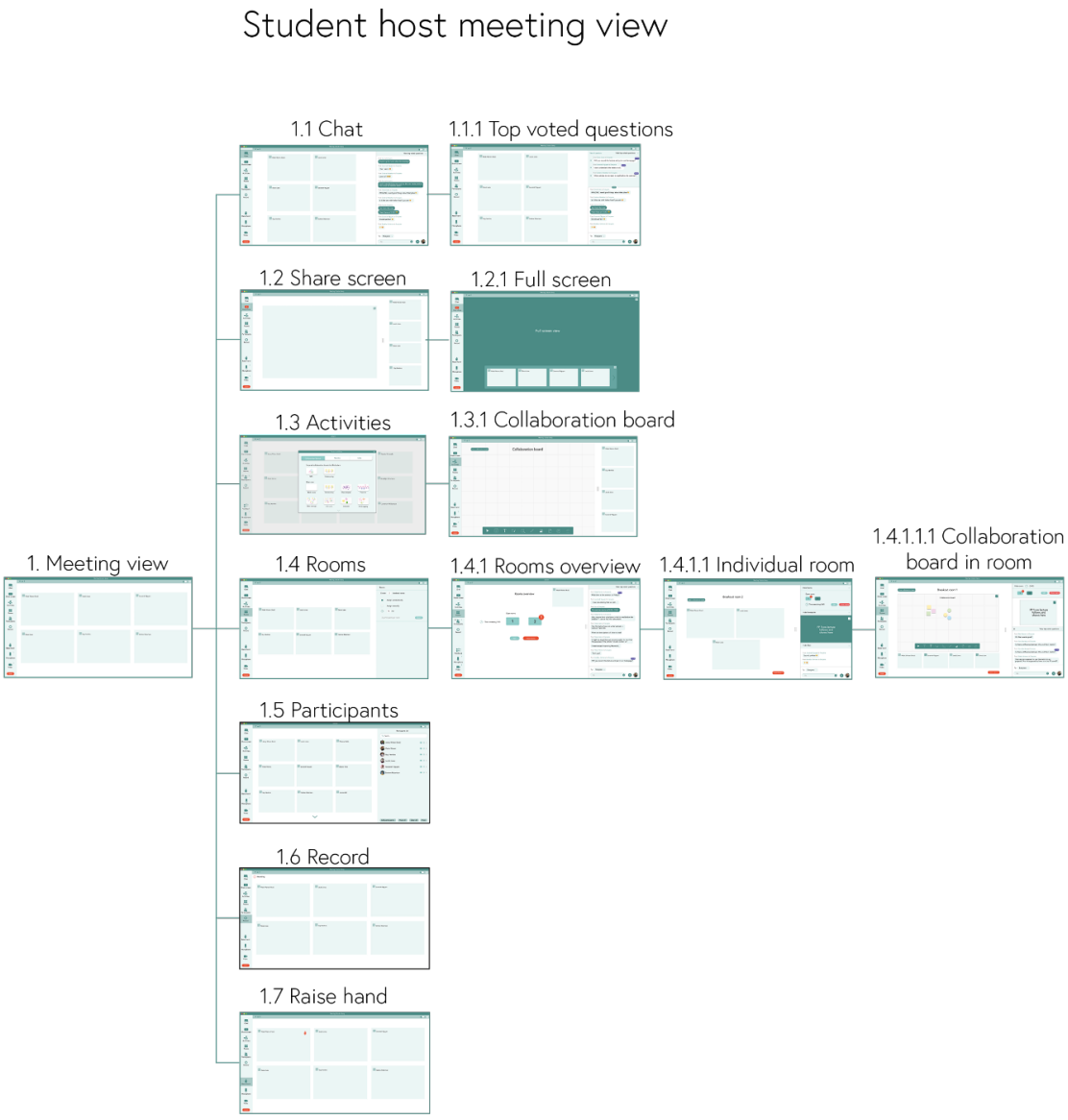


Figure 33. Wireframe structure of student host meeting view.

7. Usability tests

To evaluate the interactive prototype, four usability tests were performed together with the educators and students. The test was conducted with the intention to test all the applied ideas and newly designed features to validate if it is seen as valuable and useful. At the same time, it provided an evaluation of the overall usability of the design. The usability tests resulted in feedback of what could be improved and confirmations of what worked well in the interactive prototype.

The tests evaluated overall usability through observations of the participants' flow and movement throughout the interface. It also evaluated the user's understanding of the visual design, if it was in line with their expectations of how certain affordances, signifiers and patterns work. How well the prototype coincides with the users' current mental models and perception of how similar software functions. Finally, the general understanding of descriptions such as headlines and text was discussed as well as the overall colour scheme. The result from all tasks will not be presented since some tasks was used as warm-up and to see how well the users could navigate in the programme. The tasks presented will be the ones that focused on testing the new features.

7.1 Usability tests with educators

Two usability tests of the interactive prototype were performed together with two educators. The participants were asked to test the tasks presented in Appendix 5. The tasks that provided the most prominent insights are presented in this chapter.

Navigating in the educator homepages

The initial tasks, 1 to 4, was testing the usability of the homepages. The tasks asked the participants to discover different functions and features. The participants navigated and performed most tasks with ease. The homepage was described as functional and evident, however, a possibility to add personal customization would be preferred in order to quickly see and use the most common individually executed actions.

Task number 2, to view specific feedback, was a bit difficult since the headlines were seen as a bit misleading as they did not represent what was asked for (see figure 34 below).

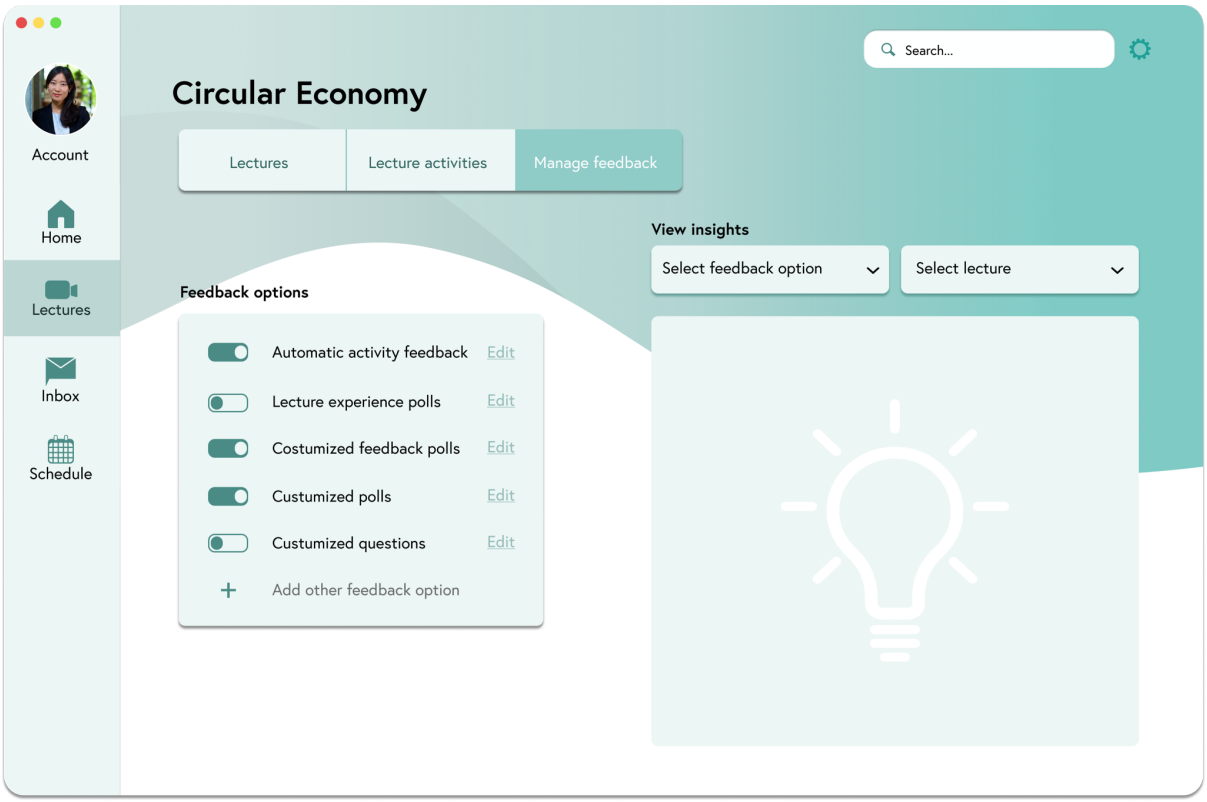


Figure 34. The feedback page for circular economy

Another insight from the tests was a reflection about what was meant with the section called lectures under a course page, see red highlighted field in figure 35 below. It was questioned what kind of purpose the section had. If it was for planning live lectures, upload recorded lectures or if it was a function that automatically recorded the live lectures and uploaded the material there. It was suggested that it could be flexible and adjusted after the educators wishes. Furthermore, in that case, it would be proficient to have a hide function so that some material can be hidden from the students and revealed whenever it is suitable.

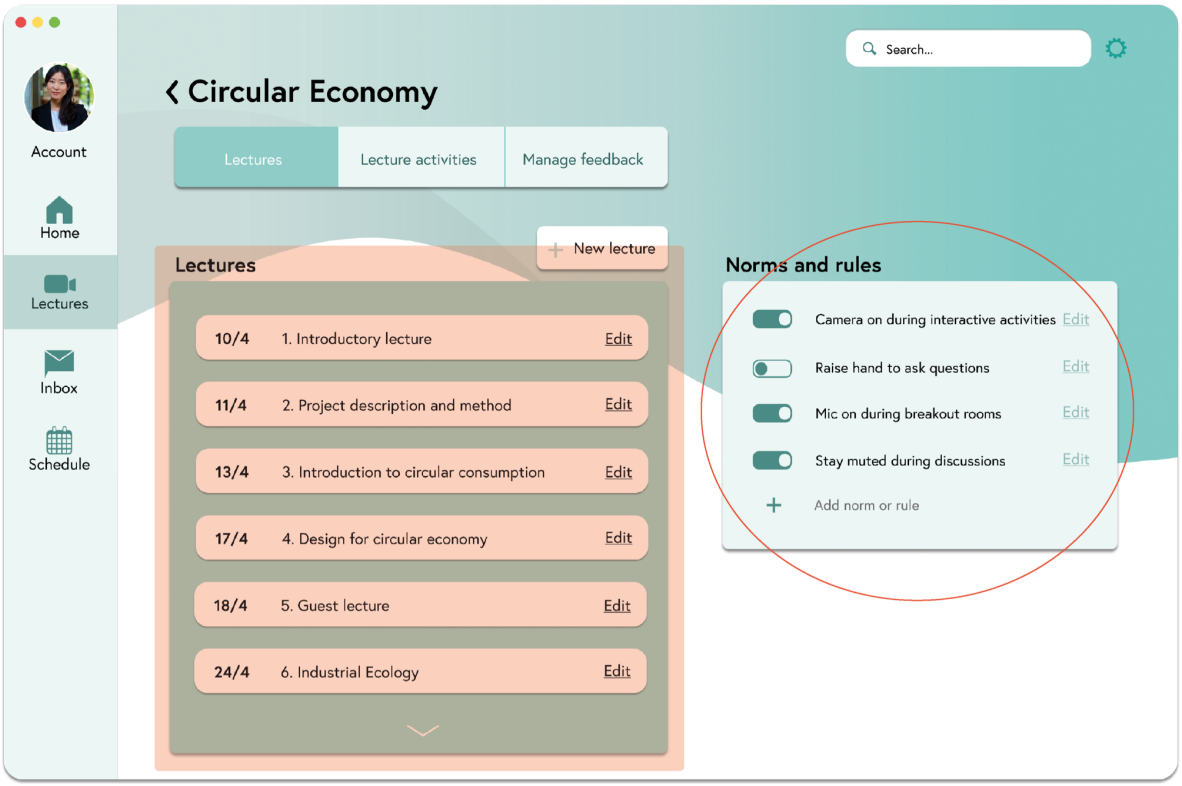


Figure 35. The course page of Circular Economy showing the sections lectures and norms and rules.

The test participants found the feature of deciding norms and rules to be a good addition, the section marked with a red circle in figure 35 above. It may be noticed and used by some of the students even if not everyone will follow. A comment from one test participant was to add a selection of "add to all live lectures" of the course or only to specific lectures.

In the activity library page, (shown in figure 36 below), it was pointed out that the pattern and unity of the page was out of balance. It was questioned why the quizzes and polls were visualized in another way than the collaboration boards and social activities templates.

