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Taking Virtual Reality into the Courtroom

An exploratory study of how to implement Virtual Reality within Swedish courts

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Master of Science Thesis (IMSX30)

Taking Virtual Reality into the Courtroom - An exploratory study of how to implement VR within Swedish courts
In collaboration with the Swedish National Forensic Centre

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Gothenburg, July 6th 2021

Carolina Nordin

Adna Zekan

Abstract

The increasing number of criminal cases creates a demand for fast development of high-quality evidence. Both the Swedish National Forensic Centre and the National Courts Administrations strive to find new ways with the help of new technology to improve the judicial process. This Master's Thesis has been in collaboration with the Swedish National Forensic Centre and the aim is to contribute to the implementation of Virtual Reality as a visualization tool that will improve the judicial system in Sweden. The project has been limited to exploring the use of Virtual Reality within Swedish courts. The project answers the following questions: Why should Virtual Reality be used in Swedish courts? Who would be the user of Virtual Reality in Swedish courts? When would Virtual Reality be used in Swedish courts? How would Virtual Reality be used in Swedish courts? The results are concluded into UX/UI guidelines which will act as an inspiration for future development projects and implementation.

This thesis has included interviews and surveys with professionals from Swedish courts and surveys with people from the public. Five use areas for Virtual Reality in Swedish courts have been found during the thesis; giving pre-trial support, viewing of object, viewing of scene, reconstruction of incident and reviewing material. Giving pre-trial support has been tested through usability tests, by testing the concept of viewing a courtroom in Virtual Reality through an Oculus Quest head-mounted display. The results include guidelines for each use area, for the experience as well as for the graphical user interface. The UX/UI guidelines are based on theory study, user study and usability study performed during the thesis.

Keywords: *virtual reality, Swedish courts, trials, evidence presentation, crime visualization, user study, user experience*

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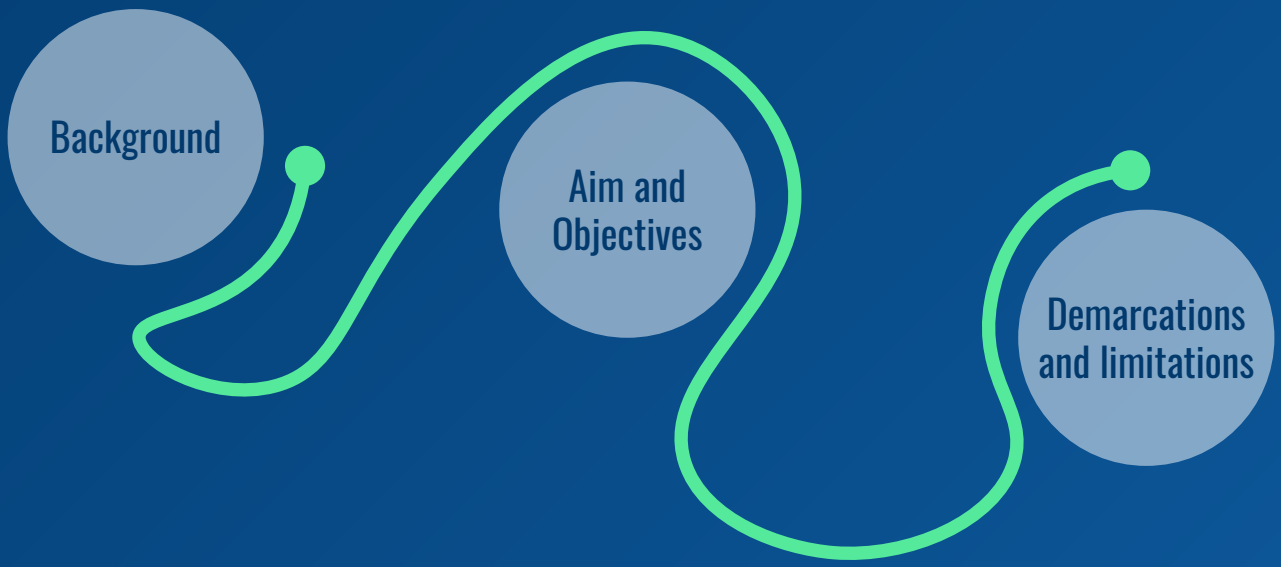
1. Introduction

This chapter presents the scope of the project. It includes background, aim, objectives, demarcations and limitations.



1.1 Background

Each year the number of cases that go through the Swedish courts increase. In 2020 a total of 212 580 cases were filed to the district courts in Sweden, and 209 502 cases were determined (Domstolsverket, 2020). The increasing number of cases creates a demand for fast development of high-quality evidence. The Swedish judicial system consists of the institutions that are responsible for the law and order and legal security in Sweden. This includes the Swedish Police Authority, the Swedish Crime Victim Compensation and Support Authority and the courts of Sweden (Regeringskansliet, 2015). The system is a subgroup of Civil law or Continental European law which is a legal system originating in mainland Europe and opposite to Common law used in Anglo-American countries (Lex Lapidus, 2019).

1.1.1 Swedish National Forensic Centre

The National Forensic Centre (NFC) is an expert organization within the Swedish Police Authority that is responsible for investigations and analyses of the forensics from crime scenes for the judicial authorities (Regeringskansliet, 2015). Their work shall be carried out with high quality, balance, logic, transparency and stability (NFC, n.d.a). One of the tasks for the organization is to conduct research and development projects in the area of forensics (NFC, n.d.b). This thesis will continue previous research made by and for NFC. The research has previously been focused on crime visualization using 3D models, Augmented Reality, Virtual Reality and other technologies. The project will both explore the user perspective of using Virtual Reality, including usability and user experiences, as well as possible implementation of Virtual Reality within Swedish courts.

1.1.2 The Courts of Sweden

If you are accused of a crime or are the victim of a crime in Sweden you have the right to security before the law and rule of law. That is one fundamental part of a democracy and the Courts of Sweden. This means that when crimes are committed, reasonable measures shall be taken to make sure that those who are guilty are convicted but also that no one should be convicted if the support from laws and evidence is not enough. Everyone should be equal before the law. The Swedish courts are responsible for making sure that everyone is able to have their case tried in an impartial court (Sveriges Domstolar, 2020). The Swedish National Courts Administration is a part of the Courts of Sweden and is in turn responsible for supporting the Swedish courts including research and development projects (Domstolsverket, 2019). This thesis will include interests from the Swedish National Courts Administration. The project will explore use areas for Virtual Reality within Swedish courts.

1.1.3 Project stakeholders

Main company

NFC

Company supervisors

Philip Engström and Anna Hultman

Supporting companies

HiQ
Domstolsverket

Supervisor and examiner

Håkan Almius

Project group

Carolina Nordin and Adna Zekan

1.2 Aim and objectives

The aim of this Master's Thesis is to contribute to the implementation of Virtual Reality as a visualization tool that will improve the judicial system in Sweden.

The objective is to get a deeper understanding of the judicial system in Sweden and gain knowledge about Virtual Reality technologies and Virtual Reality development through empirical and theoretical research. The data from the studies will act as a base for development of a requirement specification for the user interaction and user experience for Virtual Reality in Swedish courts. The thesis shall result in UX/UI guidelines and act as inspiration for future development projects and implementation.

1.2.1 Research questions

The aim will be sought to be fulfilled through exploring and answering four main questions:

- Why should Virtual Reality be used in Swedish courts?
- Who would be the user of Virtual Reality in Swedish courts?
- When would Virtual Reality be used in Swedish courts?
- How would Virtual Reality be used in Swedish courts?

1.2.2 Deliverables

The aim of this Master's Thesis will be communicated through four deliverables:

- Mapping of the needs and requirements for using Virtual Reality in Swedish courts
- Developed UI and UX for a Virtual Reality model
- An evaluation of the UI and UX
- Guide for using Virtual Reality in Swedish courts

1.3 Demarcations and limitations

Multiple demarcations were made to the project, divided into technical and situational demarcations and limitations.

1.3.1 Technical demarcations and limitations

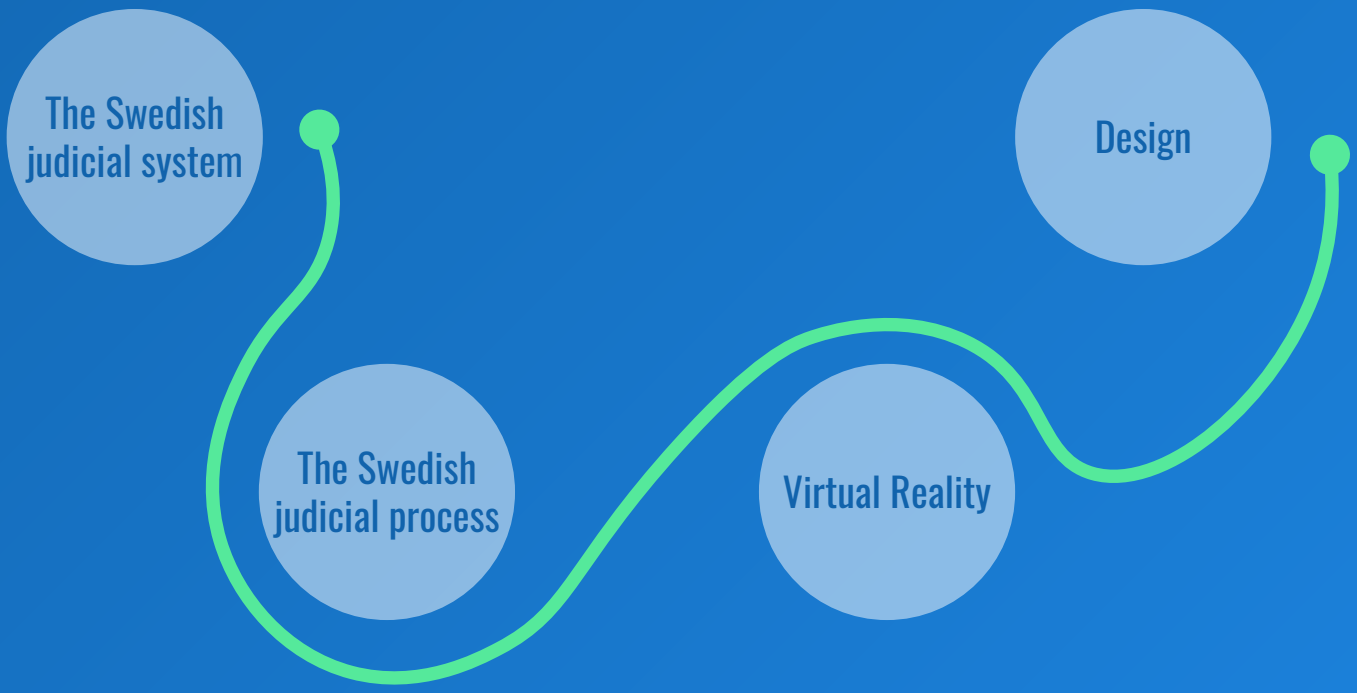
- The project will not include programming
- The project will be limited to Virtual Reality
- The project will be limited to hardware and software provided by NFC and HiQ
    - The Virtual Environment model will be developed in Unreal Engine due to previous projects by NFC
    - An Oculus Quest HMD with belonging Oculus Touch controllers

1.3.2 Situational demarcation and limitations

- The project will focus on the Swedish judicial system and process
- The user study will only include people living and working in Sweden
- The project is limited to two people performing the project full-time for 20 weeks ending in early June 2021
- Due to Covid-19 all tests with users are limited to remote questionnaires or controlled tests in real life with regards to regulations and general guidelines from The Public Health Agency of Sweden

2. Theory

This chapter will present the relevant theory to the project divided into four areas; the Swedish judicial system, the Swedish judicial process, Virtual Reality and design theories.



2.1 The Swedish judicial system

To understand the Swedish judicial system it is important to understand all the different parts of the system. Following chapter will describe the Courts of Sweden and the different courts it includes, the roles within the courtroom and the evolution of the Swedish courts.

2.1.1 The Courts of Sweden

In Sweden, there are different courts with different purposes. The Swedish courts are divided into two main categories: general courts and administrative courts (Sveriges Domstolar, n.d.a).

General courts

General courts include seven different courts, see Figure 2.1.