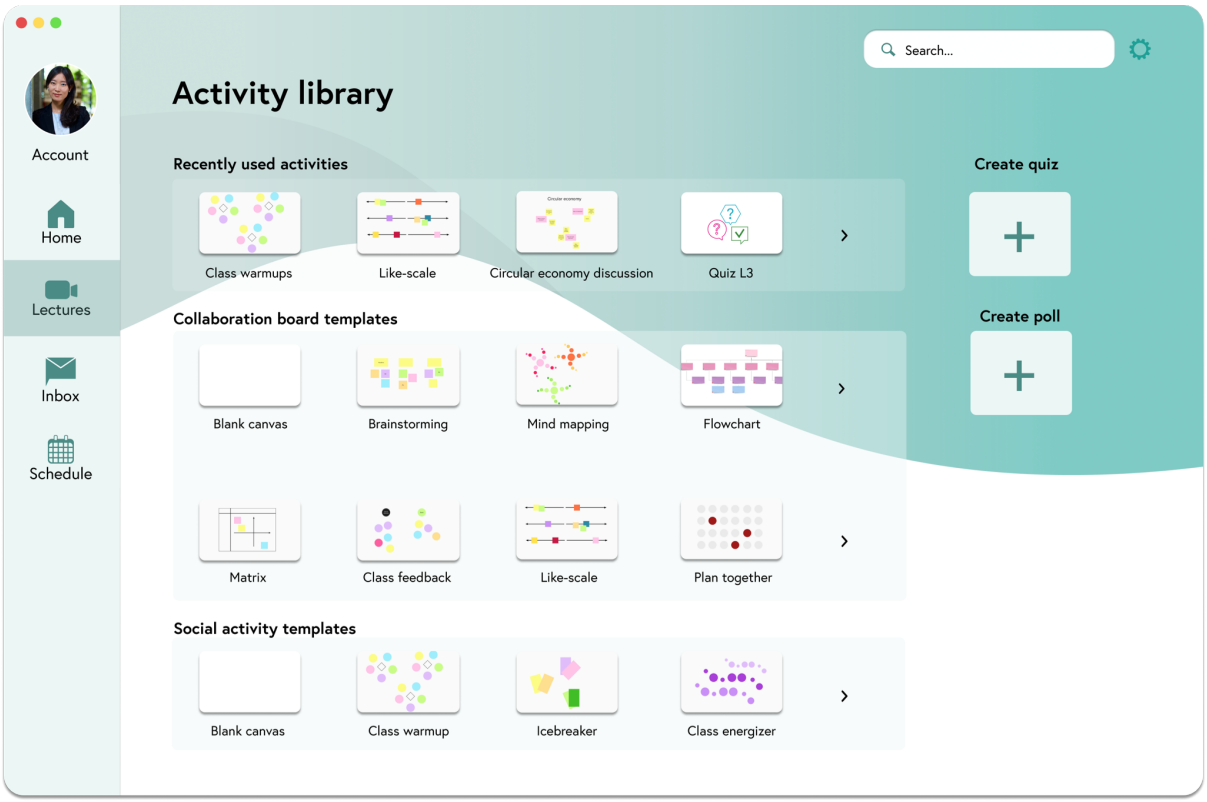


Figure 36. Lecture activities

Share screen

The new default view when sharing screen was mentioned to be very good since it offered to see the material shared as well as the chat if desired. However, it was pointed out that it also is desired to be able to see the participants list due to the ability to see if students had raised their hands. Furthermore, it was said that it would be very good if it was possible to see in what order the hands were raised.

Pop-ups

During the test, different kinds of pop-ups were tested. One is concerning technical issues, another is educational pop-ups and the last one is pop-ups in the form of reminders.

During task number 5 of the usability tests, the prototype gives a message to the user about the audio being unstable, see centre of figure 37 below for a visual of the message. The task asks what the message is and how the test participant would try to fix the audio. It was expressed that the message was shown a bit too quickly but both participants succeeded in reading it. When trying to solve the issue of bad audio the two participants both noticed the small red warning icon in the top-left corner, however, it was claimed to be hard to see due to its small

size. One participant used it anyway and found the menu to audio settings, however, the other searched in the menu bottom-left (highlighted with red in figure 37) by the microphone icon and found the settings there instead. It was suggested to move the red indication to the icon of the microphone down to the left, instead of using two options.

Figure 37. The share screen window with the message in centre and the top-left icons as enlargements.

One kind of pop-up is an educational pop-up that helps the users to find their way and discover new functions throughout the program. The participants only got an explanation of this feature since it was not part of the prototype, however, both found it to be a good idea.

The third type of pop-ups are a message that reminds the educator about the time which helps with time breaks. This feature was also seen as valuable since it was mentioned as hard to keep track of time sometimes during a lecture. The only improvement would be to have the message for a bit longer so there was time to read and notice it properly.

Chat functionality

The new look of the chat is appreciated and the bubbles around the text were praised as helping the viewer to see who has written what in an easier way, see figure 38. The new feature of top-voted questions, , see red marked area in figure 38, seemed easy for the test participants to find

and an understanding of what the function meant was coherent with the participants' impression and the intended design. Nevertheless, an uncertainty of how well it would work was communicated. There is a concern that some students might not post their own questions. Furthermore, it was worrying that the function might be used in a reckless way and upvote disrespectful questions.

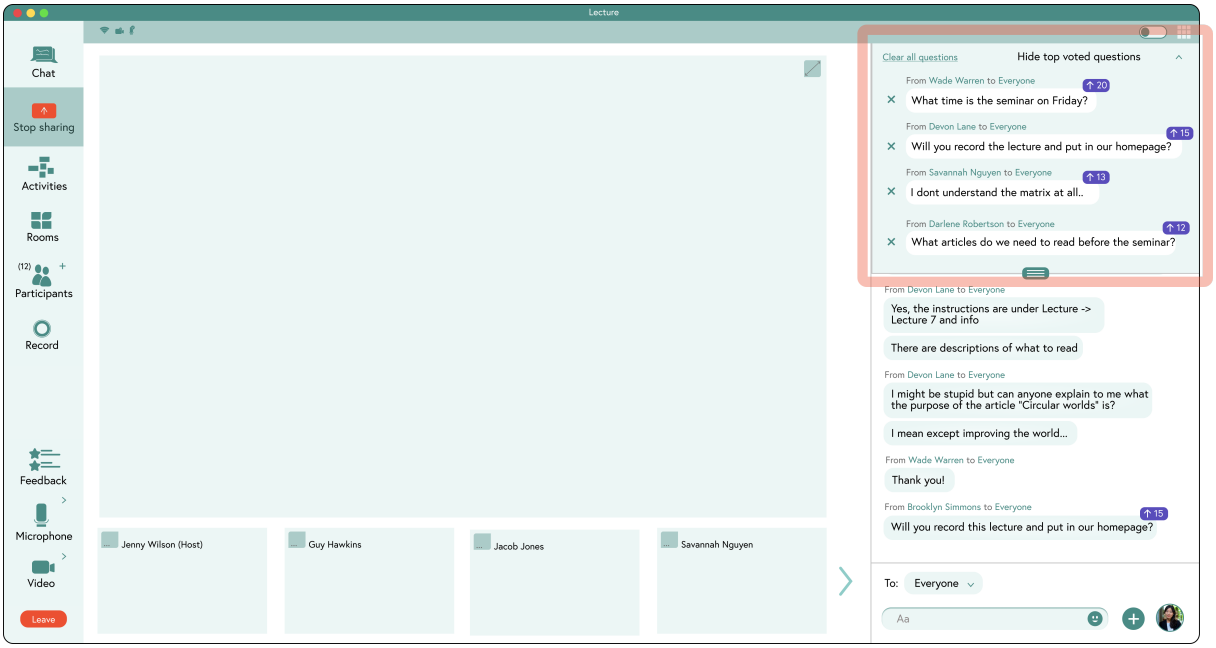


Figure 38. The chat functionality including top voted questions marked in red

Camera functionality

When the educators were asked to hide the camera view, in task 7, it seemed quite easy to do. However, knowledge about its existence might be hard to discover. Furthermore, the value of the function was questioned. It was mentioned that the user might forget that the camera is on if it is hidden and that may lead to unwanted situations.

During this task, a feature that was not considered before was raised by one test user. It is to allow for cinema view, a filter that shows all participants with camera on as if they are sitting in a cinema. It was expressed to feel more as if the class was present than the normal view does.

Activities

The integration of collaboration board, quiz and polls into the video conferencing tool was seen as very useful and valuable. Some clear advantages are the opportunities to prepare the activities

before and not having to deal with links and external web pages. It was noted that to really be of high value it needs to be able to smoothly transfer the activities between full class and rooms. Therefore, if students are allocated to the rooms, the setting should automatically follow and when closing rooms, the results should be visible in full class. Furthermore, it was pointed out to be good if the educator would be able to see the work happening live when using the collaboration board even if the students are working in separate rooms.

Feedback

Task number 9 asked the participant to request feedback from the students during a live lecture. It was easy to find in the main menu for both participants. The possibility to choose different ratings or questions were appreciated. The feasibility to prepare the feedback options before a lecture was seen as a good addition.

Rooms

During the test, task number 10 assessed the experience of the new layout when using rooms. When creating rooms one participant suggested making the timer (see enlarged area in figure 39) clearer since it was not compatible with the participants' perception of how it should look.

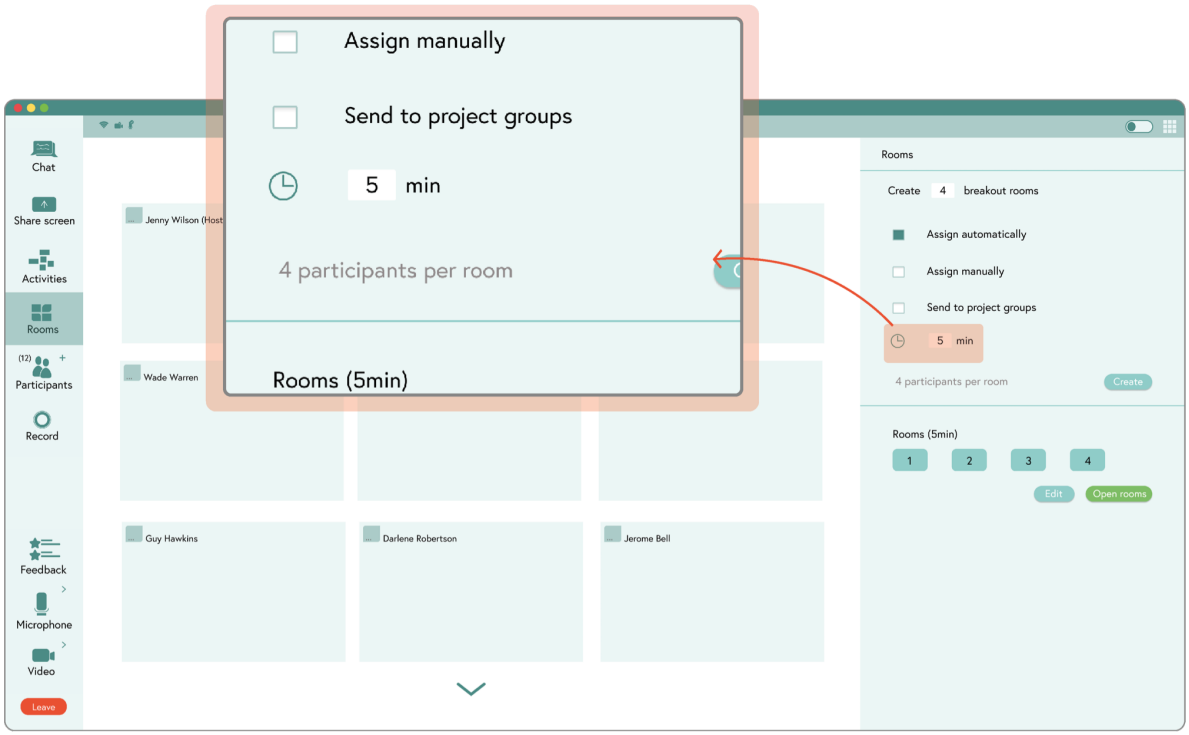


Figure 39. The view when creating new rooms.

The new room overview, see figure 40, was considered as a great asset. It provided a good overview of all rooms. However, it was pointed out that the opportunity to see all participants would be necessary. The red markings with numbers, indicating that a room needs help and in which order, were not totally obvious. However, when hovering and receiving feedback (the red marked area in figure 40 below) it became very clear.

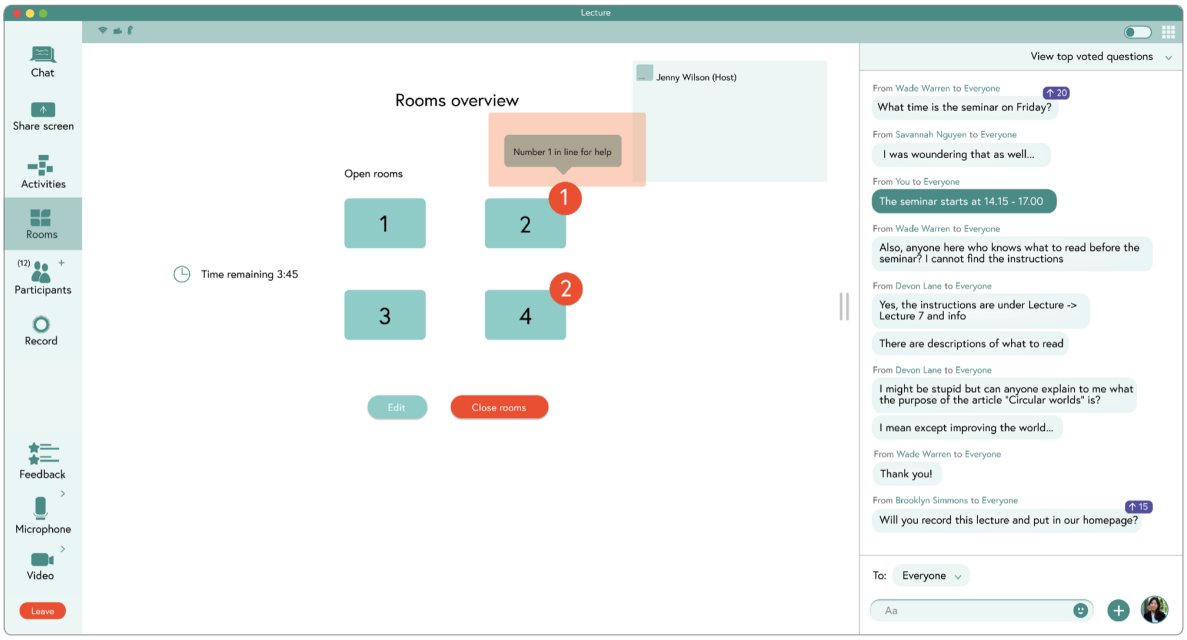


Figure 40. Room overview.

When entering a room, the menu to the right (marked in figure 41 below) was hard for the participants to find. The user's guess was that it depended on the colour, headlines or placement of the menu.

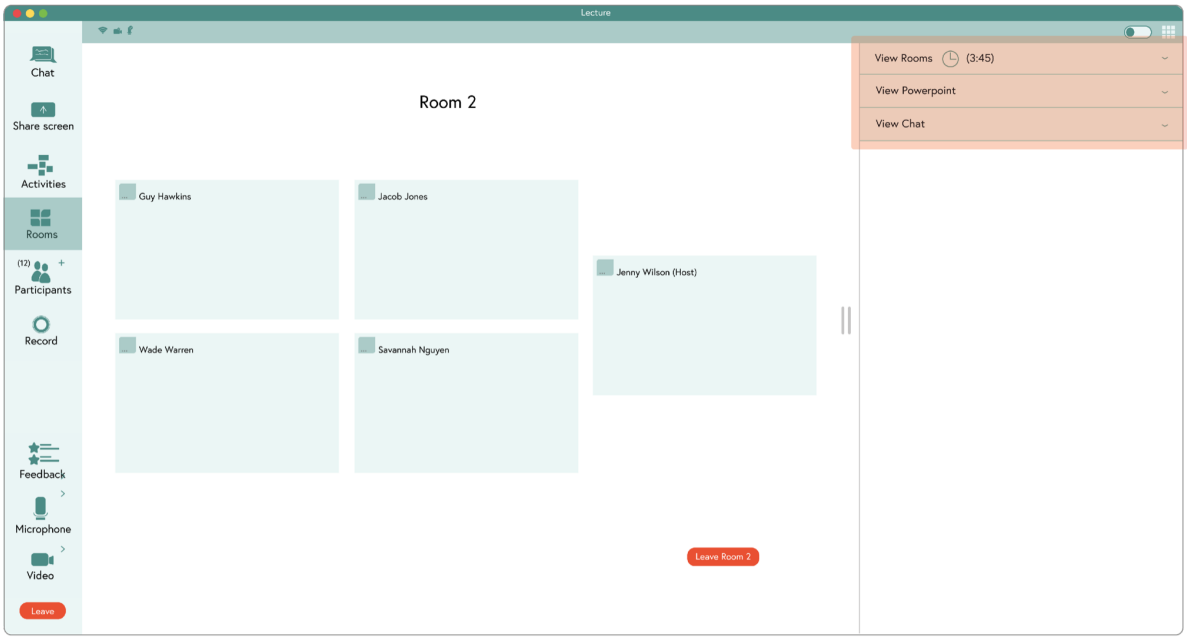


Figure 41. The view inside the rooms with the menu at the top-right corner.

7.2 Usability tests with students

The participants were asked to test the tasks presented in Appendix 6. The tasks that provided the most prominent insights regarding the student experience are presented below.

The two tests conducted together with the students resulted in several insights of what worked well with the prototype as well as what can be improved. The overall impression was expressed to be very well and thought through since it combines the functions of many applications that usually are hard to keep track of. In the prototype there was no need to search for meeting links or use external websites. Another appreciated feature was the activities which are integrated directly in the program instead of having to use multiple applications. This makes it easier to have a good overview of what you see on your computer screen. There were also constructive suggestions of how to improve the overall impression such as having a larger variation of colours to differentiate the fields with possible actions from the background. Furthermore, some text and icons are hard to see due to the small size.

Navigating in the student homepages

Task 1 to task 4 concerned trying to navigate through the new homepage. The first window, see figure 42 below, seemed to be intuitive and match the mental models of the participants of the test. They were asked to explain what was visible and how they thought it functioned. The

descriptions were in line with the ideas behind the design. However, the observations during the tests indicated that the test participants thought it would be possible to enter a video conferencing meeting with your groups directly from the homepage by clicking on the icon for a specific group.

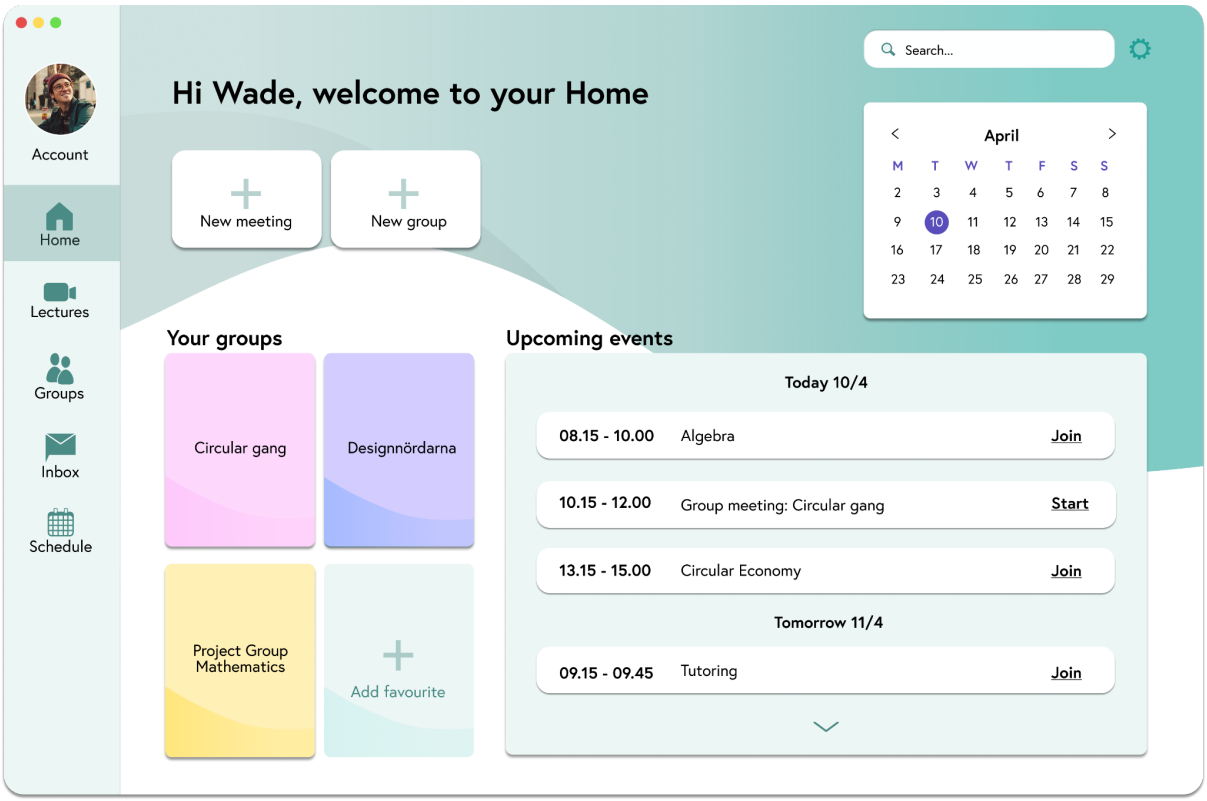


Figure 42. Homepage for students.

During task number 3 the lecture page for Circular economy (see figure 43 below) was explored and commented upon. The page is reached by using the menu to left and entering “lectures”. It was stated that the norms and rules might be good to show, however, most likely the students would not mind them. Additionally, some questions about the functionality of the list of upcoming lectures were discussed. It was desired to have the ability to join a meeting from this section.

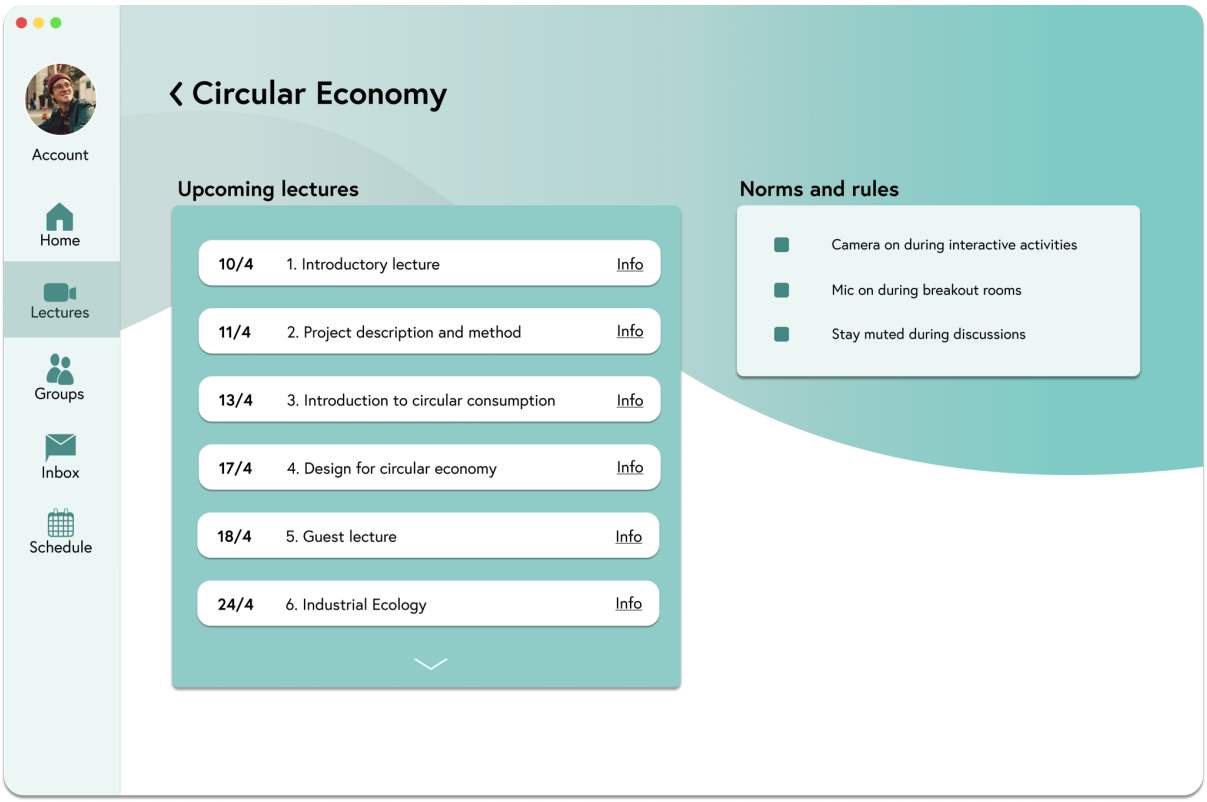


Figure 43. The lecture page for Circular Economy.

Chat functionality

Task number 6 in the student usability test concerned the chat feature and the new functionality of top-voted questions. The participants expressed that the top-voted questions function was a very good way to highlight important questions and make the educator more attentive to what many of the students are confused about. It was stated that it is appreciated to be able to up-vote a question. Up-voting makes it is possible to indicate that the question is relevant for you as well.

At the bottom right of figure 44 below, the icons of how the student can up-vote and reply to messages are shown. During the tests it was shown that the icons were hard to find and understand. It was expressed that they were hard to see since they were too small. Furthermore, the size in combination with the placement of the icons confused the participants and they thought that the only possible action was to reply to a message.

At the top-right of figure 44 below, the red highlighted area and the connected enlargement is an overview of a top menu that may be opened to show the same view as the enlargement at the top of the chat. It is a summary of the top-voted questions that are organised in order,

depending on the number of votes. This summary was pointed out as good since it enables an easy overlook of the most asked questions. However, it was a bit difficult to find the menu. It was expressed that it was too similar to the background.

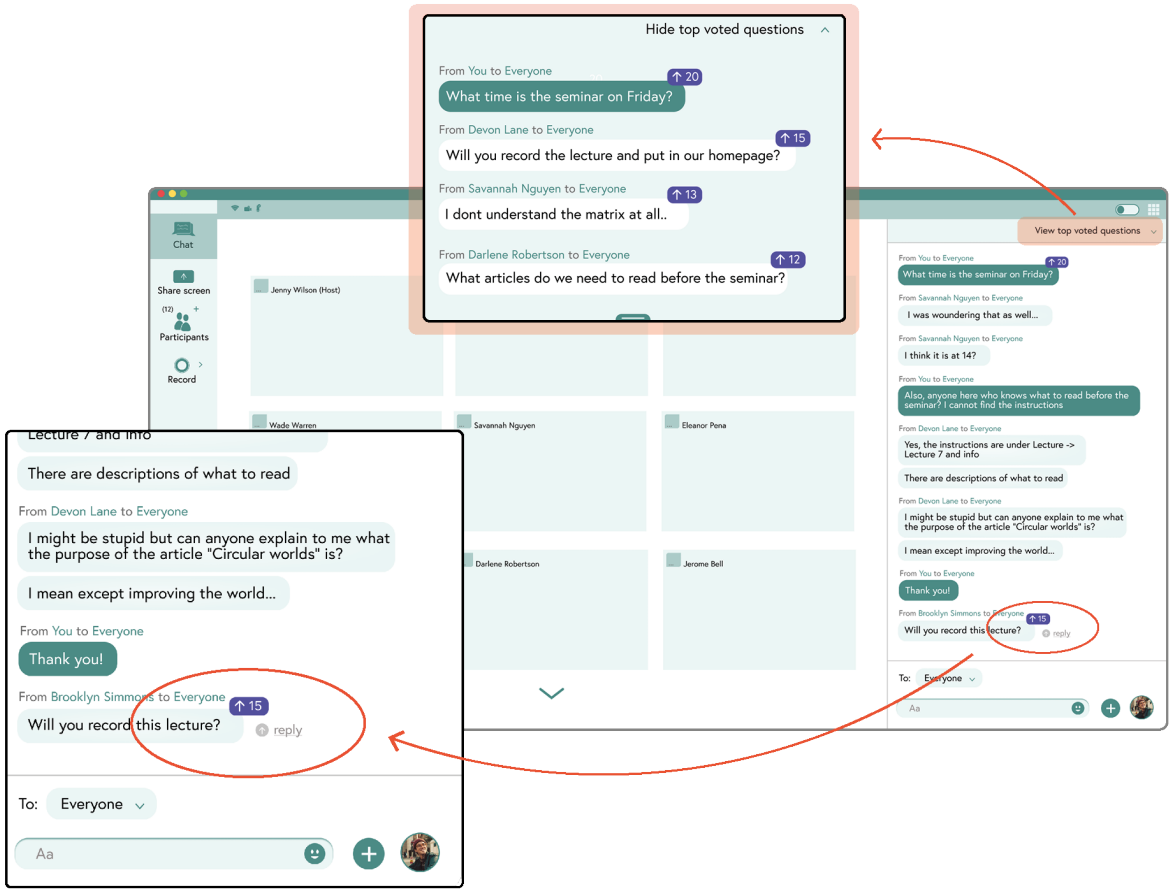


Figure 44. Bottom-right: Icons for top-voting. Top-right: Menu for summary of top-voted questions.