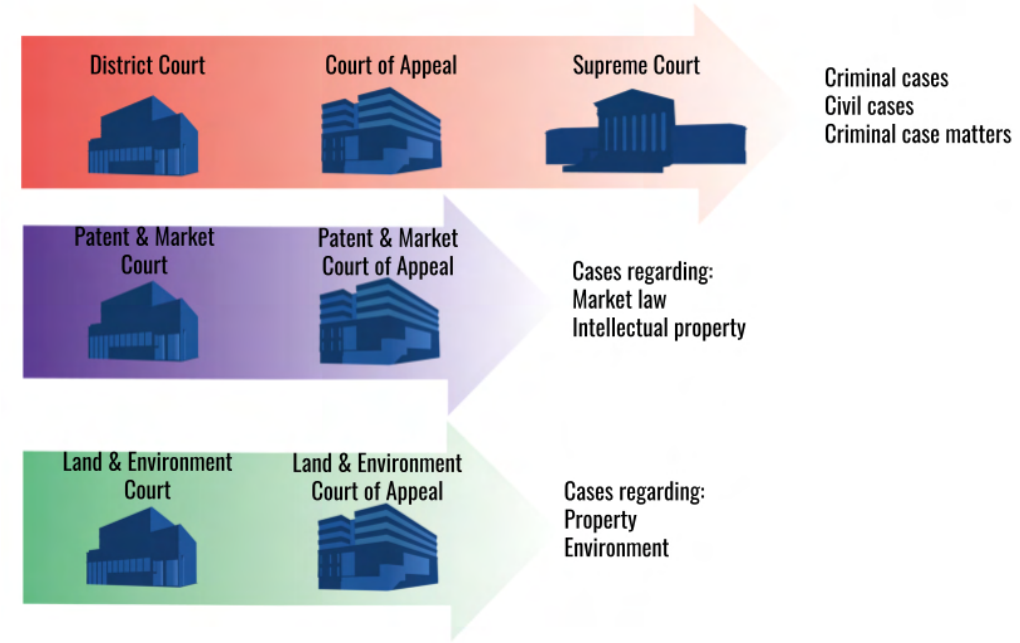


Figure 2.1 The different courts and instances of general courts.

District Court is the first court instance regarding criminal cases, civil cases and criminal case matters. There are 48 district courts in Sweden placed in different geographical locations throughout the country. The second court instance is the Court of Appeal and there are six courts of appeal in Sweden. If one is not satisfied with a trial or the sentencing from district court it can be appealed to the court of appeal. The Court of Appeal will only take on cases that have an approved permit reveal and either have new evidence or material that can have an impact on the outcome. The Supreme Court is the third and highest instance for civil and criminal cases and criminal case matters. The Supreme Court only takes on cases that are found needed to give the two lower instances guidelines on how they should manage similar cases and interpret Swedish laws (Sveriges domstolar, 2019a).

Patent and Market Court manage cases regarding market law and intellectual property. Market law implies marketing rights and rightful marketing whilst intellectual property is regarding brands, designs, artistic works and inventions. The Patent and Market Court of Appeal is the second and highest instance where one can appeal its trial from the Patent and Market Court. The Land and Environment Court manages property cases and environmental cases. The second and highest instance is the Land and Environment Court of Appeal (Sveriges domstolar, 2019a).

The District Court is most often represented by three lay judges with no law education, one judge with a law degree and one recording clerk. In total these five people will constitute the judicial table (Sveriges Domstolar, 2019b).

In the District Court of Appeal, the judicial table is represented by two lay judges without any law degree, one recording clerk and three people with a law degree where one of them act as a judge and the other two have a similar task as the lay judges (Sveriges Domstolar, 2019b).

The Supreme Court differs from the lower instances in multiple factors. One of these factors is that five judges with a law degree act as court clerks for the cases. No lay judges without a law degree take part in the trial process in the Supreme Court (Sveriges Domstolar, 2019a).

Administrative courts

Administrative courts consist of five different courts, see Figure 2.2.

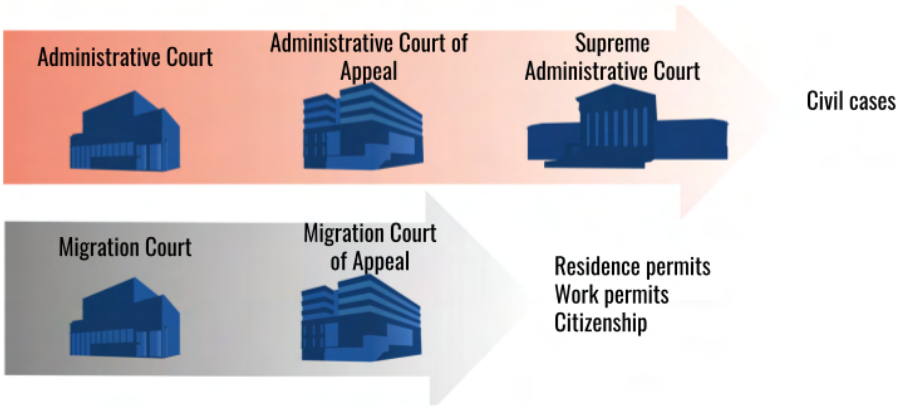


Figure 2.2 The different courts and instances of administrative courts.

The Administrative Court is the first instance that manages civil cases between private people and companies or authorities. The Administrative Court of Appeal is the second instance and the Supreme Administrative Court is the third and highest instance for civil cases. The Migration Court manages residence permits, work permits and citizenships. One appeals to the Migration Court if one is not satisfied with the outcome from the Swedish Migration Agency. The Migration Court of Appeal is the highest instance (Sveriges domstolar, 2019c).

2.1.2 Roles within the Swedish judicial system

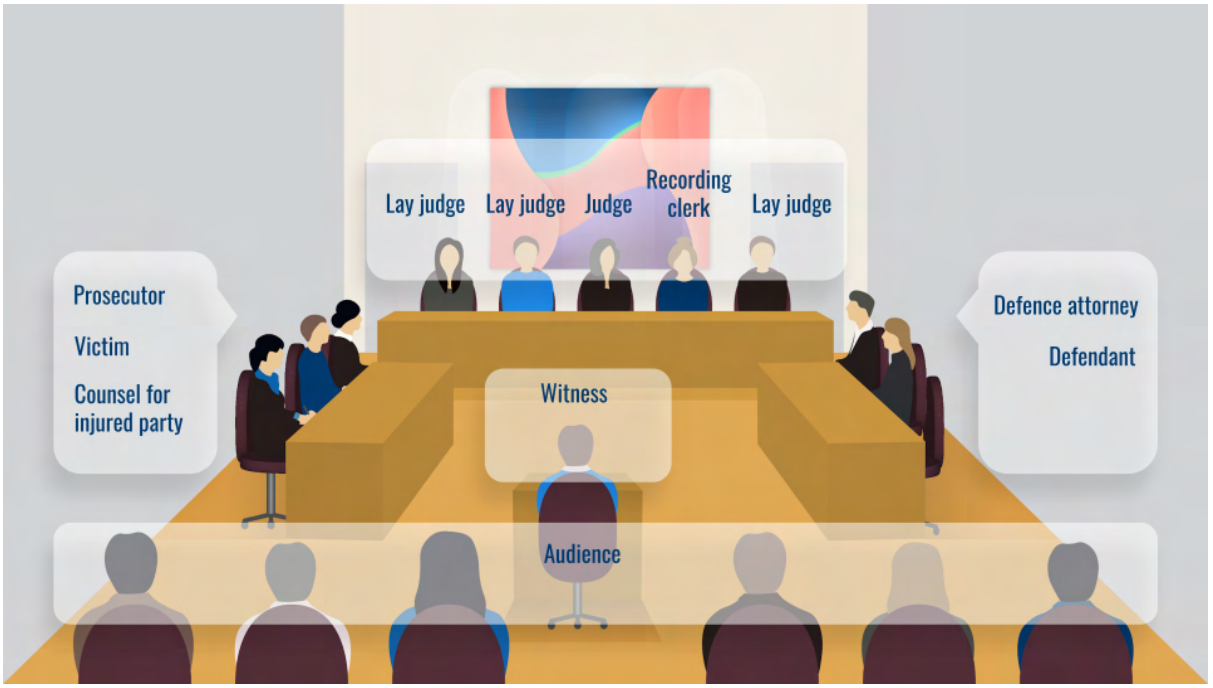


Figure 2.3 An illustration of roles that may be included in a district court.

Within the Swedish courts, there are different roles, see Figure 2.3. **The judge** is also called a legally trained judge or permanent judge and is always a law graduate. The judge is responsible for the order and safety within the courtroom (Sveriges Domstolar, 2019c).

The lay judge adjudicates together with the judge and has an equal vote. The lay judge does not normally have a law degree (Sveriges Domstolar, 2019c). The lay judges for the District Court are chosen by the municipal council, whereas the lay judges for the District Court of Appeal and Administrative Court & Court of Appeal are chosen by the regional council. A lay judge is chosen for a period of four years (Bli nämndeman, 2021).

The recording clerk is the one seated next to the judge and is responsible for managing the technology in the room, recording hearings and taking notes. A recording clerk can be a person that has graduated from law school and performs an official duty assignment but it can also be a secretary or administrator (Sveriges Domstolar, 2019c).

The prosecutor is the person that commences a prosecution and represents the state. It is the prosecutor that decides whether the defendant should be prosecuted. If the crime is of a bigger extent the prosecutor will also be the one leading the pre-trial investigation. In Sweden a prosecutor must always act objectively. The local public prosecution office is an independent Swedish authority and does not belong to the Courts of Sweden (Sveriges Domstolar, 2019c).

The defendant is the suspect, the one that is suspected of being guilty of a crime and is prosecuted for that crime (Sveriges Domstolar, 2019c).

A **public defense** is in most cases an experienced lawyer that is assigned by the court to the defendant. The defendant can ask for a specific lawyer but it is up to that lawyer whether he or she takes on the case. The public defense is paid by the State according to a specific tariff. The defendant can in some cases be obligated to pay back some or the whole cost (Sveriges Domstolar, 2019c).

A **private defense** is a defense that the defendant privately has hired. In the cases where the court does not assign the defendant a defense, he or she can pay for it by themselves (Sveriges Domstolar, 2019c).

The **injured party**, also called the aggrieved party or victim is the one that has been exposed to the crime. The injured party can be either a private person or a legal person. All injured parties do not have to attend during the trial, only the ones that will be heard or the ones that need to answer questions for the court (Sveriges Domstolar, 2019c).

In some cases the court assigns **counsel for an injured party** that helps the injured party to present from their point of view. If counsel for the injured party is not assigned, the prosecutor helps the injured party with this. The counsel for an injured party is in most cases a lawyer and is paid according to a specific tariff by the state (Sveriges Domstolar, 2019c).

A **special representative for children** can be assigned in some cases that involve children under 18 years. A special representative for children is assigned in cases if the child's guardian is suspected of a crime or if the guardian has a relationship that may not take the child's best interest into consideration. A special representative for children is usually a lawyer or a legal associate and is responsible to care for the child’s rights in both pre-trial investigation and trial (Sveriges Domstolar, 2019c).

A **witness** is a person that can tell the court about meaningful insights for the trial. A witness’s task is not to make the defendant guilty or free, but to give the court rightful insights into the incident. A witness does not have to be someone that has directly seen a crime but can also be someone that can give information that is important to deliberate (Sveriges Domstolar, 2019c).

An **advisor** or expert can also be called to court as a witness to explain from their expertise. An advisor has a responsibility to answer the questions from their best capabilities, in order to make the judges understand (Sveriges Domstolar, 2019c).

If one of the parties has difficulties in understanding the Swedish language or has a visual or auditory impairment the Court can assign an **interpreter**. The interpreter has to take an oath that he or she will perform the task to the best of their knowledge. The interpreter has to be impartial (Sveriges Domstolar, 2019c).

The injured party can choose to bring a **support person** if they have no counsel assigned. A support person can be anyone including a friend or a family member. They are not allowed to speak and are only there as support (Sveriges Domstolar, 2019c).

A **witness support** is a person who offers support and help to victims and witnesses. It is a nonprofitable role. Witness support is in most cases always present in the court to guide and help with questions outside the courtrooms (Brottsoffermyndigheten, 2021).

Members of the public can also take part in trials as audience members. All trials in Sweden are public except for in some cases when the trial is announced to be behind closed doors. The audience is not allowed to interrupt a trial. The judge has the right to send out audience members that do not follow the rules (Sveriges Domstolar, 2019c).

2.1.3 The evolution of the system

In 1942 the original Code of Judicial Procedure was implemented and had a big influence on forthcoming implementations. As an effect of the code of judicial procedure, the principle of oral proceedings, the principle of immediateness and concentration principle were implemented (Renfors, n.d). The first district court in Sweden was introduced in 1971. This was also the point where the differences between the state and the cities disappeared and all courts became a responsibility of the state (Borås Tingsrätt, 2019). In 1981 laws of security and the right to have security checks on the people visiting the courts were introduced. The law of security control has been updated four times since 1981, with the newest version updated in 2019 (SFS 1981:1064).

In 2008 the modern Code of Judicial Procedure was implemented in Swedish courts. This implementation gave new opportunities, as well as new demands of documentation of questionings in court. Since 2008 all questionings in court must be video recorded. The result of having all questionings on video eases for the next instance to rewatch the questionings if an appeal of a trial is made. It also results in possibilities of attending a trial remotely through videoconference. This implies that witnesses must not physically be in the courtroom when giving their statements, as well as other participants who may be included through a video conference (Regeringskansliet, 2008).