New video options

Task number 7 was to find different options for the video. One tested function was to hide the self-view to avoid distractions and the unnatural situation of always seeing oneself when in a classroom context. The other new feature was to only show your video to the educator. This in order to prevent uncertainty of the students that other students may be watching them. However, it would still allow the teacher to see them and not feel as "talking into a black hole" as expressed during the user research.

The overall impression of the features was divided. Figure 45 below shows how the menu looks and where it is located on the interface. Both participants considered the functions hard to find and that it would be hard to know that the function was a possible action without any guidance.

In conclusion, the function to hide your self-view was not experienced as necessary. Nevertheless, the choice to only show video for the educator was more appreciated. It was claimed that it is better because they don't want everyone to see them. Furthermore, it was pointed out that it may be good for persons with protected identity.

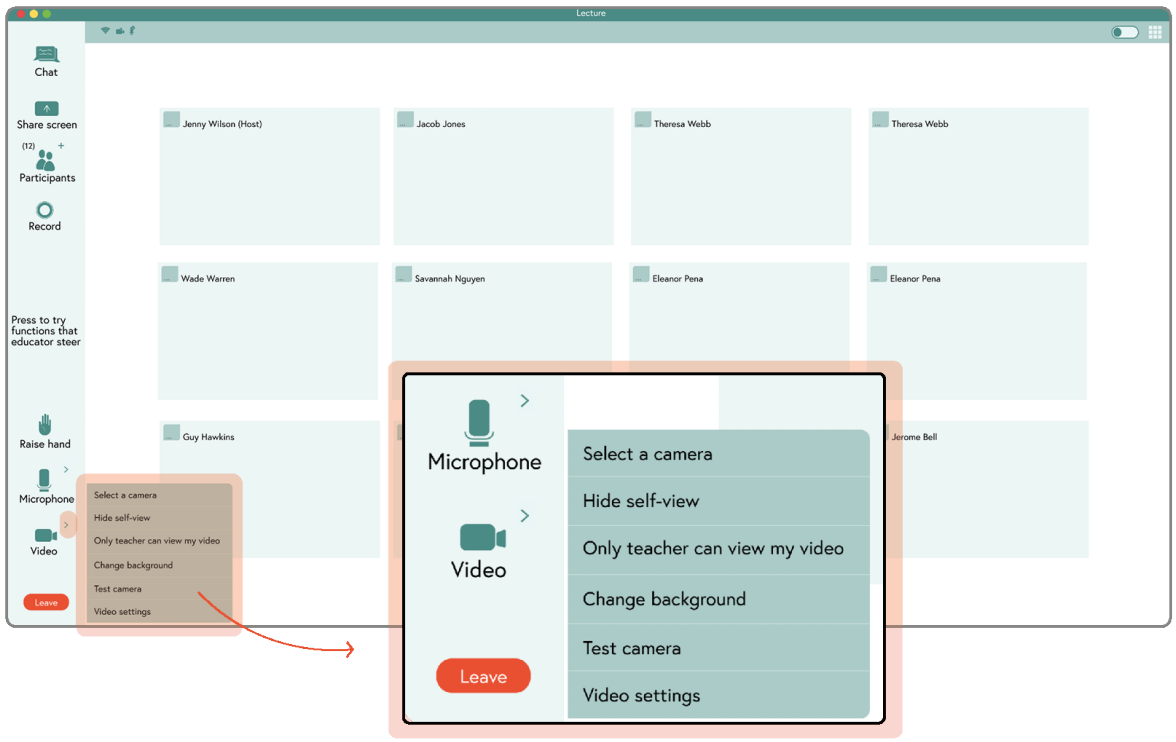


Figure 45. The location of the menu for the video functions and the menu options.

Collaboration board inside the video conferencing tool

Task number 9 tested the new feature collaboration board, which was described as very good since it was very accessible inside the video conferencing and no need to change and arrange windows. It was considered comfortable to have everything collected and not need to have a large amount of applications.

Feedback

During task number 10 it was tested how the students reacted towards a feedback popup asking them of their experience of working with the collaboration board. It was expressed that it would be ok to answer it sometimes but that it would be annoying if it would be after every activity. Furthermore, it would be good if the educators will give a heads up before sending out the feedback request. Also, if it would be a limited time there should be a timer indicating the user how long time there is to answer the question.

Divided into rooms during lecture

The rooms' view, visible in figure 46 below, are experienced as similar to the current ones in popular video conferencing tools of today but with good improvements. It was expressed that it was very helpful and good that the previous material shared during full class was visible inside the rooms as well since that always is an issue during lectures. Furthermore, it was claimed that the function to ask for the educator's help was great as well as the statement of which place the room has in the line. A suggestion of improvement is to set the default message receiver in the chat to *the group* instead of *everyone*. Another suggestion was to rethink the colour of some buttons to make them clearer and more intuitive.

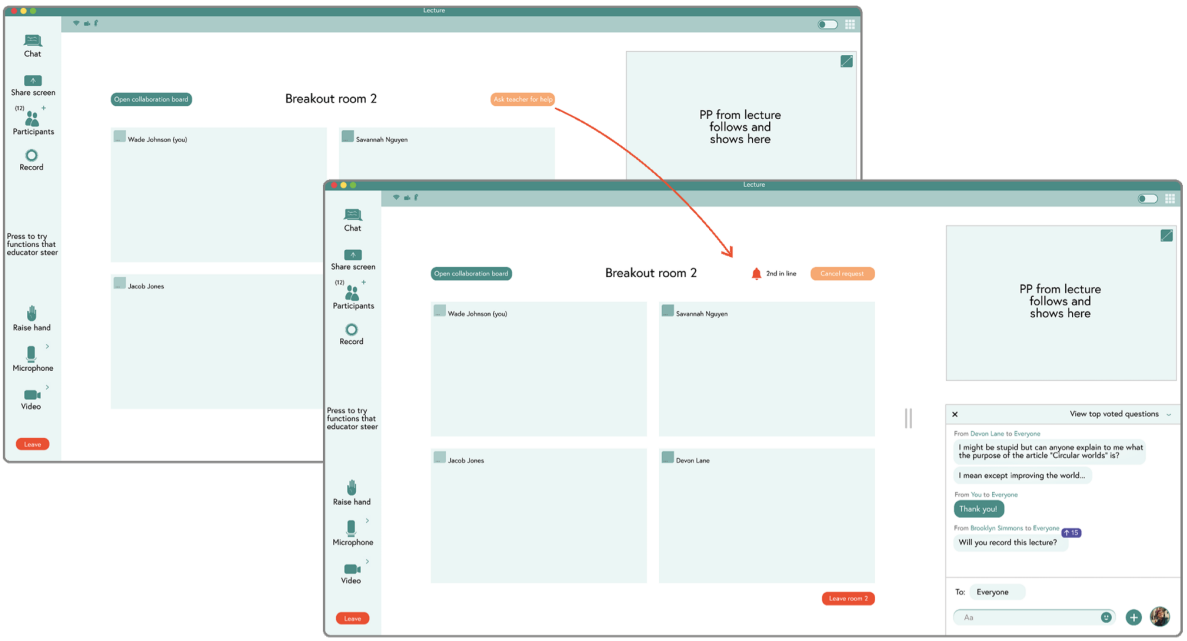


Figure 46. The view from a student's perspective inside a room.

Rooms when hosting

Task number 15 tested the video conferencing view from the perspective of a student host. The task was to create two rooms and to open them. The result was good. The way to create the rooms was considered easy. However, it was confusing when the room overview window (see figure 47 below) opens since the participant thought oneself would be in a room directly.

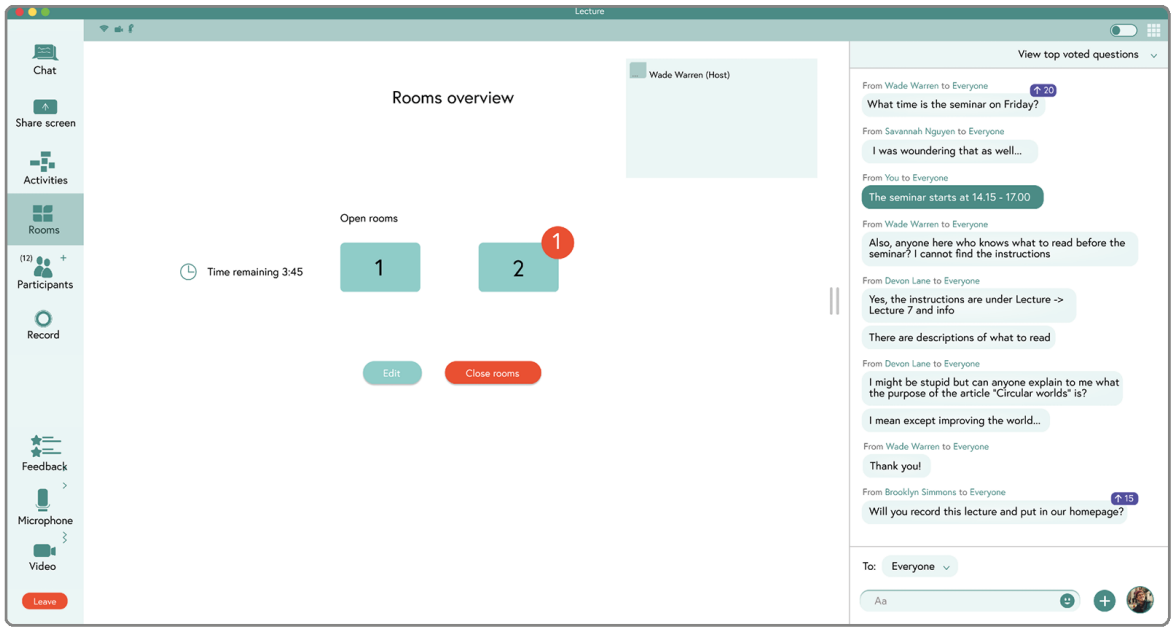


Figure 47. Room overview.

The test of the room functions detected that the menu to the top-right in figure 48 below was a bit hard to find. It was suggested to change the headlines to make it more clear what was under each menu. Furthermore, it was desired to have the time remaining displayed in the room. Another improvement could be to have clearer direction of if you are closing all rooms or only leave one room.

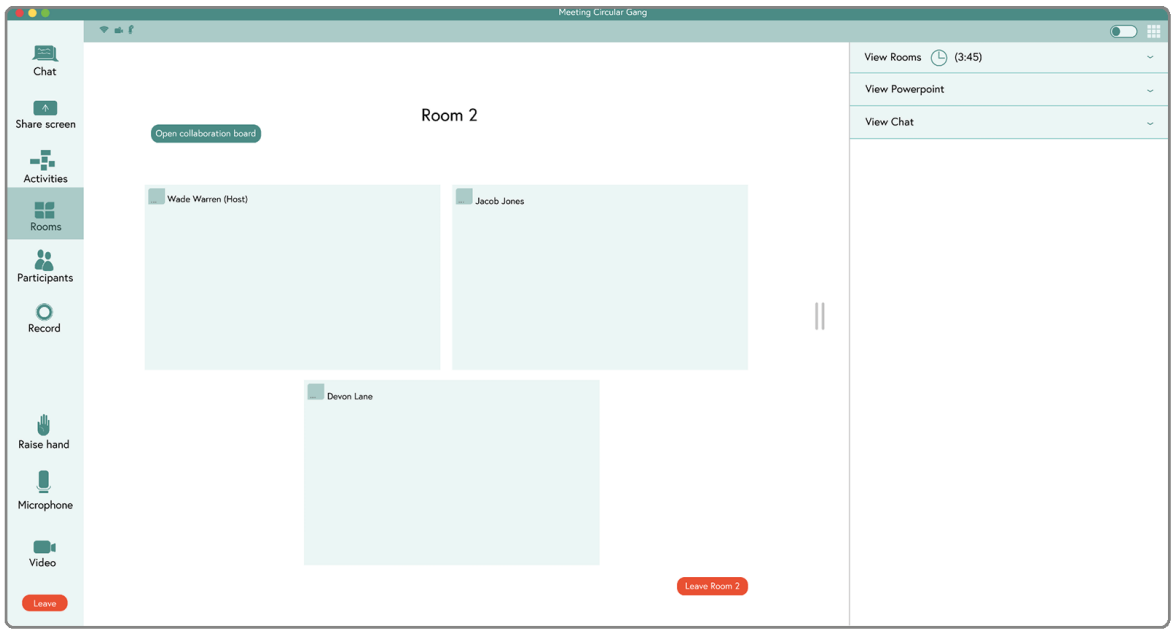


Figure 48. The default view when entering a room.

7.3 Conclusion of usability tests

The four usability tests are seen as a very good first evaluation of the interactive prototype. A summary, in the form of a table, of the usability errors highlighted during the tests and possible solutions are available in Appendix 7. The table includes all possible pages of the program and the errors related to the specific pages. This is followed by a solution and if the error is necessary or only desirable to solve based on the if the requirement the functions solved was weighted high.

8. Fulfilment of requirements

The assessment presented in this chapter is based on how well the concept fulfils the stated requirements from chapter 5.1.5. Table 4 below shows the previously defined requirements and present in what way they were considered in the design concept as well as how well the concept performed during the tasks of the usability tests.