Communication has been important to the courts in Sweden. Since 1972 the recording clerk could use a phone to call in witnesses to the room. The hearings could also be recorded with the help of a tape recorder. Telefax was also a very well-used function once it was available and quickly became an important tool for the courts. The telefax function was well kept and could for instance be used in Helsingborg court up until 2019. The main tool for sharing documents today is through email (Domstolens historia, n.d.).

With the increased availability of new technology for people of the public, criminals have also started to take advantage of modern technology. This increases the need of the Swedish National Courts Administrations to keep evolving the Swedish court system. Therefore there are a lot of projects involving innovations and technology in the Swedish courts to improve the system. The current innovations include digitization of processes and increasing the efficiency of commencing a prosecution (Sveriges Domstolar, n.d.b).

One tool that has been used by criminals is EncroChat. With help from Europol and France police, EncroChat could be decoded resulting in more than 500 people being suspects of crimes (Jansson, 2021). Since EncroChat was decoded, another platform called Sky ECC has also been decoded by the Belgian police, resulting in even more evidence against criminals. Both services give their customers an encrypted platform, complicating it for the police to reach and connect it to the user (DN, 2021). Evidence from EncroChat has evoked split discussions on whether it should be allowed to be used as evidence or not. EncroChat does however argue for a need to keep courts up to date to be able to follow the extent of the crimes happening today (Omni, 2021).

2.2 The Swedish judicial process

The process from committing a crime to being sentenced for it in Sweden can be divided into three categories; pre-trial, during trial and post-trial. Each of the following sections explain different parts of the process that will be described more in detail. It will also include theory about evidence. Pre-trial is defined from the committed crime until a prosecution is commenced. During trial is defined from when a prosecution is commenced to a set sentence. Post-trial is the process of all actions that happen after a sentence is set.

2.2.1 Pre-trial

The process for a crime starts by reporting it to the police. In Sweden, a crime has to be reported to the police either by a member of the public or by the police itself. When a proper report has been made the crime will be investigated and a pre-trial investigation is initiated. The largest and most important factors in a pre-trial are whether there is a suspect and if there is enough evidence to authenticate the allegations. If the crime conducted is a serious crime a prosecutor will be involved earlier and lead the pre-trial investigation (Brottmål, n.d.).

The purpose of a pre-trial investigation is to get closer to the truth of the actual event. This is achieved by searching and collecting evidence and investigating the material that is present (Brottmål, n.d.). Police interrogations are held with witnesses, suspects and others involved that may know something of worth for the investigation (Brottsofferjouren, n.d.a). In most cases there is already a suspect, but this must be confirmed and proven. There are different levels of designations for a suspect. The degrees are suspect, suspected on reasonable grounds, probable cause and beyond reasonable doubts. It is when there is a suspect within probable cause that the prosecutor can bring a prosecution (Brottmål, n.d.).

There are different actions that a prosecutor can perform if a suspect involved in the crime may pose a threat for the investigation either by destruction of evidence or risk of the suspect fleeing. A person can be arrested if there is a suspicion for the person to have committed a crime. It is the Swedish police that arrests the person and thereafter it is up to the prosecutor whether the person should be detained. If there is no request for detaining a person he or she can only be arrested for a maximum of 12 hours (Brottmål, n.d.).

A suspect can be held detained until a remand order has been decided upon, however only for a maximum of three days. The prosecutor must hold a detention hearing within the range of these three days. If the decision of having this person remained in custody he or she will be in custody up to the trial (Brottmål, n.d.).

2.2.2 During trial

When the pre-trial investigation is completed it is up to the prosecutor whether a prosecution should be dismissed or continued to trial. This decision should be based on whether there is enough evidence to prove a suspect has committed the crime. Should the evidence be lacking the prosecutor is not allowed to continue with a prosecution. An important aspect is that the evidence must be objective, which implies that evidence that both speak for and against whether the suspect has committed the crime must be investigated and presented. If the prosecutor makes the decision that there is enough evidence to commence a prosecution the prosecutor must fulfill and issue a writ of summons to the District Court (Brottmål, n.d.).

When a prosecution is commenced the trial is initiated. Within the Swedish courts there are principles that are followed. One principle is the principle of oral proceedings which implies that all hearings must be presented orally. . The prosecutor has in most situations no right to read from previous interrogations documented in the preliminary investigation report. Everything that has to be said or presented needs to be presented in court by the people that have stated it in previous interrogations. The only time when the prosecutor is allowed to read from the preliminary investigation report is when something that is said in court differs from what has been said in previous police interrogation (Brottmål, n.d.).

The preliminary investigation report includes material from the pre-trial investigation that the prosecutor and the police find relevant for the inquiry. This implies that not the full investigation is presented for the court but only the parts that are needed to give the judges an objective view of the crime as well as argue for the suspect being guilty. The defense attorney has the right to the full investigation and also to demand completion of the investigation (Advokatsnack, 2018).

A trial is initiated with the prosecutor presenting a statement of the crime that has been committed. If a counsel for an injured party is present this person will demand for a punishment, else it is the prosecutor that states this. The defendant claims whether they are guilty or not and after that the presentation of evidence is initiated (Brottsofferjouren, n.d.b). The prosecutor starts by presenting a statement of facts. The statement of facts should inform about the incident based on the evidence that the prosecutor has from the investigation. However, the prosecutor is not allowed to present what has been said orally in interrogations. Witnesses must tell this by themselves (Brottsofferjouren, n.d.c).

Once the statement of facts has been presented it is the victim's turn to account for what has happened from his/her own perspective. The biggest difference between the injured party and the prosecuted person versus witnesses, is that the injured party and prosecuted person do not have to take an oath (Brottmål, n.d.).

If the victim has difficulties in describing what has happened the prosecutor can help by asking questions. These questions should in no way be leading, the purpose is for the questions to be as neutral and objective as possible. The defense attorney however has the right to ask leading questions to investigate if the victim is telling the truth. Once the victim has presented from their perspective, the defendant presents what happened from their perspective (Brottsofferjouren, n.d.c).

Once the victim has told their story it is time for the witnesses to present what they know connected to the incident. The witnesses enter one by one and are not allowed to follow the trial before their own statements, to minimize the risk of being influenced by the things that have been said. When a witness enters the courtroom they are informed about what it implies to take an oath, and repeat the oath after the judge. The witness gets thereafter questions from the prosecutor, defense attorney or the judges (Brottsofferjouren, n.d.b).

Once all evidence has been presented and all witnesses have been heard, the court asks the defendant whether they have committed a crime before and asks questions about their economic situation. The economic situation can affect cases where the sentence is to pay a fine. Lastly both sides get to argue for the sentence. The prosecutor starts to argue for whether the defendant is guilty and what sentence should be given according to convictions for similar cases. The defense attorney gives their view of the crime and thereafter it is up to the judges to deliberate the trial. All parties get informed about the conviction either by digital information or by being called to the court another day (Brottsofferjouren, n.d.b).

2.2.3 Post-trial

Once the sentence is set for a trial there are two things that the victim or the defendant can do; take the sentence and be satisfied with it or lodge an appeal for the trial to proceed to the next court instance. A lodge for an appeal must be done within three weeks from the sentence. The different sentences that are possible are fines, prison, conditional sentence, probation, institutional care of young people and placement in special care (Brottsofferjouren, n.d.d). Post-trial, the victim can file for payment for damages or a criminal injury compensation (Brottsofferjouren, n.d.e). If there is a threat that is present even after a trial there is help to find for this too (Brottsofferjouren, n.d.f).

2.2.4 Evidence

The Swedish Courts have a free evaluation of evidence which implies that anything can be used as evidence, but it will be evaluated to what degree it is relevant. Therefore there are no obvious categories of evidence. In the Swedish judicial process the prosecutor is the one that holds the burden of proof. This implies that the prosecutor is the one that has to make sure that all evidence wanted has been produced. All that is proved has to be argued for to get a higher evaluated relevance and value (Holmberg & Huuva, 2019).

The Code of Judicial Procedure (SFS 1942:740) has a section dedicated to evidence with seven chapters. In the Code of Judicial Procedure the different parts of evidence are divided into witnesses, questionings with the defendant and victim, written evidence, inspection and questionings of experts. A view of the scene or inspection of objects can be done as evidence. To get a viewing of a scene approved, the scene must have information that cannot be brought into the court. Objects can also be either viewed at another location outside the court or viewed in court. All questionings must start with giving an oath of truth (SFS 1942:740).

The Swedish trials follow the rules of the concentration principle, the principle of oral proceedings and the principle of immediateness. The concentration principle argues that a trial must be continuous. It implies that a trial is not allowed to be conducted during separate occasions with longer interruptions (Lagen, n.d.a). The principle of oral proceedings argues that all hearings must be presented orally and cannot be submitted as or read from statements. The principle of oral proceedings is a result of the implementation of the principle of immediateness (Lagen, n.d.b). The principle of immediateness argues that the trial is only allowed to be based on the information that has been presented during the trial. This implies that the trial cannot and should not be based on information gained from outside of the trial (Lagen, n.d.c).

Technical evidence is all evidence that is connected to either technical, chemical or medical questions. Examples of technical evidence are DNA analysis, investigations of firearms and bloodstains or even a simple alcohol test. Technical evidence is often sent to the National Forensic Centre or to the National Board of Forensic Medicine for evaluation (Åklagarmyndigheten, n.d.). Another category of evidence is written evidence, which involves technical evidence. Evidence such as text messages can also occur in written evidence. The contrary to written evidence is oral evidence. Oral evidence involves all questionings from witnesses. In Sweden there is an obligation to witness if it is seen as necessary by the prosecutor or defense attorney (Polisen, n.d.).

2.3 Virtual Reality (VR)

The Milgram reality-virtuality continuum describes the spectra between Real Environments (REs) and Virtual Environments (VEs). Everything in between complete reality and complete virtuality is called Mixed Reality (MR). Augmented Reality (AR) refers to virtual objects augmenting the real world while Augmented Virtuality (AV) refers to real objects augmenting a virtual world (Kishino & Milgram, 1994).

Following section will describe the rise of VR including historic happenings, the technology itself and how it has been used in judicial systems. It will also include aspects important to keep in mind when designing for VR.

2.3.1 The rise of VR

The history of virtual environments began a long time ago and has gone through many evolutions. In the early 1780s, a painter named Robert Baker created a 360° landscape painting of Rotunda in Leicester Square in London. Many artists started following the painter by the beginning of the 1800s making 360° panoramas of landscapes, buildings and battles. A screen that has different painted materials on its two sides creating an illusion when illuminated from different angles was first made in 1822 by artists Daguerre and Bouton. In 1935 author Stanley G. Weinbaum wrote about being able to see a fictional world by wearing goggles that included all senses. At the same time inventors were experimenting with what would become the origin of today's AR, MR and VR. It started with a primitive flight simulator in 1929 by Edward Link, the first stereoscopic television in 1945 by Thelma McCollum to the Sensorama Simulator being created in 1962 by Morton Heilig. The simulator was described as an experience theater, realizing the vision of Weinbaum's story. The user would sit in a chair while extending their head into a surrounding machine that produced images of a virtual environment. The user also included sensory stimuli like air, sounds, smells and vibrations (Greengard, 2019).

The first head-mounted display (HMD) was developed in 1961 by Philco Corporation called Philco Headsight. The HMD tracked head movements in order to adjust the display. After years of innovations and evolution the HMD became smaller and more like goggles, the systems behind got more advanced and powerful and more components were added like touchpads, buttons and gesture recognition. The Cave Automatic Virtual Environment (CAVE) which was the first real immersive experience was created in 1992 by researchers at the University of Illinois of Chicago. The user would stand inside an immersive room wearing glasses that showed objects moving around in the space (Greengard, 2019).

Two drivers of the modern evolution of VR and AR were the military and the entertainment industry. The military has a constant need to develop better training and weapons and use AR and VR technologies for training simulations. Also, gaming motivated new innovations that created business opportunities. In 2010 the first modern version of VR was prototyped, later called Oculus Rift which entered the market in 2016. Facebook purchased Oculus in 2014 and since then Oculus has grown into a major player in commercial VR platforms. The

Quest followed and so did other companies like Sony with PlayStation VR. As the VR systems got smaller while maintaining their power, prices also dropped and many companies have entered the market since the start of the evolution of immersive technologies in the 1780s (Greengard, 2019).

Today the biggest part of the market share of VR headset belongs to the gaming segment. However the segment with the fastest growth from 2021 to 2028 is anticipated to be education. Some of the VR headsets available today are Oculus Rift, Rift S, Quest, Quest 2, Go; HTC Vive, Vive Pro Eye, Focus, Plus, Cosmos and Sony's PSVR (Grand View Research, 2021). Statistics showing the number of units of each platform being shipped from 2017 to 2019 show a continuous growth of shipments per year. It also shows that the most popular platform is Sony's VR set, with Oculus trailing in behind (Statista, 2021).

2.3.2 The technology

The current market contains VR equipment for both high-end users and budget users. The high-end market includes the Oculus Rift, Valve Index, HTC Vive and Sony PlayStation VR. As for the budget market, it includes Samsung Gear VR, Google Cardboard and Daydream. There is also more mainstream equipment such as Oculus Quest and Quest 2 (Dredge, 2016; Lynch & Pino, 2021).

High-end

Valve Index is rated as the best VR equipment available in 2021. The biggest difference between the mainstream and high-end products is their requirements of computer specifications as well as the accuracy and their ability to create a fully immersive experience for the user. The price is also another factor (Lynch & Pino, 2021).

Figure 2.4 High-end VR equipment. Valve Index (top left), HTC Vive (top right), Oculus Rift S (bottom left) and PlayStation VR (bottom right).

The most common characteristic of the HTC Vive is that it consists of a headset, two controllers and two cameras for tracking, see Figure 2.4. There are however models that do not require tracking cameras (Vive, n.d.a). The headset has built-in headphones and is directly connected to a computer through cables during use. The cameras are put on a height with a specific distance in between, allowing the user to move within the space that the cameras cover. The controllers have buttons for pressing up, down and to each side as well as a trigger, side button and a menu button (Vive, n.d.b).

Oculus Rift S is Oculus's high-end model of VR equipment designed for PC games. Oculus Rift S is a newer model of the Oculus Rift. Oculus Rift S uses only a headset and two controllers. The headset requires a connection through a cable to a computer when used for PC games. It has built-in speakers, increasing the awareness of the virtual environment one enters. The controllers have a trigger button, side button, two buttons facing towards the user, a menu button and a joystick (Oculus, n.d.a).

Valve Index is one of the most expensive VR equipment on the market. Valve Index includes a headset, two controllers and two base stations acting as cameras. The headset has off-ear speakers and requires a computer to be connected through a cable. The base stations cover an area in which the user can walk. The controllers differ from the standard straight form that the rest brands have. By having a curved design it can track finger movements on all of the user's fingers, and not only from the index and middle finger. The controllers have two buttons facing the user, a joystick, a trigger button, a middle button and a menu button (Valve Index, n.d.).

Sony PlayStation VR is an additional product that can be used with other PlayStation products. By using the PlayStation Wand or control, the PlayStation VR gives users the possibility of experiencing VR games on their PlayStation (PlayStation, n.d.).

Mainstream

Oculus Quest 2 is an Oculus model for the mainstream market. Oculus Quest 2 is a newer model of the Oculus Quest. Oculus Quest 2 includes a headset and two controllers, see Figure 2.5. The headset is a wireless model that can be connected to a computer through a USB-C port. The controllers include a trigger-button, side-button, two buttons facing the user, a menu button and a joystick. The Oculus Quest 2 asks the user to create a boundary or place a seated boundary when using, to ensure that the user will not injure themselves during use (Oculus, n.d.b).

Figure 2.5 Mainstream VR equipment, Oculus Quest II.

Budget

The phone-based VR equipment, allowing users to connect their phone to a specially built VR headset, has more or less disappeared from the market. The Samsung Gear VR, see Figure 2.6, has for instance not been updated since Samsung released their Samsung Galaxy S9, making the VR set unsuitable for the newer models of phones (Greenwald, 2021). Samsung was not the only one investing in mobile VR equipment. Google invested in Daydream, a headset aimed at mobile VR. The market also included brands such as Homido, Mattel and cardboard models. The phone-based VR equipment allowed the user to have a VR experience by connecting their smartphone to a headset. However the phone-based VR equipment provides no controllers, resulting in less functionality than mainstream or high-end VR equipment (Robertsson, 2019).

Figure 2.6 Budget VR equipment. Samsung Gear VR (left) and Google Daydream View (right).

2.3.3 VR in the judicial system

Simulations are thoroughly explored, but can only present visual information. The powerful tool VR is less explored but has the ability to make someone believe that they are present in

the environment (Leith & Hoey, 1998). The first VR experience in a courtroom in the US was for Stephenson v. Honda Motors Ltd. Of America in 1992. Honda was being sued for a motorcycle accident. Honda made a reconstruction of the scene from a first-person narrative. The jurors were shown the rough terrain and speed of the driver and Honda ended up winning the case (Dunn, n.d.).

In the last couple of years, the use of 3D models and VR in the judicial system has become a popular research subject and appears more frequently. In 2016 a 3D model was used in the continued Nuremberg trials, assisting the prosecution of a war criminal. The Bavarian State criminal office in Munich created the model by using laser scans and old blueprints and it was created to be viewed on a 2D monitor in the courtroom. The model has been adapted to VR since the trial (Cieslak, 2016).

On March 1st 2018, VR was taken into a courtroom in China for the first time. Beijing No. 1 Intermediate People's Court used an HTC Vive on Mou Dong, the witness of a murder case. Everyone in the courtroom could follow what Dong was seeing through a projector and screen in the room as he described what happened during the time of the crime and where he was standing (Nafarrete, 2018).

University of Salford has also been using VR technology in court but for children. The aim is to make the experience of going through family court proceedings less intimidating for children. The children get to experience the whole process from entering the building to sitting in an ongoing hearing. The project launched in 2018 and has been received positively (University of Salford, 2019).

2.3.4 Psychology of VR

For a virtual experience to be perceived as real, one needs to consider multiple complex factors. Software and hardware need to interact seamlessly with no delays, glitches or errors. A delay of only 50 milliseconds is noticeable for the user of the virtual environment. A user needs cues and signals throughout their virtual experience. The system and the user must inform and understand each other at all times. It is also important to note that the virtual environment does not need to be an exact replica of the real environment. The experience only needs to be as real as necessary to produce the desired responses. If the experience is too real it can put the user in a dangerous situation possibly causing panic attacks, fear, psychosis or other serious problems (Greengard, 2019).

Proprioception is a term that refers to how humans sense their environment and navigate through it by moving the body from what we sense. This allows us to eat without seeing our mouth or changing gear when driving. The sense works almost the same for everyone and is fundamental to our everyday life. The perception of the virtual world is not reality, it is the interpretation of reality. This intersection between psychology and physiology is a critical factor for the virtual experience. When people have been blindfolded or used VR they have believed that they walk in a straight line while actually curving because of the lack of feedback. The experience will be unsatisfactory if not all sensory signals are represented

because there will be a mismatch between sensory input and output. Designers have the opportunity to manipulate the human mind but it is important to not take advantage of this and overload the user. The system needs to have balance and avoid taking the user to their mental and physical limits (Greengard, 2019).

2.3.5 Physical effects from immersive environments

The biggest struggle with VR is the physical effects it has on the user both during but also post immersive environments. The physical effects from an immersive environment are often related to simulator sickness, such as disorientation, oculomotor and nausea. It has shown that the physical effects correlate to the time being exposed to the immersive environment (Lampton et al., 1994).

An immersive environment is an environment including *sensory richness* and *interaction*. Sensory richness is when a user is isolated from the sensory input from the real world and substitutes these senses with input from a computer-generated world. Interaction aims for the user to modify the computer-generated world, with either transportation of oneself or things in the surrounding (Fuchs et al., 2011). When a user is exposed to an immersive environment, illness in the form of motion sickness is a common physical effect. There are three types of conflicts that induce the feeling of motion sickness. The first type is when two signals from different senses are contradicting each other or present unrelated information. The second type is when an expected sensorial signal correlated to the signals that are expected, are absent. The third type is the reversed result of type two (Cobb et al., 1999).

Using HMD's to display an immersive virtual environment leads to sensory conflicts due to the difference in the relation between the visual and the bodily approach. The issue is due to optical lags or the fact that one is transporting through a hand device. These types of sensory impairments do not only cause nausea but can also affect the user in the form of headache, sweating, disorientation or postural instability. The physical effects do not only affect the user's wellbeing but may also affect the use of HMD's by a change of behavior which may result in fewer movements within an immersive environment or less head movement (Cobb et al., 1999).

It has shown that it is important to consider how one introduces VR to new users and that it would be appropriate to do so by a structured program. Jamie (2017) mentions that it would be convenient to introduce VR for new users with a shorter exposure at first, comparable to what Cobb et al. (1999) argues for. It is also shown that longer use of VR increases the possibility of catching any of the physical effects mentioned, which is why multiple authors argue to keep the time exposed for VR under 20 minutes (Cobb et al, 1999; Kaufmann & Duenser, 2007; Lampton et al., 1994).

2.3.6 Designing UI for VR

In real environments people are used to reading in 2D, so interfaces in 2D in 3D environments would not be an obstacle but rather something recognizable.

Intended viewing distance decides the size and density of visual information which makes designing for VR more difficult because it is not just one type of screen at a certain distance. One way to go around this is to design the interface using angular units so that the text has the same size at an angle, no matter the visual distance, see Figure 2.7 (Google developers, 2017).

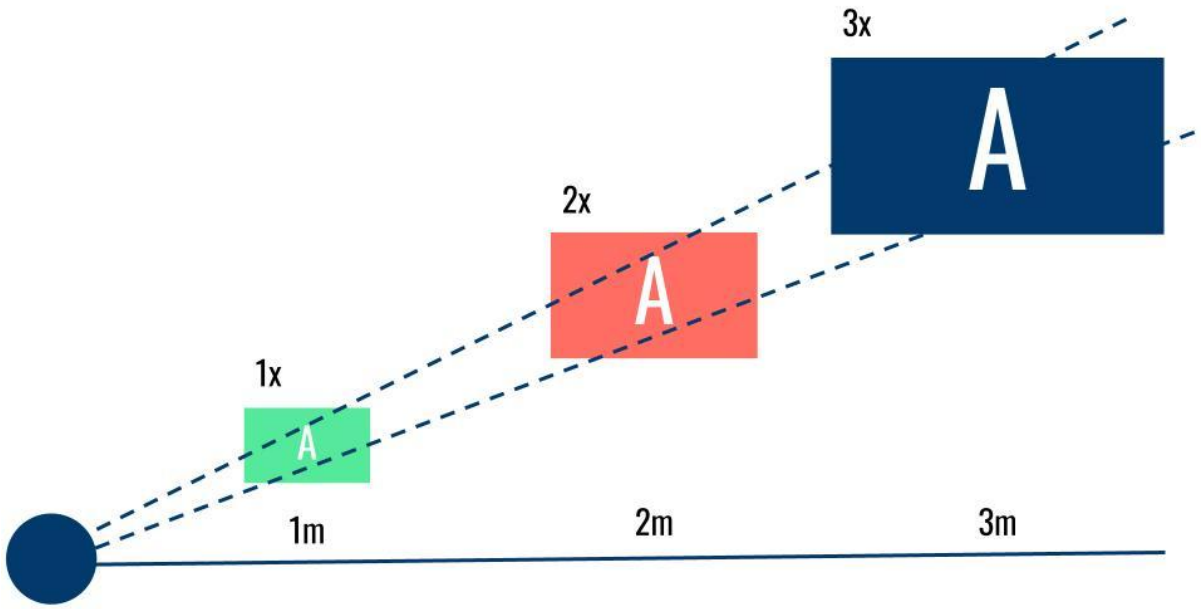


Figure 2.7 Scaling of UI depending on the viewing distance.

When elements have the same angular size, both texts and shapes visually have the same size independently of distance. Distance-independent millimeter (DMM) is an angular unit that represents 1 millimeter viewed at 1 meter away. This is useful when importing UI graphics into a VE. The graphic elements can be done in one size, to later be scaled to an appropriate size depending on the viewing distance (Google developers, 2017).

Diegetic UI means that the UI elements are integrated into the virtual environment such that all actors in a world would be able to see them. Non-diegetic UI is more common and means that the elements are placed flat in front of the environment, for only the user of the virtual environment to see. Diegetic UI increases the feeling of immersion as it is more similar to real environments compared to non-diegetic where elements stay fixed in the field of view (University of London, n.d.). Immersive experiences can also be created using binaural audio which also can guide the user of where to direct attention (Jamie, 2017).

Since one of the biggest issues with VR is motion sickness, the UI must be designed to limit this side effect. One solution is to give control of the camera to the user. This also increases the feeling of immersion and control. Another factor to keep in mind is to limit sudden changes in light as this may take away from the experience and be uncomfortable for the eyes. Fading transitions help the user to adjust when switching between scenes. Flashing lights, high spatial resolution images and acceleration should also be avoided to limit motion

sickness (Jamie, 2017). UI elements can furthermore look pixelated in VR. Therefore elements should be kept as simple and clean as possible, avoid using too much detail or large paragraphs with text (Purwar, 2019).