Table 4. A description of how the requirements were fulfilled in the concept.

Number	Requirements	Requirement fulfilment
1.	Provide sufficient interaction and usability	The design concept is considering the theories of interaction design and usability design. Functions are visualized with commonly known (among the target group) signifiers as well as reasonable mappings. This was proven during the tests since all participants had a good flow using the prototype even though it was the first time. Most colour choices were good; however, some could be improved.
2.	Adapted for educational purposes	The concept is adapted after the specific needs of students and educators in higher education and is therefore fulfilling the requirement. This is validated through the extensive user studies performed together with exclusively students and educators of higher education.
3.	It should be possible to divide a class into smaller groups	The concept includes a room feature that allows classes to be divided into smaller groups. During the tests it was stated to be much better since it now offers a room overview which gives the host a better chance to manage the rooms. Also, the students liked the feature of asking for help, being able to see the previously shared material in the rooms as well as the opportunity to use a collaboration board.
4.	Facilitate interactive activities	The concept provides users with opportunities to incorporate more interactive activities in lectures. For example, the room function makes it easy to divide the class into smaller groups. Furthermore, the activities feature enables use of collaboration boards, quizzes and polls in lectures. Also, the overall communication using the chat facilitates better interactions within the class.
5.	Facilitate more social interaction among users	The rooms feature along with the activity feature allows for more social interactions during class.
6.	Facilitate	The chat, the top voted questions feature and the rooms

	communication between all users	feature facilitates the written and verbal communication between users. Further, the video tool and the collaboration board both facilitates visual communication through body language and visual media.
7.	Provide feedback	Another feedback function is the pop-ups of either technical issues, educational guides or reminders. These were seen as great assets to use the software in an easier way. The only improvements would be to show the messages a bit longer. The general feedback of the whole design concept such as buttons changing colour when hovering over or additional messages asking if the user really wants to leave a room was, based on observations during the tests, working very well.
8.	Facilitate tools to visually perform presentations, exercises and collaboration	The possibility to share screens enables users to visually present media. Further, the collaboration board is a tool for users to visually collaborate and communicate.
9.	Enable easy establishment of norms and rules for class behaviour and culture	The rules feature allows educators to set up rules for online lecture behaviour.
10.	The interface and functions should consider Wickens multiple resource theory (Wickens, 2008).	The design is considerate of how attentional resources are used when using the software. This in order to prevent high mental workload.
11.	The design should consider users' current mental models.	The users' mental models were considered in the concept as the most common functions and features of similar software were used to match users current understanding.
12.	Prevent technical stress	In order to prevent technical stress all links to lectures are gathered in the homepages to avoid confusion. Further, the video conferencing tool has a feature that notifies users whenever there is something wrong with the connection, sound or video.
13.	Provide opportunities to give and receive feedback	The feedback feature allows educators to request feedback from students. It also enables students to give feedback to the educator.
14.	Provide training of software	The current design does not meet the requirement of providing training for the software. However, if further developed the feature would be developed.

As described in the table above all requirements except for requirement number 14 has been assessed in the developed concept. Number 14 was not met as it was weighted the lowest out of all requirements presented in table 1 and because of a time constraint the project group chose to focus on the higher weighted requirements first. However, the other requirements have been fulfilled which means that the solution will meet the needs identified in the study and potentially enhance the experience of online lectures for educators and students in higher education.

9. Discussion

The study was successful in answering the research questions formed within the scope. Research question number 1, *What are the requirements of a digital software for online live lectures?* was answered in the study by conducting an extensive user study where the needs of students and educators that take part in online live lectures in higher education were explored. The needs were analysed with the help of an affinity diagram and turned into requirements. Furthermore, research question number 2, *How can a digital software for online live lectures be designed?* was answered in the concept development phase where a prototype was designed based on the requirements established in the user study. The prototype was designed with consideration to the theories described in the theoretical framework: Cognitive ergonomics, User experience design, Interaction design and design for Usability. The theories within cognitive ergonomics contributed to the study by making sure that cognitive capacities were considered in the design of the prototype. User experience design was useful when exploring the target groups current experience of video conferencing software and when working on improving that experience through the design of the prototype. Theories within interaction design were useful when designing the prototype interface and design for usability when developing and performing usability tests to validate the design.

9.1 Contextual, societal, and ethical aspects

The pandemic covid-19 has had an impact on the work since it has restricted most communication and interaction to be performed remotely. The situation caused by covid-19 may have influenced the project's findings as well as outcome. However, it is hard to know what the concrete effect on the result has been. To give a context, the pandemic has affected everyone's habits and behaviours during the year 2020 and still today in 2021. In Sweden, people are not allowed to be together in larger groups than 8 people and the number of people inside for example grocery stores are limited.

From a societal perspective, it seems as if digital live lectures and education are here to stay. The study is a validation of the need and desire to have a digital software that accommodates the needs of online live lectures. This is not only due to the consequences of the pandemic but also due to online education giving more people the opportunity to take part of high-quality education even from a distance. It was discovered during the user study that most students

preferred a mix of traditional and digital education. However, the educators preferred traditional education but expressed that the flexibility of digital education was very good. We guess, based on this study, that the future will offer a more flexible way of studying. A choice of participating either physically or digitally. To meet this demand, the concept and insights provided in this study is a good first step that we hope can be the initiator for further work within the area. From an ethical perspective, developing tools for online education could have a positive impact by making education accessible for more people. This is in line with goal number 4, Quality education, in the United Nations 17 sustainable development goals (United Nations, 2020).

9.2 Methodology discussion

The approach Research through design for this project was very well suited for the format and the desired outcome. The process utilized several methods and tools from the design practice processes that resulted in a large variety of information that could be turned into valuable insights. The project process was mainly inspired from the double diamond process model and followed a divergent and convergent way of working which worked well with the chosen methods. The data collection methods delivered large amounts of data, however, there was a low diversity of participants since there was a limited access to contact persons within the specified target groups. The engagement and diversity from students responding to the survey was higher than the educators which may have affected the results.

All the user studies as well as most of the concept development have been performed remotely. This has influenced the methods and tools in some way. Most have been updated by the project group to fit the format better and that might be reflected in the results. For example, all interviews and workshops has been conducted via Zoom. However, the online format may have increased the number of participants as well as the variation of people taking part in the study. Therefore, that may have affected the results positively as more diversity and variation may give more realistic data compared to if the participants all for example went to the same school.

Another aspect important to consider is the fact that the interactive prototype was limited in what actions were possible to perform, which may have affected the fidelity of the prototype that in turn may reflect on the results from the usability tests.

9.2.1 Application of the benchmark in the study

The benchmark conducted in the study was used mainly in the ideation and concept development phase. The benchmark represented all the best and necessary features existing in similar software on the market today and was therefore a valuable tool when developing a concept. By considering the benchmark, the project group could make sure that all necessary features for a video conferencing tool were incorporated into the prototype. This later proved valuable in the user tests where the majority of the users had an easy time to navigate and comprehending the prototype. Because the project is situated early in the development phase the benchmark did not include aspects within pricing or other business related aspects. However, if the project were to continue and move into further development of the software and target the business perspective it would have been valuable to extend the scope of the benchmark.

9.3 Application of theories in the study

In this section the application of theories used in the study are discussed and reflected upon.

9.3.1 Cognitive ergonomics

Cognitive aspects were continuously considered throughout the project. First off, the results from the user study clearly indicated that there are cognitive challenges within today's usage of video conferencing tools in online lectures. For example, a practical implication that was commonly described by educators was that the teachers found it difficult to verbally present while keeping an eye on the chat. This is in line with Wickens multiple resource theory which in this case suggests that the reason why educators found this hard is because when reading and talking at the same time the same attentive resources are being used (Wickens, 2002). To reduce the educator’s mental effort and consider cognitive capabilities a new feature called top voted questions was developed in the prototype. Top voted questions allows students to up-vote questions that are common in the class. The top voted questions are thereafter shown separately from the regular chat which makes it easier for the educator to prioritise what questions to answer first. From a cognitive perspective this will decrease the mental workload for the educator that no longer need to view the full chat to the same extent.

Another insight that had cognitive relevance was that students experienced it as hard to stay focused for a longer period of time when a teacher was presenting. When viewing the theory

regarding vigilance, Warm et al. (2008) claims that vigilance decrement can start after between 5-15 minutes of monitoring if the task is demanding. However, another study exploring vigilance decrement specifically for students in a classroom setting suggests that this claim is false (Rosengrant et al., 2021). Instead the result of that study suggested that well-structured lectures that include interactive activities can be effective for students to be able to focus for an entire class. This is in line with the results of a study by Young, Robertson & Alberts (2009) that also claims interactive activities to be effective for sustaining attention. However, this study also suggests that lectures that have any type of variation could be useful, not only interactive activities.

To deal with the dilemma of vigilance, several solutions were developed. First off, the possibilities to have interactive class activities in the program are improved compared to the software used today. For example, the rooms' function allows for educators to create rooms where interactive activities more easily can take place. The feedback feature allows educators to receive feedback on how to improve activities performed during a lecture. Additionally, the activity feature makes it easy for educators to both prepare lecture specific activities like collaboration boards, quizzes, and polls. To sum it up, by providing educators with tools to incorporate more interactive activities in lectures this will facilitate more variation in lectures which hopefully contributes to students being able to focus better and for a longer period of time.

Mapping the emotions of students and educators was also an important part of the user studies. To map emotions, the method AEW was used where students and educators were asked to describe what activities that were performed before, during and after a lecture and how the emotional state changed during this time. These insights were later visualized using a customer journey which made it possible to make connections between what activities that caused positive or negative emotions. Understanding where emotions originated and why they appeared is important as positive emotions can direct a user's attention and influence performance positively (Brave and Nass, 2002). When working on the design of the software it was therefore important to promote the positive emotions further and counteract the negative emotions.

For educators many of the positive emotions related to them performing lectures and interacting with students. To promote the positive feelings further, the software provides features to interact

with students more easily and more easily perform lectures. The negative emotions however related to the teachers finding it difficult to perform online lectures, not receiving any feedback from the students or them feeling lonely and unmotivated because very few students had the camera on. To prevent the negative emotions a feedback feature was developed along with the collaboration board and the rules functionality. The feedback feature allows educators to receive feedback on the lectures and get an idea of what students appreciate and not. The collaboration board helps teachers monitor the work and engagement of students which also provides feedback of how proficient tasks are performed. Furthermore, the rule functionality allows educators to clarify what rules apply regarding for example camera use during class. Finally, to decrease the technical stress a feature in the software will notify educators whenever something is wrong. Decreasing the negative emotions by changing the activities the emotions originated from will hopefully put the educators in a better mood which will increase the ability to perform, think and solve problems (Brave and Nass, 2002).

The same goes for students whose positive emotions were mainly related to social interactions and interactive activities which are promoted further in the solution as the software makes interaction and social activities more accessible. Furthermore, the negative emotions related to technical stress and frustration about finding zoom links. This was solved by gathering all necessary links and lecture information under the student homepages to avoid confusion. Negative emotions originated from it being hard to focus, ask questions or feeling lonely. To decrease the feeling of loneliness, the software is, as mentioned above, improving interaction between students. The focus is increased by providing the opportunity to have more interactive activities and asking questions is easier as the chat is further developed. This will hopefully put the students in a more positive affective state which can improve thinking and problem solving (Brave and Nass, 2002)

Considering users' perception and mental models were very relevant in the concept development phase. Matching the design of the software with users' mental models is beneficial as it gives users a more intuitive user experience (Interaction Design Foundation, 2020). In order to match the user's current mental model of similar software a benchmark was created and the most common and necessary features identified, see chapter 4.1. After the user study was completed the functions from the benchmark that were considered necessary were incorporated into the concept. However, if some of the functions from the benchmark were described as malfunctioning in the user study those were further developed or excluded from

the concept. When testing the prototype with users it was proved that the concept matched the users' mental model and previous experiences of using similar software. The users could easily comprehend the prototype content and navigate through the system.

9.3.2 User experience design

UX design is a broad term that describes the holistic user experience of a design. In this project the largest focus from this theory has been the three levels: Why, What and How. The why was considered early in the process and is the reason why educators and students need a digital service to educate and to be educated. It was found that the pandemic Covid-19 was a catalyser for this change and the restrictions to not meet in person made it utterly important to find digital ways of continuing the higher level education. This situation is foremost the Why, however, the reasoning is that even if the pandemic is to be ended, there will still be a demand for this kind of service. The user studies in this project has found several positive effects of having lectures live online. Therefore, the Why in this study is to facilitate those needs to have live lectures online. The next question is What, which in this case is the created concept presented as a prototype. It represents what the user can do with the new design. Lastly, the How is the design of the functions in the prototype.

9.3.3 Interaction design

Interaction design and its five principles was considered during the whole process. The user studies and benchmark explored which affordances, signifiers, constraints, feedback and mappings was considered useful or unnecessary.

Affordance is what actions are possible and this was applied during the project by understanding the actual potential of interaction considering education in a digital format. Furthermore, one of the most used principles of interaction design is signifiers. The indicators that imply what actions are possible. In the beginning, the user studies and the benchmark provided data of which icons and symbols as well as colour has a certain meaning. Furthermore, this was considered important in the prototyping and design phase and evaluated and tested with usability tests. Consciously, icons and symbols recognizable from previous software used in the higher education environment were used in the design. Another very important principle is mapping which was used to evaluate the current apprehension of the users to improve the

new design. The mapping concerns the reasonable relations between elements. The principle is about having the same design for functions that perform the same action or gathering of similar action under the same menu. For example, the main menu to the right are all “clickable” and an instant feedback is presented to the user. Another example is the submenu by the camera, where all extra functions that are related to the camera are gathered at the same location as the camera. Constraints are used in the design to hinder some actions, for example the student cannot perform as many actions when attending a live lecture as if hosting a meeting on their own. This is to create less distractions and confusion for the students as well as restrict, otherwise, possible interruptions of the educator’s lecture. Feedback is another very important principle when designing for interaction. The new design has a lot of different feedback telling the user if an action is performed with success or not. The feedback that is unique for the design, unlike the current tools on the market, is to first imply to the user that the internet, audio or microphone is not working correctly and then also guide the user where to examine and fix the problem. Most feedback is chosen to be coloured red if it is a warning to catch the users attention. However, feedback in the form of sound and lights have been avoided to not disturb the educator too much during presentations. Finally, conceptual models which can be related to the mental models described in cognitive ergonomics are an important part of the design. Consciously, the design has shapes and colours that are intended to meet the conceptual models of the users.