Since the user is cut off from reality, important factors are control and trust. The UI should be easy to learn so that the user feels in control and the user should always be informed of what they can expect from the experience. The user should be able to customize at any time to allow for people with injuries, disabilities or preferences to adapt their experience. When multiple users are in the same environment these should be represented in a way that matches the situation. Avatars can create immersion if the user's movements are aligned with the avatar. They can also be harmful if they are too real, what is known as uncanny valley or if the user believes that their virtual body is their own (Jamie, 2017).

2.3.7 Accessibility of VR

Virtual reality can be both a useful tool for some people but a difficult obstacle for others. When developing VR experiences one needs to proactively consider cognitive and physical variations for the experience to be as accessible as possible and avoid having to fix it later.

For people with mobility impairments VR can open up opportunities previously hindered by physical barriers. However, some mobility impairments also include difficulty with precision and can make it difficult to click on small targets. Tools that can help are focus indicators, showing what element is in focus, and multiple input possibilities, increasing the accessibility (The University of Melbourne, n.d.).

Virtual environments can be helpful for people with cognitive impairments as it can act as a mediating object for communication, learning and focus. Cognitive impairments can make it difficult to learn new interfaces and master new skills. The virtual environment can also cause seizures if it contains flashing or moving elements. To ease the usage, the user should be given time to learn the interface which should be designed to support the user and guide if an error occurs (The University of Melbourne, n.d.).

A majority of the virtual environments being created today heavily rely on visual cues. When developing a VR experience it is important to consider if people with visual impairments will use it. People with low vision may experience difficulties with identifying and perceiving static or dynamic elements. Elements that are important to see or read should have sufficient contrast against the background and users should be able to increase the size of elements such as text. For users that can not read text, it can be a good idea to include verbal descriptions of elements in order for them to be able to navigate in the environment (The University of Melbourne, n.d.).

People with hearing impairments will be able to perceive the visual cues of an interface but virtual experiences can include many audible cues as well. For these users, the virtual environment needs to contain visual or haptic elements that replace the audible cues (The University of Melbourne, n.d.).

2.3.8 Health guidelines

Since the hardware is in direct contact with the user's skin, including both hands and the face region, it is important to keep the hardware clean. The hardware will have to withstand sweat, dirt and natural oil from the user's hands and face. Therefore it is important to apply general health guidelines to the use of VR. Before use, it is important that the user has washed their hands to minimize the risk of contaminating the surface when using the hardware (PrecisionOS, 2020).

It is recommended that the hardware that is used can withstand being wiped or cleaned off with anti-bacterial cleaning agents in between uses. One can also consider using disposable protection that is mounted on all the surfaces that touch the user's skin. It is also argued, from a health perspective, to not use VR for a longer period than 60 minutes, and to have a break between sessions for at least 10-15 minutes (Gromala, 2018). As earlier mentioned it has been argued that VR usage should be held under 20 minutes to minimize the risk of physical symptoms. If the HMD is going to be wiped with cleaning agents consisting of alcohol it may be an idea not to do so too often. Different users have different skin and alcohol may cause irritation to skin or eyes. HMDs are usually not designed to resist such strong agents which may cause damage to the hardware itself (HTCVive, 2016).

2.4 Design

Different theories can increase the likelihood of creating a useful and user-friendly product. In this chapter theory about what design aspects need to be taken into consideration will be presented.

2.4.1 Usability

According to the International Organization for Standardization (ISO, 2018) usability is defined as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".

When creating an interface and aim for high usability, one should also take the utility into consideration to create a useful solution. Usability is the knowledge and implementation of how the interface should visually look as well as how the UI should be formed in order to create an understanding of how the product should be interacted with. Utility addresses the different functions that are overall needed, the functions that are needed to use the product. By combining usability and utility the solution will achieve higher usefulness (Interaction Design, 2018).

Jordan's five Components of Usability

To achieve high usability Jordan (2002) defines five components of usability to guide a designer. These are; guessability, learnability, experienced user performance, system potential and re-usability. Guessability is associated with the first time a user is using a product and attempts to solve a task. It is a measure of the cost to perform the task for the first time and the cost can be in terms of time resources or errors made. Learnability is associated with continuous or recurrent use and how well the user can learn how to perform the wanted task. Experienced User Performance is associated with users continuously using the product and not losing their efficiency in performing a task. System potential is the minimum level of actions that one has to perform in order to complete a task. Re-usability indicates the ability to return to a product and redo the task that has previously been achieved through the product (Jordan, 2002).

Jordan's ten Principles of Usable Design

Jordan (2002) defines ten principles that are usable when designing an interface. The ten Principles of Usable Design are; consistency, compatibility, consideration of user resources, feedback, error prevention and recovery, user control, visual clarity, prioritization of functionality and information, appropriate transfer of technology and explicitness (Jordan, 2002).

If a product has a high consistency it implies that similar tasks within the product are performed in a similar way. Compatibility is similar to consistency in the way that compatibility aims for a user to recognize functions from other known products. High compatibility implies that the product follows common knowledge and user expectations that are present or derived from other products. Consideration of user resources aims to not overload the user's senses and functionality. Feedback means sending clear feedback to the user, creating awareness of actions performed (Jordan, 2002).

Error prevention and recovery aim for the product to enable the user to easily recover when errors occur. User control signifies giving the user as much control as possible or the feeling of having control. Visual clarity encourages information to be displayed in a way that eases the reading of information. Prioritization of functionality and information is similar to visual clarity by creating a natural way of taking up information based on the hierarchy (Jordan, 2002).

Appropriate transfer of technology implies using present technology and functions in other products that have the potential to benefit the user. Explicitness implies that the design of the product is clear in the way it should be operated with. The product should give cues to create an understanding of how it should be operated to increase the explicitness (Jordan, 2002).

Norman's five Principles of Usable Design

Norman (2013) has developed five principles based on the psychology of artifacts to achieve high usability in a product. The five principles are; mental models, affordances, constraints, mapping and knowledge in the world/knowledge in the head.

Mental models aim to create an understanding of how the user will perceive the product, based on the mental model of the designer. The purpose of mental models is for the product to be coherent to the user's perception. Affordances aim to guide the user on how to use elements within the product. By doing so, the user will naturally perform the action that is needed (Norman, 2013).

Constraints aim for the user to limit the user choices and combinations to ease a correct use. Physical constraints imply physical limitations to ease a correct use. Cultural constraints are based on cultural behaviors and norms. There are also semantic and logical constraints. Semantic constraints rely on the meaning of the situation to increase the control of the different operations that can be performed. Logical constraints are based on the logical knowledge of a process (Norman, 2013).

Mapping is a theory of the placement of different elements to create visual groups and connections. Knowledge in the world is a theory of using external knowledge that is known by the public. This implies creating a product whose intended usage is clear and known thanks to including knowledge that is already present. Knowledge in the head is the knowledge that the specific user may have, that is not known by the world. To import functions that are known by the head, the user, it is important to know who the user is and what knowledge can be imported (Norman, 2013).

Gulf of Execution and Gulf of Evaluation

Gulf of execution is defined as when a user has a goal and tries to evaluate how to perform the action in order to achieve the goal. In other words the difficulty to translate a mental goal into physical action. Gulf of evaluation is when an action has been performed and the user is trying to evaluate what actually happened. In other words, the difficulty in evaluating the product's response and whether it is consistent with the aim (Norman, 2013).

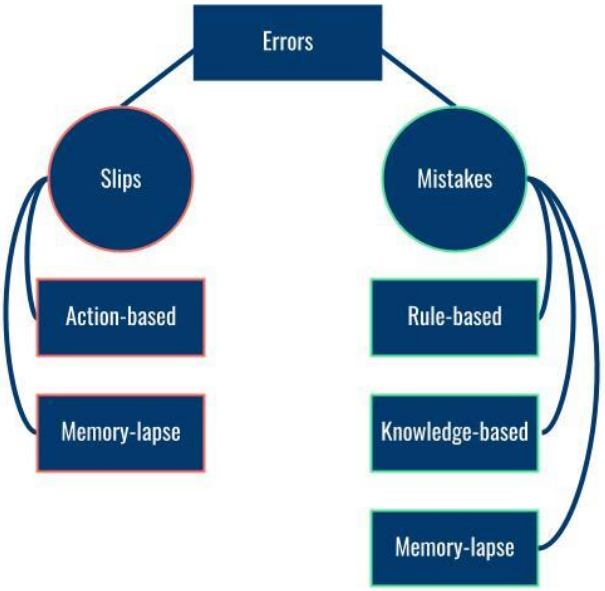


Figure 2.8 Categorization of human errors.

User errors can be categorized into two different types: slips and mistakes, see Figure 2.8. A slip is when the user aims to do one thing but ends up doing something else. In other words, the action that is executed is not the same action as the one that was planned. Slips are further divided into two categories; action-based and memory-based. Action-based slips are when the action performed is wrong in itself or wrong by completing the wrong object. Memory-based slips are actions that are forgotten due to a lack of memory (Norman, 2013).

Mistakes occur when one aims for the wrong goal or the wrong plan of action. From that part on, every step going further will increase the mistakes made. There are three categories of mistakes; rule-based, knowledge-based and memory-lapse mistakes. If a rule-based mistake is made, the user has rightfully analyzed the problem but has chosen to follow a rule that is not correct for the problem intended. A knowledge-based mistake is made when the problem is wrongfully analyzed, which may be caused by a lack of or incorrect knowledge. Memory-lapse mistakes are mistakes made due to the user forgetting one of the stages needed to complete a task (Norman, 2013).

2.4.2 Human information processing

Cognitive ergonomics is the knowledge of designing a solution that is adapted for the users ability and limitations. The challenge within cognitive ergonomics is to produce a user interaction that is well formed based on how users interpret and process information. By including knowledge of cognitive ergonomics the solution has a higher likelihood of improving the work performance as well as increasing the user experience (RISE, n.d.).

By implementing aspects regarding cognitive ergonomics the designer needs to keep three attributes in mind. It is important that the designer understands how the design and the

process for design may influence the user behaviour. It is also important to include the psychological and cognitive process that the user will perform and support it through design. The third aspect to keep in mind is to create awareness regarding the impact that the solution will have in the form of health and safety towards both the user and the environment (McLeod, 2015).

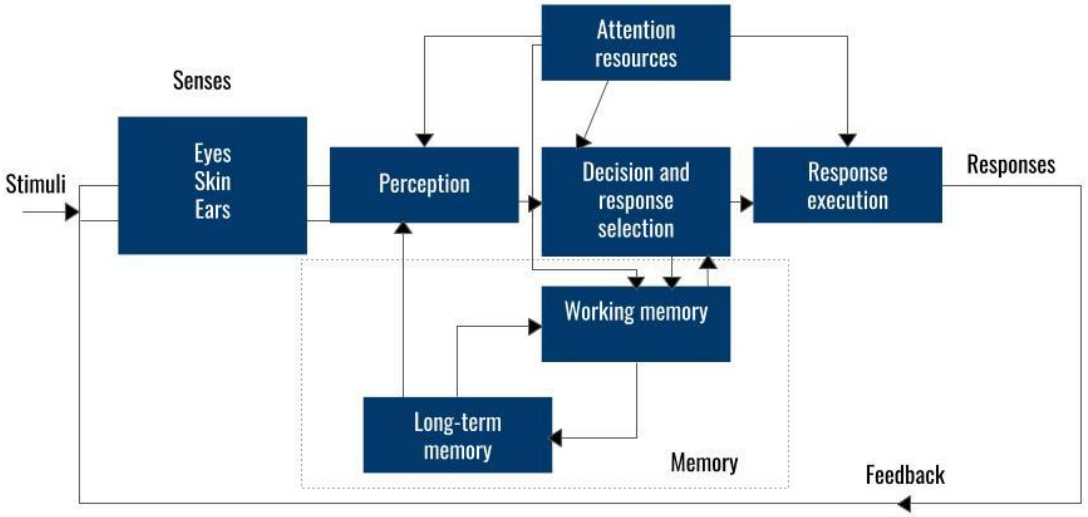


Figure 2.9 Wickens model of human information.

Wickens (2012) models the human information processing stages, describing the mental operations as humans perform tasks, see Figure 2.9 (Wickens et al., 2012).

Stimuli

Information from the environment acts as stimuli and is first taken in by the senses through our sensory organs. The basic human senses are sight, hearing, smell, taste and touch. The visual sense is the most dominant one and is responsible for about 80 % of the information humans take in. The visual sense is completed by the auditory sense. The haptic sense is used to explore the environment close by. If multiple senses are stimulated at the same time it is called multimodality. Humans are able to turn off the visual sense but the auditory sense is always receiving information. The human senses can also work together and create congruence or work against each other and create incongruence. When designing for stimuli it is important to consider the length of exposure, contrast to other stimuli and the correlation of multiple senses (Wickens et al., 2012).

Attention

The attention steers the focus but resources are limited. Attention can be divided into selective attention, focused attention, shared attention and vigilance. It's affected by factors like expectations, needs and memory. Attention can both direct focus on stimuli or shut them out. If a stimulus is constant it is given less attention than stimuli that stand out. Stimuli are harder to tell apart when they activate the same processes and demand the same

response. How fast stimuli is found depends on sample size, peculiarity and experience (Wickens et al., 2012).

Perception

Human perception gives the sensory stimuli meaning. Selection and interpretation depend on internal factors relating to the human and external factors which are related to the stimuli. Pattern recognition can help to organize individual units into one whole. The Gestalt principles are useful when designing for perception, see Figure 2.10. Affordances can guide the user to correct use through clues. All humans perceive stimuli in different ways and therefore each user will be unique (Wickens et al., 2012).

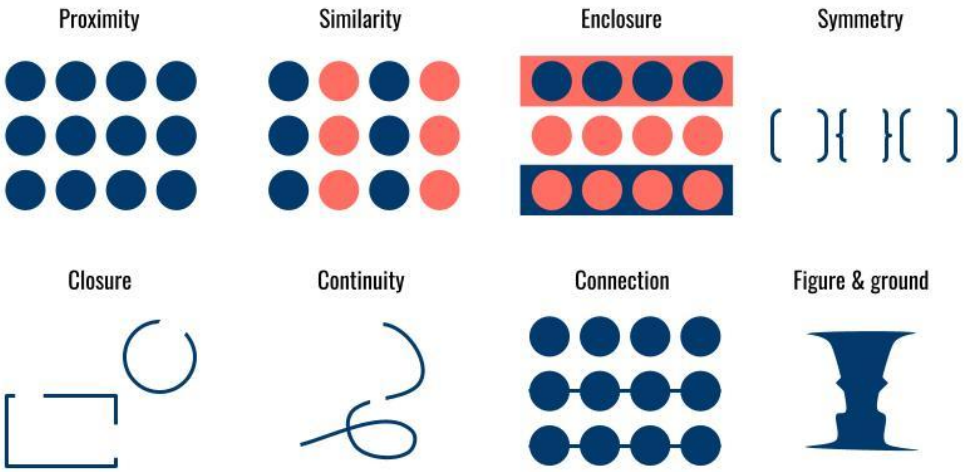


Figure 2.10 The Gestalt principles.

Memory

Human memory allows the ability to store and recover information. In order to recover the memories a retrieval procedure must happen (Chen & Jones, 2010). Memory is divided into three types; sensory memory, working memory and long-term memory. They help to interpret and recognize information. Sensory memory stores the stimuli from the environment for about 0.1-5 seconds. The sensory information then goes through perception before going into the working memory (Wickens et al., 2012).

Working memory is also called short-term memory where information is temporarily stored for a short time, maximum of 30 seconds. Repetition and the emotions of the user can affect the capacity. Information to the working memory can both come from the sensory memory and the long-term memory. When designing for the working memory it is important to not overload with information or force the user to remember too much information. Most of the information is sorted out permanently but a part of it goes into long-term memory through encoding. The information in the working memory needs to be stored for at least 5-10 seconds and divided into small groups for the encoding to be effective. How efficient the encoding is depends on age and external stresses (Wickens et al., 2012).

The information is encoded into the long-term memory through learning and training and is stored uniquely in each user. Once the information has been stored it will stay there for life (Wickens et al., 2012). There are two main categories within long-term memory. These are procedural memory (also called implicit memory) and declarative memory. Implicit memory defines memories that do not require any significant mental effort to retrieve. Motor skill or any skill that is well trained can be defined as implicit memory. Since implicit memory often is recovered automatically it is difficult for the person to explain why one does or reacts accordingly. Declarative memory is all explicit knowledge. It requires encoding by the brain to store and an effective retrieval process to be able to be recovered. Most memory issues are often found amongst declarative memories (Chen & Jones, 2010).

Recall and recognition are used when retrieving information. Recall refers to the production of information stored in long-term memory and relies on the knowledge of the user. Recognition means that the user needs to decide if the information matches with what is stored in long-term memory relying on the user's knowledge of the world. Mistakes can be made when retrieving information caused by insufficient clues or too much time passed. If the information that is going to be stored is too similar to the information already stored in long-term memory it can also cause interferences. When encoding information visual material can be stored as both visual and verbal information which increases the chance of a correct retrieval to maintain the skill (Wickens et al., 2012).

Selection and execution

Decisions and the response selection acts as awareness and response execution corresponds to how humans act based on their decision making. The action results in feedback for the system that becomes new stimuli. Performance factors that affect the use can be both internal and external. Internal factors are divided into physical conditions like age, sight and fitness level as well as mental conditions like personality, behavior and motivation. External factors can both be latent like the use of environment, leadership and rewards as well as operational factors like instructions, tools and methods. Stressors also affect performance. Psychological stressors can be high workload, threats and risks while physiological stressors can be exhaustion, pain or lack of sleep (Wickens et al., 2012).

Normative decision-making refers to getting the most out of something for the least amount of costs. This is done by listing and weighing the important factors. Descriptive decision making on the other hand means that a decision is made based on access to resources which results in a satisfying decision that may not be optimally produced. Naturalistic decision-making refers to how experts make decisions in demanding situations based on recognition (Wickens et al., 2012).

How the users then act can be divided into three awareness levels. The first is actions without any active awareness which are routine actions like opening a door or walking. The second level is actions based on rules and knowledge like using a computer program. The third level is actions that demand high awareness due to new or unknown situations (Wickens et al., 2012).

2.4.3 Physical ergonomics

Stress injuries can be caused by biological factors like illnesses, muscle strength, physical impairments or age. It can also be caused by factors in the working environment like heavy loads, repetitive tasks or stress. When the body is exposed to external static, dynamic or transient load it will cause internal stress (Bohgard et al., 2015).

The back, neck, shoulders and hands

The movements in the spine are flexion, extension, rotation, lateral flexion, compression, tension and shear. The back can get fatigued from too much static work, repetitive tasks and heavy loads. The back loses its ability to manage loads when the spine is rotated or bent (Bohgard et al., 2015).

The neck's function is to support the head on the spine and is typically very exposed to strain. The neck can be injured by rotating or bending it forwards or backward. The shoulders are functionally connected to the neck and are also a common area for pain and injuries. Negative effects in the shoulders can be caused by forward rolled shoulders, held tension and frequent work above shoulder height or with extended arms. The neck and shoulders are also more likely to get injured if movements are too rapid or are exposed to heavy loads. To prevent injuries in the neck and shoulders the users shall keep their hands in line with the waist and close to the body, when possible support shall be provided for the arms (Bohgard et al., 2015).

The hands are gripping tools but are sensitive to touch, temperature and pressure. The force and precision vary with different types of grips. Affecting factors to consider are the individual work methods, variation of tasks, needed precision or force and the work environment. A good tool should enable use with a straight wrist and should fit the user's hands (Bohgard et al., 2015).

To prevent physical injuries during work, static and repetitive tasks should be avoided. The tasks should also be adaptable to the needs of each individual of different ages, sizes and abilities. Ideally, the tasks should allow the body to be in a natural position; keeping the S-shape of the spine and the natural grip of the hands while keeping the neck, wrists, hands, and back straight. Any load should be kept symmetrical and act on the muscles instead of ligaments and joints (Bohgard et al., 2015).

The eyes

In order to understand how the human vision is affected depending on different attributes, it is important to partly understand the anatomy of the human eye. The lens changes shape depending on the distance between the eye and the object in focus. The lens is an adjustable part of the eye that tends to get stiff with age. This is partly a reason why people, as they get older, find that they need to get reading glasses (1177 Vårdguiden, 2019). The pupil regulates the amount of light that enters the eyes. When the lighting is bright the pupil contracts and in poor lighting the pupil expands. Therefore the depth of field increases with better lighting as

the vision is more focused. For comfortable viewing, the display should be accessible with a straight neck and the eyes in a position lower than horizontal. Non-important objects should also be avoided close to the display that can cause misdirected focus and blurring of important distant objects (Bridger, 2009). Humans have a field of vision of 150° horizontally and 120° vertically, but only 5° make up the field of vision that is good enough for demanding tasks. This field of 5° corresponds to what the eyes are focusing on (Forensic Architecture, 2020).

Biological variations

The ideal age for physical performance is between 20-25. Thereafter lots of physical factors like muscle strength, sight, hearing and joint mobility typically degrade. Although the changes are very small up to the age of 40. As humans age their skills and experience increase but their physical capacity and their tolerance level decrease (Bohgard et al., 2015).

2.4.4 Design for experience

An experience is developed from the assimilation of motivation, action, perception and cognition. An action is in multiple theories connected to thoughts and emotions and is affected by them. An experience is not about the technology but rather about building a meaningful experience for the user through a product. It is about the degree of meaning we connect to the product and the usage (Hassenzahl, 2011).

Usability is an important aspect to consider when designing a product but so is enjoyability and whether the user experiences it with a product. This aspect has changed the way of measuring the user experience of products. Perceived usefulness is an aspect that does not always create a good product, for instance in websites for entertainment. It has been shown that the experience of a product is what is communicated from users to potential future users. Therefore the experience of a product may set the behavior of the future user towards the product (Kujala, et al., 2011).

Attraction towards a product has been shown to relate to user satisfaction as well as fulfilled user expectations and willingness to recommend the product to other users. However, the attractiveness and user experience are related to the users' characteristics and may differ from user to user. It is important to design the experience in relation to the users' characteristics (Kujala, et al., 2011).

When creating a product it is important to take the users' cognitive characteristics into consideration. The end user's characteristics should be a guide for design choices. This will also affect the attitude towards the product. Creating a solution that the user does not have prerequisites for, creates negative emotions, such as annoyance and dissatisfaction (Jordan, 2002).

Defining what emotions are has been an ongoing discussion. Emotions are evoked by stimulus events, referring to something that happens that stimulates or triggers an emotional reaction. This may be external factors or internal factors, such as the behavior of others or the behavior of oneself. The evoked emotions will be affected by the design choices (Scherer, 2005).

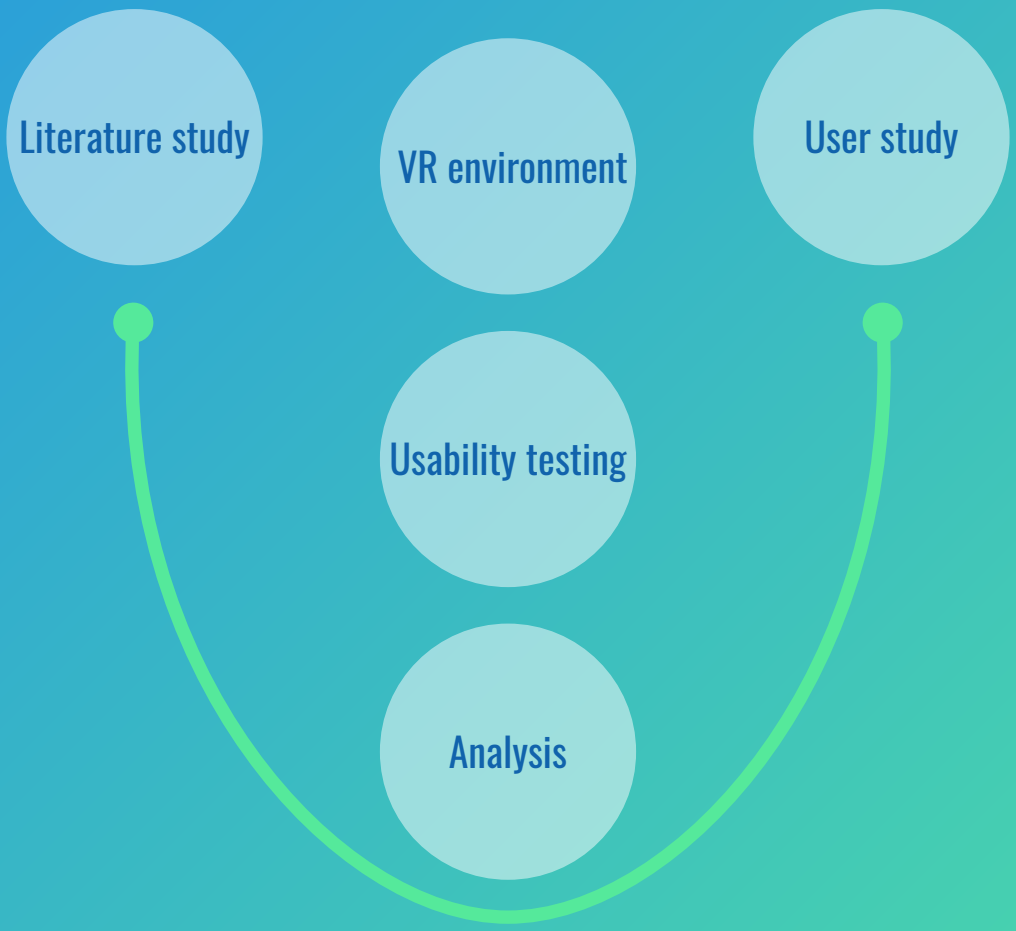
2.4.5 Graphical user interface

When designing a digital interface it is important to consider the readability of the text to avoid eye strain and use errors. The highest readability is reached by using dark colors like black or dark blue for texts together with cool and desaturated backgrounds. The best combination is therefore black text on white background. The opposite use of color, white text on a black background, will have low readability as the background will overpower the text which will appear blurry. Also, avoid combining vibrant colors as they will create a vibrating effect and very low readability, although they may have sufficient contrast (Nielsen & Loranger, 2006).