9.3.4 Usability

The theory of usability was used to understand what elements to consider when defining the target groups and what kind of design was appropriate for that kind of users. The personas were based on the collected data from the user studies but also on the elements described by the theory as important to consider. The concept concerns the five principles: guessability, learnablity, EUP, system potention and re-usability by Jordan (2002). The usage of the design is mostly expected to be daily or a couple times a week, however, sometimes it will not be used during a comparatively long period of time. Furthermore, there will be first time users fairly often. Therefore, the design of the new tool is designed with icons, symbols, colours and feedback that are commonly known and have a high guessability. Nevertheless, the design is targeted to be for experienced user performance. The design is mainly supposed to be used often and therefore it should be quite complex and allow for elements that require training. If it only was designed for guessability it would be too simple for the more experienced users.

The usability tests were a good evaluation of how well the design fulfilled the principle of guessability. The tests were performed without any major issues and it seemed as if the test participants felt comfortable in the format and how to navigate inside the tool. However, there were elements described as more difficult yet this would be the functionality design for learnability and experienced user performance which was not possible to test since only one time tests was conducted. This is a possible future evaluation, to see if the participants learn the functions that require more experience and training and if the program is seen as more functional or too complex.

9.4 Future research

A suggestion for future work would be to work in an agile manner, to release an updated version considering the errors described in Appendix 7 and test it again and do this iteratively. Agile work is described by Pinto (2012) as a sufficient approach if the user requirements may change with time and the desired result is unclear. Furthermore, Maylor (2010) states that agile is suitable for software development since it is flexible and values the users and interactions above planning. Therefore, if to continue the study, an agile way of developing the design further seems appropriate.

In parallel with further development of the tool itself, a business analysis would to be a good way to continue the research. For example, the competitiveness of the product and the marketing perspective. How is it possible to sell the service? How can the customers be convinced to use this tool instead of all the competitors' tools on the market? Beyond that, several important aspects were too complex and extensive to consider due to the limitations of this project. For example, software compatibility and design of different formats that work with diverse systems, applications, and screen sizes. Another is the capacity, for example how many users the tool may facilitate.

One ecological aspect that can be taken into consideration for further development is the energy and space consuming servers that are needed to run the online tool. Manufacturing, shipping, and operating these machines may result in large material resources being extracted and energy consumed. Moreover, consider the requirement of the user to have a computer, which requires additional materials and energy being spent.

10. Conclusion

The purpose of the thesis was to explore the experience educators and students in higher education have of online live lectures and use the findings to develop a digital solution that is adapted after the identified needs. The study showed that there are several opportunities for improving the functionalities within the most used software for online live lectures. The main challenges related to the issue of achieving high quality interaction, communication, and collaboration in an online context. Furthermore, most of the software used to perform online live lectures are mainly adapted for the needs of business meetings rather than for educational purposes. In the absence of software dedicated towards the needs of education this new concept is important to improve the quality of online education. Extensive user studies discovered data that could be defined into requirements. To meet the requirements a concept was developed and prototyped with consideration of theories within cognitive ergonomics, user experience design, interaction design and usability design. Utilizing methods and tools of the theories resulted in the prototype successfully being sensitive to human capabilities and providing high quality interaction. The user experience was verified through usability tests performed with the target groups. Furthermore, the tests implied future improvements of the software.

The whole study was performed in the context of the pandemic Covid-19 which required all work to be performed remotely. The remote way of conducting user studies, ideation and testing may have had practical implications on the result. The data, ideas and test results might not be as qualitative as if the studies could have been practiced in a traditional manner.

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Appendix

Appendix 1: HTA showing structure of video conferencing tools and the homepages

Appendix 2: Survey 1 Educators questions

Appendix 3: Survey 2 Students questions

Appendix 4: Activity-Emotion walkthrough

Appendix 5: Usability test 1 Educators

Appendix: 6 Usability test 2 Students

Appendix 7: Usability errors

Appendix 8: Benchmark

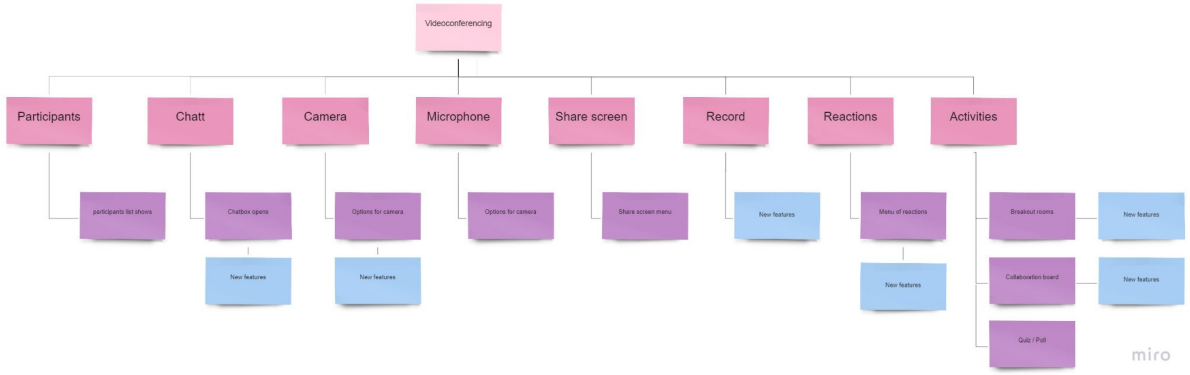
Appendix 9: Customer Journey opportunities 1 educators

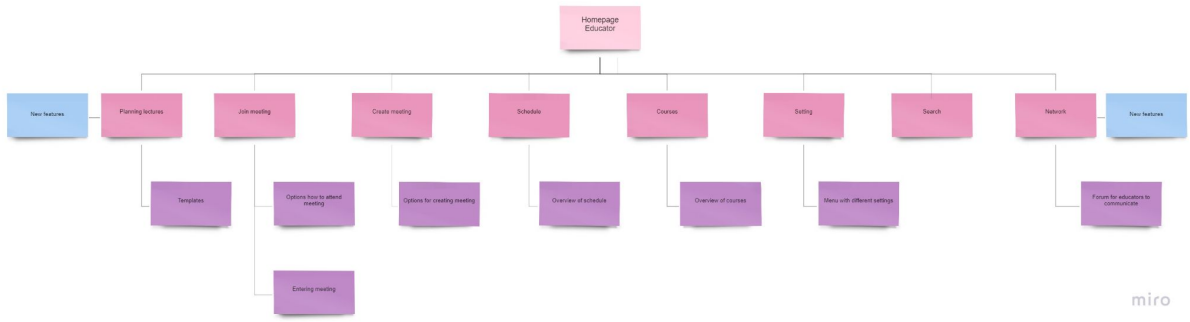
Appendix 10: Customer Journey opportunities 2 students

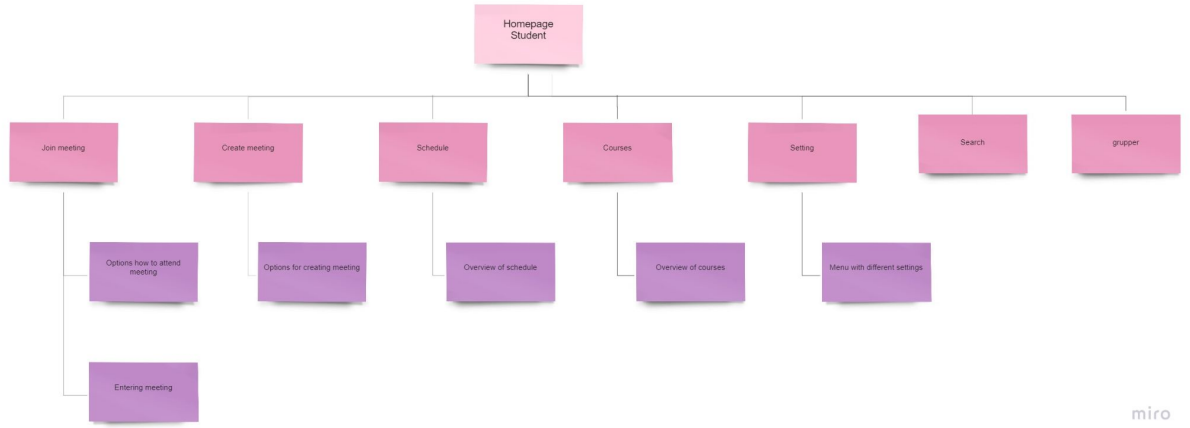
Appendix 11: Group workshops: Kreativ studio 1&2

Appendix 12: Detailed description of selected solutions

Appendix 1: HTA showing structure of video conferencing tools and the homepages







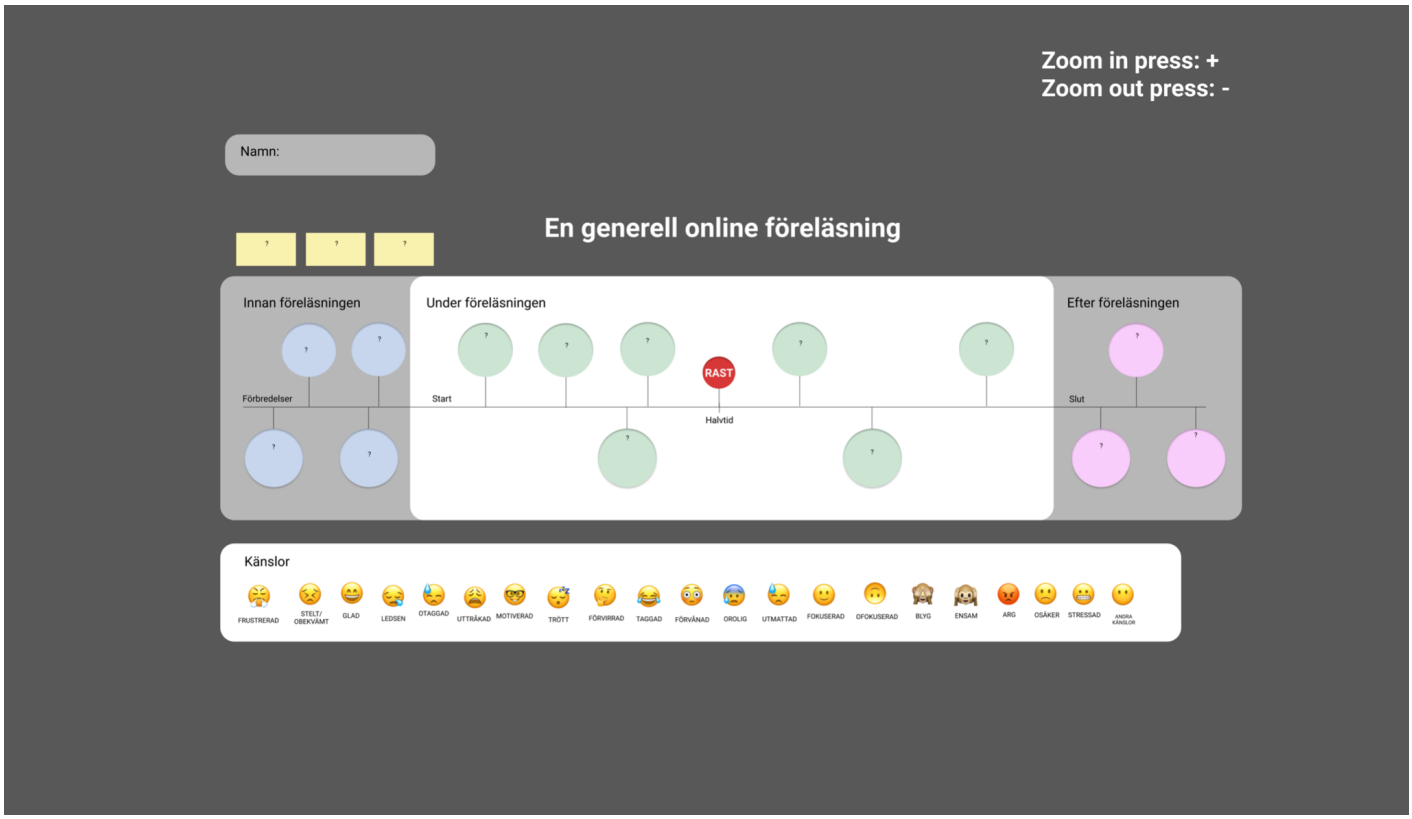
Appendix 2: Survey 1 Educators questions

1. What university do you teach at?
2. What subject do you teach?
3. What online application did/do you use for online lectures?
4. How easy do you think the application is to use?
5. What makes the application hard/easy to use?
6. How is your overall experience of performing these lectures?
7. Can you motivate your experience? Why good/bad?
8. Do you prefer teaching in person or online?
9. Can you motivate your answer? Why?
10. What are the POSITIVE aspects of having lectures online compared to in a classroom?
11. What are the NEGATIVE aspects of having lectures online compared to in a classroom?
12. Other then talking about a subject, what other activities do you use to teach in your online lectures?
13. Do you use any additional online programs/websites (other than zoom etc.) when teaching online lectures? If yes, what programs?
14. How much do you think students engage during a lecture? (ask questions etc.)
15. Why do you think the engagement is high/low?
16. Is the student interaction different online vs in a classroom?
17. If so, how is it different? and why?
18. Can you tell us about a fun event that occurred during one of your online classes?
19. We are looking for participants for short online interviews. If you find our study interesting and want to contribute more, please leave your email below and we will get in touch!

Appendix 3: Survey 2 Students questions

1. What University (or equivalent) do you attend?
2. What application is/was used for distance online lectures?
3. How easy do you think the application was/is to use?
4. What do you prefer?
5. Can you explain why?
6. What do you think is the difference between traditional lectures in a classroom VS online lectures?
7. Where do you think you learn the best?
8. Can you explain why?
9. What are the advantages of online lectures compared to lectures in a physical classroom?
10. What are disadvantages of online lectures compared to lectures in a physical classroom?
11. Where do you feel the most motivated to participate (actively listen, take part in discussions, etc.) ?
12. What makes you motivated to participate and why?
13. How do you experience interacting (speaking/writing) with the teacher or classmates during online lectures vs traditional lectures in a classroom?
14. Where do you think it is the easiest to focus?
15. Can you motivate your answer?
16. Where do you feel the most comfortable?
17. Can you motivate your answer?
18. Can you tell us about a fun event from an online lecture?
19. Are you interested in helping us further? Please fill in your email and we will contact you. We are looking for participants for short online interviews and fun tests! Of course we will give you corona-friendly fika as a thank you :)

Appendix 4: Activity-Emotion walkthrough



Appendix 5: Usability test 1 Educators

Usability test Educator

Är det ok om vi spelar in?

Testet är inte ett test av dina förmågor utan endast prototypens funktioner.

Uppmuntra till att hen ska prata sig igenom sina tankar.

Uppgifter:

I homepage:

1. Kan du skapa ny aktivitet i Schemat?

2. Kan du gå till lektionssidan för circular economy och hitta feedback: Automatic activity feedback från lektion nummer 1?

- Kommentarer?

3. Kan du skapa ett nytt möte?

4. Kan du starta den närmast kommande lektionen?

5. Kan du ifrån chatten gå till ett möte?

6. Kan du gå till mötet tutoring ifrån schemat?

Kommentarer?

I videoconferencing view:

1. Kan du öppna chatten. Sedan vill jag att du testar att öppna upp "top-voted questions".
    - Vad tror du att "top-voted questions" är? Tycker du att det är en bra ide?

   Kan du "svara" studenterna på den första och sedan trycka bort den.

- Hur tycker du det fungerade?
  Kan du gå tillbaka till förstasidan?

2. Kan du testa att dölja din egen kamerabild? Kan du testa att få tillbaka bilden?
    - Vad tycker du om den funktionen?

3. Du ska nu dela skärm. Vad stod det på meddelandet? Kan du visa var informationen till mikrofonen syns på skärmen? Kan du sluta dela skärm?

- Kommentarer?

4. Kan du starta aktiviteten "Collaboration board" och öppna upp sticky notes? Kan du avsluta Collaboration board?

- Kommentarer?

5. Kan du skicka iväg en förfrågan till studenterna om att få feedback? Kan du även titta på insamlad feedback?
    - Vad tycker du om feedback funktionen?

6. Nu skulle vi vilja att du skapar 4 rooms. Sedan vill vi att du öppnar rummen och efter det besöker rum nr 2. Kan du i detta fönstret få en överblick över alla rum? Kan du se vad som visades på en PP du delade innan du skickade ut studenterna i rum? Kan du även ha koll på chatten?
   Kan du nu gå in i Rum 1? Kan du nu lämna rum 1?
    - Vad tror du att dem röda markeringarna innebär?

7. Education popups. Vore det hjälpsamt?

Avslutning:

Vad tycker du om helheten?
Finns det saker du funderar över?

Appendix: 6 Usability test 2 Students

Usability test Student

Testet är inte ett test av dina förmågor utan endast prototypens funktioner.

Uppmuntra till att hen ska prata sig igenom sina tankar.

Uppgifter:

I homepage view:

1. Log in to your homepage

2. Can you describe what you see on the homepage, what actions do you think you can do here?

3. Can you go to lectures and then to the course circular economy. What do you think about being able to view what rules there are for lectures in this course?

4. Can you join the next upcoming lecture?

5. What do you see on the pop-up? Comments?

I video conferencing view:

6. Open the chat. You have the same question as Brooklyn, can you upvote her question.
   - Can you view all the top voted questions?
     - What do you think of this feature?
     - Comments?

7. Can you try and hide your own camera view? How did it work?

Now the teacher starts sharing their screen. “Press to see functions that the educator steer” and choose “share screen” to see what you would have seen in a real lecture.

8. Now press the Share screen. Can you make your share screen a full screen?

Send to back.

Now press “Press to see functions that the educator steer” and choose “Collaboration board”

9. Try to enter the “Collaboration board”. Open the sticky notes. Would you find this feature useful? comments?

10. You are now done with this activity and you close the collaboration board. Something pops up on the screen, send in your feedback. What did you think of the feedback feature? Comments?

“Press to see functions that the educator steer” and choose “rooms” to see what you would have seen in a real lecture.

11. When in rooms. Open a collaboration board to brainstorm questions from the PowerPoint. You find it hard and have a question for the teacher.

12. Ask the teacher for help! How many groups are before you in line for help?
    You figure out the answer and therefore cancel your request.
    Leave room 2 and then leave the lecture.

13. You now want to start a meeting with the circular gang group. Go to groups and open meetings.

14. You are the host of this meeting and you want to brainstorm ideas. Open a collaboration board. Comments?

15. It is now time to divide the group into breakout rooms. Create 2 rooms and open them. How did it go?

16. You now see an overview as a host of the meeting. What do you think the red marking means in room 2? Go to room 2.

    When in room 2 you wish to view an overview of the rest of the rooms. Open view rooms. YOu also wish to see the PowerPoint that was shared and the chat, open view on them both. Finally, you think it might be easier to discuss with a collaboration board, open a collaboration board. Close collaboration board.

17. Go from room 2 to room 1. And then leave room 1. Finally close all rooms.

18. The meeting is now over. End the meeting.

Avslutning:

Vad tycker du om helheten?

Appendix 7: Usability errors

Nr.	Page name	Usability error	Solution	N=Necessary D=Desired
Educator homepages				
1	Login page	-		
2	Home	No flexibility	possibility to add personal customization	D
2.1	Lectures	-		
2.1.1	Activity library	pattern and unity of the page was out of balance	Change layout	N
2.1.2	Course overview	Purpose of the section “Lectures” was unclear. Would like a hide function Change the headline rules and norms Add selection of all lectures or individual to the norms and rules	Describe the purpose better Add hide function Change headline Add function	N D D D
2.1.2.1	Course activities	-		
2.1.2.2	Course feedback	Misleading headlines	Change headlines	N
2.2	Inbox	-		
2.2.1	Messages	-		
2.3	Schedule	Have integration possibilities	Add integration	D

Nr.	Page name	Usability error	Solution	N=Necessary D=Desired

Homepages student view				
1	Login page	-		
2	Home	Seemed to lack the possibility to enter group meeting from here	Add possibility to enter group meeting from home	D
2.1	Lectures	-		
2.1.1	Course overview	The functionality of the list of upcoming lectures were discussed. It was desired to have the ability to join a meeting from this section	Add join lecture	N
2.2	Groups	-		
2.3	Inbox	-		
2.3.1	Messages	-		
2.4	Schedule	-		

Nr.	Page name	Usability error	Solution	N=Necessary D=Desired
Educator lecture view				
1	Full class view	-		
1.1	Chat	-		
1.1.1	Top voted questions	There is a concern that some students might not post their own questions. Furthermore, it was worrying that the function might be used in a reckless way and upvote disrespectful questions.	It is hard to know exactly how the feature will be used in this early stage. Needs more testing before changing.	

1.2	Share screen	Desired to be able to see the participants list due to the ability to see if students had raised their hands and in what order the hands was raised	Have raise hand at the pictures or at the right menu bar to show that someone is raising their hand and show the order	N
1.2.1	Full screen	-		
1.3	Activities	So if you allocate students to the rooms, the setting should automatically follow and when closing rooms the results should be visible in full class.	Having the collaboration board visible in the room overview so it is possible to see the action in the rooms	N
1.3.1	Collaboration board	-		
1.4	Rooms	When creating rooms one participant suggested making the timer clearer since it was not compatible with the participants perception of how it should look	Change visual of timer	D
1.4.1	Rooms overview	It was pointed out that the opportunity to see all participants would be necessary.	Add hovering effector similar to see the participants in each room	N
1.4.1.1	Individual room	When entering a room, the menu to the right was hard for the test participants to find	Make the manu another color and change the headlines	N
1.5	Participants	-		
1.6	Record	-		
1.7	feedback	-		

	Pop-ups	Too fast too see them. Hard to see warning symbols. Hard to know which menu to enter to fix the problem.	Add more time to the messages Move and enlarge symbols Mark the appropriate menu with color	N N D
	View options	It was mentioned that the user might forget that the camera is on if it is hidden and that may lead to unwanted situations. Cinema view is nice	Take away the function of hiding self-view? Add view	D

Nr.	Page name	Usability error	Solution	N=Necessary D=Desired
Student as host				
1	Meeting view	-		
1.1	Chat	-		
1.1.1	Top voted questions	During the tests it was shown that the icons were hard to find and understand. It was expressed that they were hard to see since they were too small. Furthermore, the size in combination with the placement of the icons confused the participants and they thought that the only possible action was	Make the symbols larger and place them differently, maybe add color	N

		to reply to a message. It was a bit difficult to find the menu. It was expressed that it was too similar to the background.	Change color of menu, add education	N
1.2	Share screen	-		
1.2.1	Full screen	-		
1.3	Activities	-		
1.3.1	Collaboration board	-		
1.4	Rooms	-		
1.4.1	Rooms overview	However, it was confusing when the room overview window opened since the participant thought oneself would be in a room directly.	Choose when creating rooms to be part of the rooms or not	D
1.4.1.1	Individual room	The test of the room functions detected that the menu to the right was a bit hard to find. it was desired to have a time remaining displayed in the room. Another improvement could be to have clearer direction of if you are closing all rooms or only leave one room.	Change colour and headlines Add timer Add feedback pop-up	N D N
1.4.1.1.1	Collaboration board in room	-		

1.5	Participants	-		
1.6	Record	-		
1.7	Raise hand	-		
Student at lecture (all above is true for student at lecture except rooms)				
	Rooms	A suggestion of improvement is to set the default of the chat to the group instead of everyone. Another suggestion was to rethink the color of some buttons to make them clearer and more intuitive.	change the default setting Change the colors	D N
General functions				
	Camera	Both participants considered the functions hard to find and that it would be hard to know that the function was a possible action without any guidance. In Conclusion, the function to hide your self-view was not seen as necessary.	Take away hide self-view	N
	Feedback	It was expressed that it would be ok to answer it sometimes but that it would be annoying if it would be after every activity. Furthermore, it would be good if the educators give a heads up before	Add timer	N

		sending out the feedback request. Also, if it would be a limited time there should be a timer indicating the user how long there is to answer the question.		

Appendix 8: Benchmark

Software	Target group / Industries	Main Functions	Reference
Zoom	Business Healthcare Education Finance	Video conferencing, share screen, chat, breakout rooms, whiteboard, emotions, hand raise, go faster/slower. Reactions, close captions, record, polls, remote control	(Zoom, 2021)
Google meet	Mainly targeting businesses but do offer google meet as a part of the solution Google workplace Education Fundamentals.	Live subtitles, test of video and microphone before meetings, control panel for meeting host, chat, share screen, compatible with rest of google software.	(Google, 2021)
Microsoft teams	Business, healthcare and education.	Videoconferencing, share screen, chat, recording, remote control	(Microsoft, 2021)
Blackboard	Blackboard collaborate: Higher education Blackboard: business	Videoconferencing, whiteboard, share screen, raise hand, emotions, polling, recording	(Blackboard, 2021) (Blackboard Help, 2021)
Cisco Webex Meetings/ Webex for education	Business, healthcare and education.	Chat, breakout rooms,	(Cisco Webex, 2021)

		videoconferencing, emotions/reactions	

Appendix 9: Customer Journey opportunities 1 educators

O1. How can equipment that works for digital education be provided?	It could be a rental service or rental space that offers different equipment and software as well as internet connection.
O2. How can it be easier to prepare lectures?	It could be a function in the program that helps the educator to structure and create lectures online.
O3. How can the flexibility to decide where to work be utilized?	There could be a solution offering good equipment and workspace/work furniture to feel good when working at home. The more people work from home, the less offices are needed. This may give room for other buildings, greenery or similar. Furthermore, less travels are needed which is more sustainable. The user also saves time not travelling.
O4. How to best send out links?	Have favourites, have one for each course. Should be in everyone's homepage/app
O5. The educators usually do not get any replies when saying hello. How can this be changed?	If there is a clearer culture as well as norms and rules, it would be easier for everyone to know how to act and interact during a digital lecture. More interactive activities might help the setting by creating a more comfortable environment for everyone.
O6. How can the lecture be introduced in a good way?	To introduce the lecture more clearly, there could be an agenda that is visible or easy to access any time.
O7. How to perform discussions that are efficient and good?	Promote written discussions, use discussion rooms. Promote more interactive activities to make people more comfortable. Use several mediating tools.
O8. It is usually quiet when asking questions to a class, how can this be improved?	It is important to have many options of mediating tools to encourage everyone to ask questions. It could be to be anonymous.
O9. How can there be more interactive activities?	The software can offer different functions that helps to create social connection and enhance engagement and motivation
O10. What is a good final activity?	Interactive finish with questions and summary. Make it easier to create polls or quizzes. Function that singles out most asked questions.
O11. How can it be easier to update lecture material?	Have feedback so there is something to update the material with. Software suggests change

O12. How can it be promoted to talk to other educators and learn from each other?	Possibility to share whiteboards templates, quizzes, forums for helping others and receiving help or being inspired by other educators' ideas. Groups of educators based on educational areas. Support system.