Around 8 percent of men and 0.5 percent of women have some sort of color blindness. This prevents users from perceiving the difference between certain colors. Red-green color blindness, deuteranopia, is the most common one and means that it is difficult to differentiate colors that contain red and green. When designing a graphical user interface (GUI) it is a good idea to use black and white when possible. Otherwise one can quickly check if the contrast is good enough by viewing the interface in grayscale. Another way of helping users with color blindness is to use additional cues other than color, like shape or motion (Nielsen & Loranger, 2006).

3. Process

This chapter will present the used methodologies and how they were implemented during the project.



3.1 Literature study

There are two types of data that can be collected; quantitative and qualitative data. Quantitative data has the ability to give a clear index by which decisions that will give more effect. Qualitative data has the ability to give richer descriptive data (Jordan, 2002).

The aim of the literature study was to gain information about similar projects as well as gain more knowledge of the specific areas involved in the project. The literature study was based on three main categories; VR, Courts in Sweden and VR in courtrooms, see Chapter 2. Theory.

3.2 User study

A user study was conducted to gain more knowledge from the users within the Swedish courts and the future users of VR. The aim of the user study was to involve and to create a result that would match according to the future users.

3.2.1 Methodologies

When designing the user study multiple methods were used to achieve a good result. The forthcoming part will describe the methods.

User sampling method

When conducting a user study it is important to have a representative user sample. In order to create a representative sample one has to consider three different aspects; sampling methodology, sample size and response rate (Janhager, 2005).

The user can be divided into four categories: primary user, secondary user, co-user and side user. The primary user is the user that is interacting with the machine and using it for its actual purpose. The secondary user is a user that is using the machine but not for its primary use such as maintenance or reparations. A co-user is a user that collaborates with the primary or secondary user which can be someone that sets up the technology. A side user is a person that is affected by the product, in both positive or negative ways, but cannot directly affect the use of the machine (Janhager, 2005).

Sampling methodology is divided into two categories, probability sample and non-probability sample. A probability sample consists of six different methods that all use a random process, stratified random sampling is one of them. Stratified random sampling is a random process within a set of common characteristics. The characteristics can be different aspects such as age, income, education or profession. Non-probability sampling consists of three different methods, convenience sampling is one. This method is based on choosing users that are found suitable and are strongly influenced by who is found and if it is difficult to find a broad group of members (Acharya et al., 2013).

Interviews

The aim of conducting interviews is to gain qualitative information about the users by gaining knowledge of how users think and reason. Each interview will be affected by the interviewee's personal thoughts and preferences. Interviews can take three different forms; structured, semi-structured and unstructured. A structured interview has set questions and the one interviewing should not ask any other questions than the ones that are pre-decided. A semi-structured template of an interview has set questions that should be asked, but one may also ask additional questions depending on what one finds interesting, this is called probing. An unstructured template gives the interviewer the possibility to freely discuss a specific theme (Wikberg Nilsson et al., 2015).

Structured interviews are effective when specific responses on options are wanted. Semi-structured interviews are effective when there is a clearer picture of what is wanted to obtain. Unstructured interviews are an effective tool to use when the outcome is unknown and the result can guide into what should be investigated (Jordan, 2002).

Surveys

The aim of conducting surveys is to gain quantitative information about specific information or subjects. When creating a survey it is important to define what the purpose of the survey is and what findings that one wants to gain from it. Thereafter the questionnaire should be formed to fulfill the purpose (QuestionPro, n.d.).

Questionnaires can be divided into two groups; fixed-response and open-response questionnaires. Open-response questions are useful for when the response is unknown and when the important factors are unknown. Fixed-response questions are effective when there are different options and the participants' thoughts on what is best is wanted (Jordan, 2002).

Observation

The aim of conducting observations is to get a better knowledge of the environment as well as the usage. When conducting an observation it is important to keep the focus high, especially if the observation is done without specific points to observe. When observing one should focus on the behavior of the people included in the environment observed, as well as the actions that are taken. It is important to consider the time and day that the observation should be conducted, since this may affect the results (Wikberg-Nilsson, Törlind & Ericson, 2015).

3.2.2 Implementation

The user study was designed based on previous methods that have been defined. The forthcoming part will describe the implementation of the methods in the project.

Defining the user

The user in this study is defined as every person that is either associated with or is present during a judicial process in Swedish courts. This includes all the participants within the courtroom such as lay judges, prosecutors, lawyers, the defendant and the victim as well as the public.

Interviews

In total 15 interviews were conducted with four different categories of users early in the project. The participants were lay judges, prosecutors, defense attorneys and witness support, see table 3.1. Each interview template was formed for each category of user to maximize the insights, see Appendix A.

Table 3.1 Participants in the interviews.

Nr.	Role	Media
#1	Lay judge	Zoom
#2	Lay judge	Zoom
#3	Prosecutor	Phone
#4	Defense attorney	Phone
#5	Lay judge	Zoom
#6	Lay judge	Zoom
#7	Lay judge	Teams
#8	Prosecutor	Phone
#9	Witness support	Zoom
#10	Prosecutor	Phone
#11	Prosecutor	Phone
#12	Prosecutor	Phone
#13	Defense attorney	Teams
#14	Lay judge	Zoom
#15	Prosecutor	Zoom

The interviews were all based on a semi-structured template of approximately 30 to 45 minutes length, including probing. Seven of the interviews were conducted through Zoom, six through telephone and two through Teams. Each interview started with a small intro about the project and what the purpose of the interview was. Each participant was asked for permission to record the conversation so that it could be transcribed after the interview and erased within seven days.

The templates were formed with four different sections. The first section focused on the profession and personal experience, with the aim to get a better understanding of each task that the different users have. The second section focused on personal thoughts on trials, likings and dislikings. The third section focused on the advantages and disadvantages of different types of evidence and the last section focused on the potential of and attitude towards VR.

All interviewees were contacted through email. The sampling method of the prosecutors and defense attorneys was based on convenience sampling, whereas all the prosecutors and defense attorneys whose contact information could be found, were emailed. The sampling method for the lay judges was through stratified random sampling. An email was sent to a joint email to a specific district court. All participants were active in the Swedish court system.

Survey

Throughout the project, two surveys were conducted. Each survey had its own purpose. Quite early in the project, a survey was conducted to find the public's thoughts and preferences associated with VR and courtrooms separately, see Appendix B. The public is the user group that acts as witnesses, victims or defendants. According to the sampling theory, a convenience sampling method was used for the first survey with an attempt to randomize the participants. The survey was posted on different Swedish sites on Facebook with members that were in no way connected to the authors. Every participant decided by themselves whether or not they wanted to participate. In total 109 people participated.

Towards the end of the project, another survey was conducted with the aim to gain final opinions and insights from the users, see Appendix D The survey involved questions regarding different use areas found during the project. Questions about the implementation of virtual reality within each use area were asked. The survey was sent separately to witness support from the rest of the users. The surveys had a total of 33 participants. Participants with different roles within the court were included and these participants either were and/or had been one of the roles, see table 3.2.

Table 3.2 Number of participants in the survey.

Role	Amount
Lay judges	19
Attorneys	3
Prosecutors	5
Recording clerks	4
Judges	2
Administrators	1
Witness support	3
Coordinators	2

Observation

During the project, three observations were conducted in a district court in Gothenburg. Each observation was conducted in a different courtroom. The first observation was during a trial where the defendant was accused of assault. This was the biggest courtroom by size that was observed and had two rows of chairs for the public. The trial included two witness questionings and the whole trial continued for three hours. During the trial following actors were present: defendant, defense attorney, victim, counsel for an injured party, three lay judges, a recording clerk and a judge. There were three people present from the public. The prosecutor attended through Zoom.

The second observation was during a trial where the defendant was accused of a serious narcotics crime. The trial was ongoing for multiple days with multiple witnesses. Statement of facts was presented during the first day. The defendant in this trial was a detained person. The project group was only present during the first four hours of the first day. The courtroom was a standard-size courtroom and only had one row of chairs for the public. The statements of facts included information on interception and surveillance as well as information gathered from the cracked code of EncroChat. During the trial following actors were present: defendant, defense attorney, two employees from the correctional treatment, prosecutor and a police employee as help, three lay judges, a recording clerk and a judge.

The third observation was conducted in an empty courtroom, see Figure 3.1-3.5. The courtroom was similar in size to the second observation. The third observation took one hour and consisted of taking measurements and noting down details of the courtroom. Pictures and videos were taken of the room.

Figure 3.1 The courtroom.

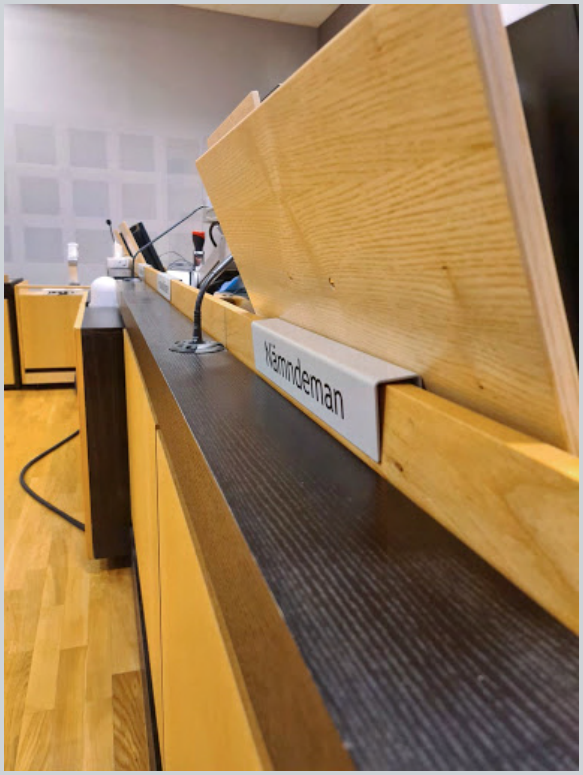


Figure 3.2 Signs for seating.

Figure 3.3 The judge's table.

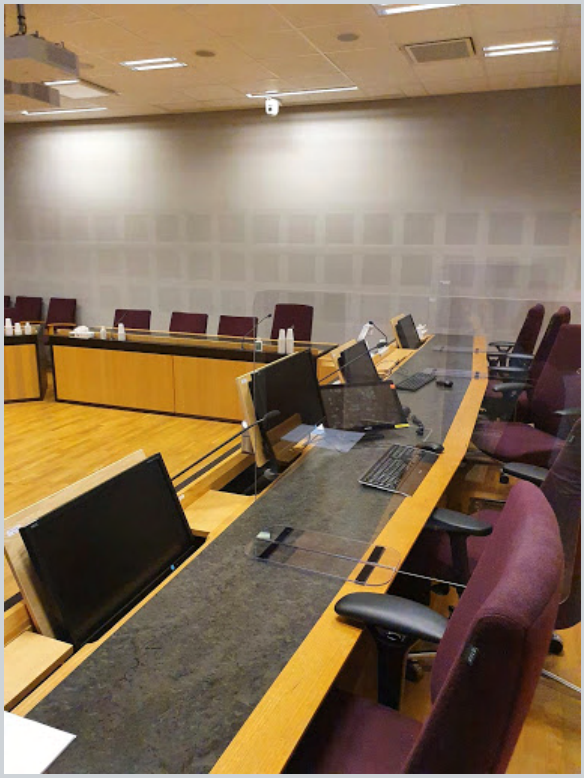


Figure 3.4 The judge's table.

Figure 3.5 The witness table.

3.3 Developing VR environment

The aim of the VR environment was to create an environment that could be used in the usability tests. The model was created for the purpose to test the pre-trial support perspective and evaluate from a usability perspective. The forthcoming part will describe how it was created in this project.

3.3.1 Methodologies

To create a fully immersive virtual environment with objects, software will be needed. Objects, furniture and details can be created through Blender, 3ds Max, Maya or Cinema 4D. The different software differs in the complexity of learning but also the time needed for each object. Maya and 3ds Max are the most time-consuming but standard in higher quality creation. Blender however is easier to learn and is a beginner-friendly choice that is a free software (Altexsoft, 2018).