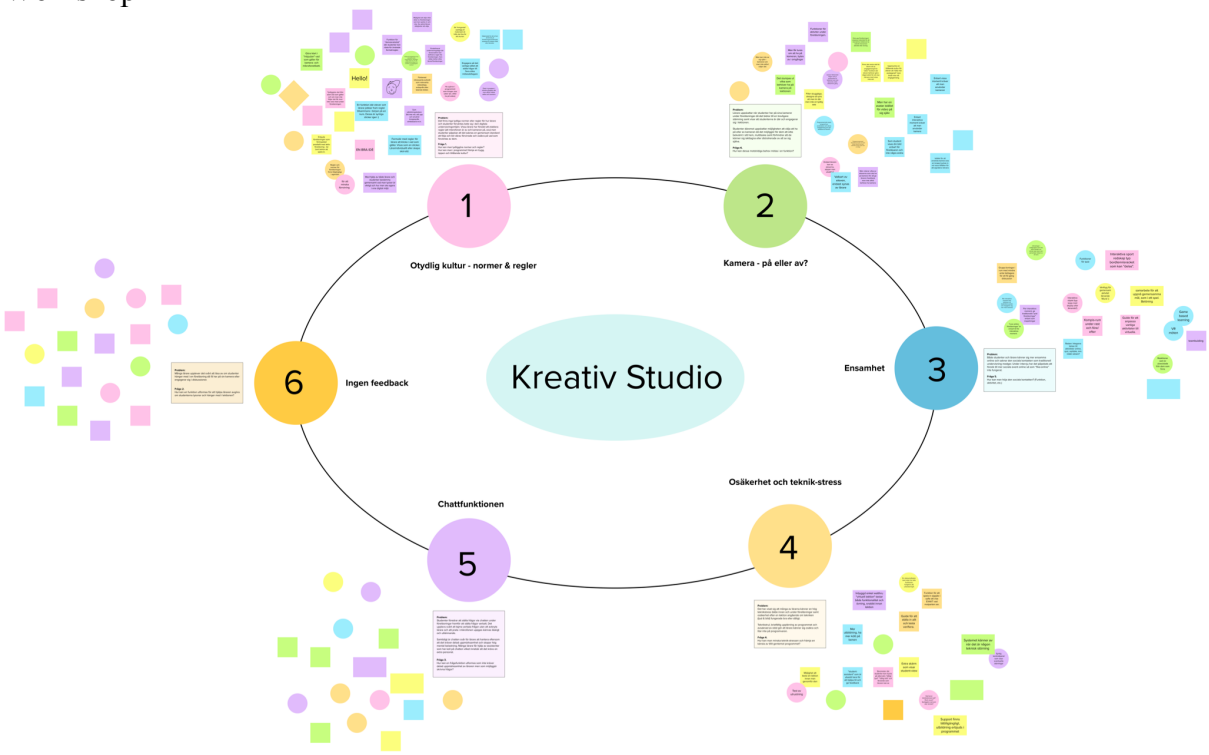
Appendix 10: Customer Journey opportunities 2 students

O1. How to get good and affordable equipment?	Provide service to rent equipment to students and educational institutions. Possibility to rent a space/office close to the student apartment.
O2. How to easily find links for all lectures and meetings?	Save favourites. Create groups for project work, project meeting rooms. Meeting rooms and contacts are available on the student's software homepage.
O3. How to make it more engaging and motivating to listen and watch during lectures?	Promote more interactivity during lessons to make them more motivated. Provide more interactive functions in software. Software automates quizzes based on lecture content.
O4. How can it feel better to be part of discussions?	Provide more options for mediating discussion. Visual tools, chat, groups.
O5. How can the positive reaction towards having a break be used as inspiration?	Taking smaller breaks helps the students to stay focused. Reminder for teachers to take breaks. Software promotes taking breaks to gather new energy.
O6. How can it be easier to ask questions?	Provide more different opportunities to ask questions in discussion groups, chat forums. Help groups are always open for students that are online.
O7. How can the interactivity be enhanced?	Interactive activities are opportunities to motivate and make the students feel more positive emotions. Provide many occasions where it is possible to interact.
O8. How can the good feeling of closing the application and end the lecture be used as inspiration to enhance the experience during the lecture?	Having a clear agenda so the students know what to expect. Provide students with a summary of the lecture, most valuable insights that are listed by the educator.
O9. How can questions for teachers by email be prevented?	Forum in the software connected to the specific course so it is easy to ask the educator or other questions. Have more opportunities to ask questions during the lectures.
O10. How can it be easier	See answer to O1.

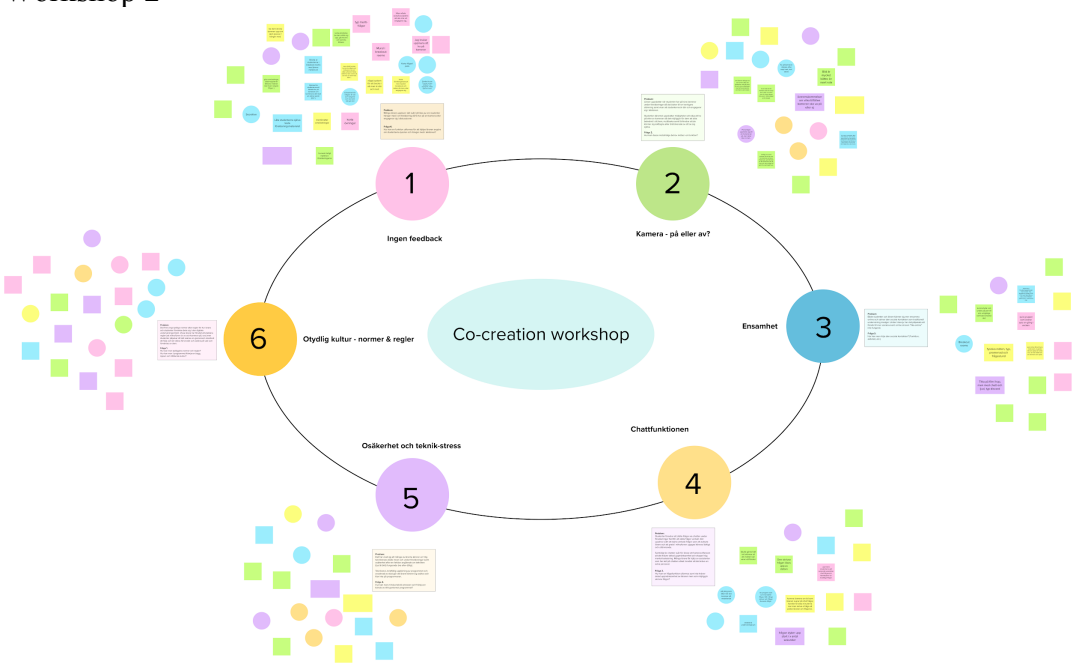
and more affordable to update equipment?	

Appendix 11: Group workshops: Kreativ studio 1&2

Workshop 1

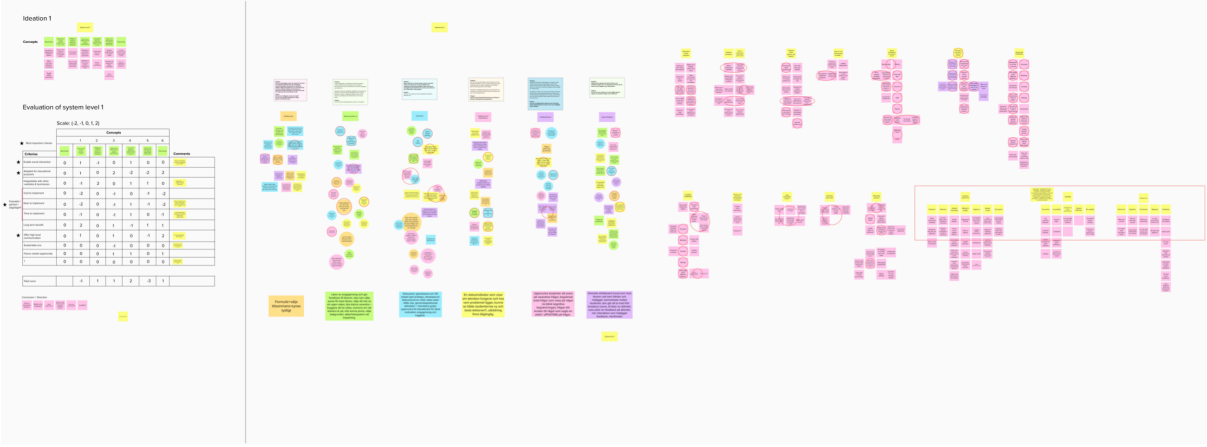


Workshop 2



Appendix 12: Detailed description of selected solutions

Ideas in sorted in Mural.



Summary of selected ideas

Challenges	General	Educator	Student
Hard to achieve high quality interaction	The software will focus in providing usable interactive tools and activities that can be used during lectures. Functions that will promote quality interaction are: - Breakout rooms	Breakout rooms: - Can send message to one, selected amount or all rooms - Can easily move between rooms - Ability to see all rooms at the same time and if they have questions or need help - It is possible to share visual material such as questions or tasks in the breakout rooms - Overlook of participants in each room - Show time remaining	Breakout rooms: - Students can ask for the educator to join the breakout room to receive help - Can message educator - Possibility to use the collaboration board separately or shared with other rooms - Can indicate if more time is needed or if finished with the task - Show time remaining
Lack of social interaction	The software will promote and present more options for interactive activities that will increase the		

	social interaction in class. Functions that will promote social interaction are: - Collaboration board - Discussion groups (breakout rooms) - Chat forum - Quizzes - Games		
Hard to stay focused & keep the attention	The user study indicated that students have an easier time focusing during interactive activities. Therefore interactive activities will be promoted.		
Lack of norms and rules	In order to make rules and norms for how to behave during a lecture more clear there will be a functionality that allows the teacher to pick out specific rules either alone or together with the class. The rules will be visible together with the preparatory lecture information and accessible during the lecture. This will make it easier for students to know what behaviour is expected during that specific lecture.		
No training	In order to make it easier for students	Educators will have access to forums where other	

	and educators to learn how to navigate to program instructional guides and videos will be available in the software homepage as well as on the web. .	educators can ask questions or be inspired by how functionalities are utilized by others.	
Hard to follow chat	The chat function will have an up voting function that will indicate for the educator what if several students are wondering the same thing. Questions can be pinned to specific powerpoint slides to make it easier for the educator to know the origin of the question. The software will promote students to answer each other's questions. This will increase the interaction between students and the educator and can focus more on performing the lecture.	The educator will receive indications if there are questions in the chat. The educator can choose how to receive questions, as either pop up on the screen or notifications only on upvoted questions.	
Communication			
Unregulated use of camera	A general solution to create a more comfortable climate for more to feel comfortable using cameras, the software will	The teacher can choose what is shown in the recorded videos. This to consider both teachers and students' integrity. The rules and norms	In order to prevent the uncomfortable feeling of being watched by strangers the students can choose to only allow the teacher to see them.

	promote the use of more interactive activities. Interactive activities will up the social interactions and create connections between students that will in turn contribute to creating a safer atmosphere. The functionality that enables an easy establishment of rules will make it more clear when students are expected to use their camera. It is only possible to pin the hosts video. This regulation makes it harder for people to watch each other for negative reasons.	function will enable the teacher to influence when and how students use cameras. If there are only a few students having the camera on these will be shown as larger videos in order for the teacher to see them better.	Students can choose not to see the video of themselves if it is found distracting.
Technical issues	The software will have a functionality where students and teachers can test the equipment before the lecture in order to confirm it working. Teachers and students will also be able to access information about the equipment status. The information will show whose equipment or internet connection is failing and		

	suggest how to fix it.		
Educators lack feedback of the students understanding and engagement in lecture	The software will promote more interactivity which will make it easier for educators to trough for example discussions to determine if students are understanding the lecture. The collaborative board is a function that allows the teacher to follow the engagement of the students. The collaboration board is a tool where educators can use and adapt pre-existing templates to fit the purpose of for example a group or class discussion. The collaboration board will function as a whiteboard, allowing students to collaborate and visualize their thoughts and ideas using sticky notes, figures and text. Educators can follow the progress of students working in real time and thereby receive feedback on students understanding of the task.	The teacher can request the students to answer feedback during the lecture regarding for example activities. The feedback will help educators identify opportunities for improvement of lectures and of students' experience of the lecture content.	

Encourage positive emotions	Negative emotions are often connected to technical issues during class. In order to decrease the technical stress the control panel will provide an overview and help both students and teachers confirm if their equipment is working correctly. By providing usable chat options the need for having a functional microphone will decrease along with the negative emotions associated with using malfunctioning equipment. Further, positive emotions during class were often related to interactive and social activities. Therefore the software will promote the use of interactive activities that will increase social interaction.		The feedback functions, see XX, will make it possible for students to a greater extent influence the lecture structure and content which may result in a feeling of involvement and positive emotions.
Confusing where to find data	In order to avoid confusion for educators and students all lecture information is gathered in the homepage of the software.	Homepage of educators include features and possible actions such as: - Schedule - Meetings - Contacts - Settings - opportunity to plan lectures and use templates	The student homepage allows students to access. - schedule - lecture information - lecture link - lecture rules and norms - lecture material - contacts - ability to create

		- Tips & tricks for how to perform a good lecture - Ability to upload material - Ability to pre-upload videomaterial - Forum for educators to communicate - Ability to view feedback from students - Ability to create classes/groups - Mapping of all courses - receiving/ sharing link and lecture invitations - Ability to plan lectures and lecture activities using templates in the collaboration board, preparing quizzes and other interactive activities offered by the program.	project groups - start and plan meetings - access to discussion rooms and forums - receiving/ sharing link and lecture invitations