A game engine is required to create an interactive virtual environment. The main engines available for use today are Unity (n.d.), Unreal Engine (n.d.) and CryEngine (n.d.). Unity uses C# scripting language for writing commands within the game or environment created whereas Unreal Engine and CryEngine use C++. Unreal Engine also provides an alternative scripting language called Blueprints Visual Scripting, enabling developers without scripting knowledge to create environments and interactions (Altexsoft, 2018).

3.3.2 Implementation

Unreal Engine 4.25.4 was used to create the 3D model for VR. From the measurements taken inside the courtroom in Gothenburg furniture and details were created in Blender and imported to Unreal as FBX models. The 3D model was made to imitate the real courtroom taking material, placement and appearance into consideration.

The materials were created in Unreal, either by importing the materials from Blender and refining them, importing materials from Quixel Bridge (n.d.) or creating new materials. Once all the furniture and equipment were imported and placed correctly according to the original room, lights were imported. The furniture and all objects were set to allow the user to walk on the surface that the furniture stood on, otherwise the user would be very limited to small pieces of walking areas.

Lastly GUI was made to instruct the user of the VR environment and how to use it. The non-diegetic GUI was made in Illustrator and imported into Unreal as JPG. The instructions were made in Swedish since the environment is made for use in Swedish courts. Diegetic GUI was also placed inside of the environment for the user to exit the courtroom and go back to the main menu.

3.4 Usability testing

The aim of the usability testing was to try different methods to move around in the environment and see what was most suitable to use. It also tested how well the users would understand the environment with no help from other people.

3.4.1 Methodologies

When designing the usability tests, multiple methods were used to achieve a good result. The forthcoming part will describe the methods.

Thinking aloud method

In order to understand what is going on inside the (test-person's) head the participant can be asked to think aloud while conducting the test. This implies urging the participant to think aloud about the things that pop up in their head during the test. During a think-aloud session the investigator may ask further questions to gain more knowledge of the participant's thoughts. To be successful with the thinking aloud method, the participant will have to have a task to complete. The downside of the thinking aloud method is that the participant in one way is asked to perform two tasks, both the task from the test, but also to constantly communicate their thoughts. It is also important to consider the risk of the participants rationalizing their choices as they are talking through the procedure, and therefore thinking the process through more than they would otherwise (Jordan, 2002).

Hesselgren's emotional scale

Hesselgren's emotional scale is based on Hesselgren's Semantic Differential scales that measure the intensity of emotion felt in regards to an experience or product. The scale includes the basic emotions which are; expectation, surprise, joy, sorrow, disgust, fear, anger and liking. Each emotion has a scale of 0 to 5 measuring the intensity of the emotion, where 0 equals the feeling not being felt at all. The scale must be applied in regards to a product or experience to achieve a usable result as well as express emotions that are usable for the product or experience (Uzzel & Romice, 2003).

Semantic differential scale

A semantic differential scale is a scale that includes bipolar adjectives in a scale. The size of the scale is up for the designer to decide but the most common is having the size of five or seven. The semantic words can differ, depending on what the designer includes (Garland, 1990).

Scenario-based questions

Using scenarios for questions helps the participant to be involved with the situation and reflect on their actions. By creating empathy from the participant they will react based on

their intention and motivation (Rosson & Carrol, 2007). Scenario-based questions are a good tool to engage users in the test and enhance their realistic behavior. The tasks must be realistic, actionable and not give the user any clues or describing steps (McCloskey, 2014).

Test participant sample

Multiple authors have published studies saying that most usability problems are identified after five participants in the tests (Virzi, 1992; Nielsen & Landauer, 1993; Lewis, 1994). To collect the right data it is important to include participants that match the target audience or users. The participants should have similar characteristics to the target user. Right characteristics refer to the characteristics of users that may play a part in the usability of the product (Kantner, 1994).

3.4.2 Implementation

The usability tests were designed based on previous methods that have been defined. The forthcoming part will describe the implementation of the methods in the project.

In total 11 participants were included in the test, see Table 3.3. The attributes and characteristics that were important to look for were whether the participant had been in a Swedish court and if they had tried VR before. 2 out of 11 had been present in a court before whereas 9 out of 11 had not. 3 out of 11 had tested VR before and 8 out of 11 had not. All three participants had tried VR through a phone and have therefore never tested VR equipment including controllers.

Table 3.3 The participants of the usability test.

Participant	Experience of VR	Experience of trials	Impairments
#1	None	None	Visual impairments
#2	VR for phone	None	Visual impairments
#3	VR for phone	None	Visual impairments
#4	None	Injured party	Visual and auditory impairments
#5	VR for phone	Study visit	Visual impairments
#6	None	None	Visual impairments
#7	None	None	Visual, auditory and physical impairments
#8	None	None	Auditory impairments
#9	None	None	None
#10	None	None	Visual impairments
#11	None	None	Visual and auditory impairments

Setup

Due to complications with the model, the usability tests could not be done independently on the Oculus Quest but had to be connected to the program via a laptop. All tests were therefore conducted through the play function on Unreal Engine, playing the model through a USB cable connecting the headset to the laptop. Due to this setup, the users had to sit in a stationary location, see Figure 3.6. The participants were video recorded by a camera being attached to a tripod located approximately 1,5-2 m away from the participant. The test involved equipment such as; a laptop, an HMD, a USB to USB-C cable, a chair, a tripod and a camera.

Figure 3.6 Usability test setup.

The set-up was similar in every test. The laptop was placed on a table facing away from the participant, with the USB connector facing towards the participant. The headset and controllers were placed on the table in front of the participant. Three of the test participants had a swivel chair, while the rest participants had a chair with stationary legs.

Performing tests

Before initiating the test all participants got an explanation that the test evaluated the environment that had been created, and not them. They were all asked to think aloud when conducting all parts of the test, even the surveys. They were asked for the right to record the part of them being equipped in VR equipment and to take notes during the surveys, so that analysis could be done at a later stage. They got an assigned number so that the results of the surveys and the test in VR could be analyzed against each other. Thoughts and

comments that were said during the surveys were noted down. Comments during the VR-test were recorded and noted down later.

The participants were asked to answer a survey before the part of the test within the VR environment, see Appendix F. The questions were asking how familiar the participants were with Swedish courts as well as with Virtual Reality equipment. They got scenarios for witnessing in trials and were asked the likelihood that they would ask for support in these. Lastly, they were asked to mark present symptoms and if they have any visual, auditory, cognitive or physical impairments.

Once the pre-survey was answered the participants were presented with a scenario, see Table 3.4, and were asked to put on the headset and follow the instructions. Thereafter all assignments the participants were asked to perform were presented as scenarios. The fifth and ninth task had predetermined levels of help since they were found to have a need for help in the pre-analysis of the test. They both had four levels of help, and if the user after four clues still was not able to complete the task, they were shown how to and the task was marked as incomplete.

Table 3.4 Scenario-based tasks during the test.

Order	Given scenario-based task	Real task
1	Could you begin the usage?	Follow the instructions by both reading and executing the actions.
2	Show me where you would be seated?	Enter the witness-environment by choosing “Jag är vittne”.
3	In case of fire, do you know where you can exit the room?	Point at any of the four doors.
4	Your friend is going to the trial with you, where will they be seated?	Point to where the audience is seated.
5	Are there other perspectives for you to view the environment? - Help 1: Can you exit the environment? - Help 2: Is there anything close by that indicates that you can exit the environment? - Help 3: Is there a button close by? - Help 4: Can you press the menu-button?	Exit the environment by pressing the “MENY” button, go back to the menu.
6	Now you want to explore the courtroom and see what it looks like from the judges table.	Enter the environment “Utforska rättssal”.
7	Now you want to explore the courtroom and see what it looks like from the judges table.	Move to the judge’s table and rotate.
8	Who is seated at the judges table?	Find who is seated at the judge’s table by reading the signs.
9	Where were you as a witness supposed to be seated?	Point to where you as a witness would be seated.
10	Could you now leave the room? - Help 1: Can you exit the environment? - Help 2: Is there anything close by that indicates that you can exit the environment? - Help 3: Is there a button close by? - Help 4: How would you have left the room in real life?	Go towards a door and exit the environment through the door.

The tests were designed for each participant to be exposed to an immersive virtual environment for a maximum of 20 minutes. Once this part of the test was finished the users were once more asked to complete a survey. The second survey aimed to gain insights into how the knowledge of Swedish courts and VR had changed after use. The users were once more asked to mark their present symptoms so that this could be compared with the results from the first survey.

The second survey had additional questions asking about the experience of the test and environment. To evaluate the experience, a semantic scale, an emotional scale and statements were used. The semantic scale included bipolar adjectives and a grade of 1 to 5 for the user to rate with regards to the experience. The wheel of emotions involved eight different emotions with grading from 0 to 5 for the users to define to what grade they felt each emotion. The statements were opinions connected to the instructions where the users were asked to define whether they agree, agree to some extent, or do not agree with each statement. In total eight statements were presented.

Health aspects

The usability study was conducted during the Covid-19 pandemic. For that reason, additional security measures were taken. The participants were seated two meters from the test leader. Only one of the project members led the test and was equipped with a facemask. There were face masks available for the participants as well, see Figure 3.7. The participants were asked to answer the surveys through their own phones. The first survey was sent to the user before the test started. When the participant was to take on the VR-equipment they were offered hand sanitizer and gloves. The equipment was thoroughly cleaned after each participant, and only participants that meet each other on a daily basis were allowed to do the test during the same day.

Figure 3.7 Some of the safety aids offered to the users before the test.

3.5 Analysis of empirical and theoretical data

The information found in the literature study, user study and usability tests were analyzed. The findings from the analyzed data could later be used as a foundation for the requirements specification as well as the guide.

3.5.1 Methodologies

When performing analysis of data multiple methods can be used to achieve a good result. The forthcoming part will describe the methods used in this project.

HTA

A Hierarchical Task Analysis (HTA) is used to analyze a task. When conducting an HTA the task is divided into smaller sub-tasks until it eventually includes all actions that are needed for the main task to be completed. All sub-tasks that are divided into further tasks have a sub-goal or an element that is achieved by conducting all the tasks connected to the divided task. The results of an HTA are most often presented in a hierarchical tree diagram (Bligård & Osvalder, 2014).

CW and PHEA

For the usability tests, Cognitive Walkthrough (CW) and Predictive Human Error Analysis (PHEA) can be used to analyze and predict errors that may or do occur. PHEA focuses on the errors that arise during use (Bligård & Osvalder, 2014).

CW is a method based on cognitive theory for predicting what choices the user may take and analyzing why. To be able to perform a CW there needs to be an understanding of who the user might be, a specific task to conduct and a list of the correct way to perform the task (Rieman, Franzke & Redmiles, 1995). CW is based on four questions that are asked for each step that the user takes when trying to conduct the task (Bligård & Osvalder, 2014).

PHEA is a good tool to use when an issue or error has been detected to find the reason behind it. It gives additional questions about the error, the reason behind it, the consequences it gives and whether it is detected and how to recover from it. If CW and PHEA are combined and used at the same time, potential errors regarding usability can be found that will not present themselves during the actual usability tests (Bohgard et. al., 2015).

KJ method

KJ method, also known as an affinity diagram, is an efficient method to group information and analyze it. The method is based on grouping information into smaller categories and thereby finding connections between different information. First, the information needs to be separated into sentences and written on separate notes. Group the notes by either set

categories or by growing categories as you go. Once all the information is divided into different categories, each category can be analyzed and findings can be exported (Plain, 2007).

Requirements specification

A requirement is something that the user needs from the product or the service. It can be a specific function, feature, quality or a principle that must be followed for the end result to be fully accepted. Requirements can be exported from all types of information. A requirements specification is a list where all requirements have been combined into one list, which may or may not consist of categories (Kulak & Guiney, 2012).

3.5.2 Implementation

The analysis was performed based on previous methods that have been defined. The forthcoming part will describe the implementation of the methods in the project.

User and literature study analysis

Findings from both the empirical and theoretical studies were analyzed with help from the KJ method, see Figure 3.8. Text from the theoretical analysis as well as material from the interviews was printed out and important quotes or statements were cut out and placed in one big pile. Once all findings were cut out, the process of categorizing was begun. To keep track of the different user groups and whether they had aligned or different opinions, each user group got assigned one color and every quote from a specific user group got a mark with the assigned color.

Figure 3.8 KJ analysis of user study and literature study.

The categories were made up with time as the quotes that fit together were gathered together. By doing so, the groups with matching quotes displayed common characteristics and specified their own category. From the KJ method categories were formed, which were later further combined.

Usability test analysis

An HTA was conducted on the specific tasks that the participants were asked to perform during the usability test, see Appendix G. CW and PHEA were conducted on the tasks to find potential issues. From each task, an analysis was made on whether it was believed that the user would perform and complete the task or not, and the cause of the problems. From the CW and PHEA additional guidelines could be found.

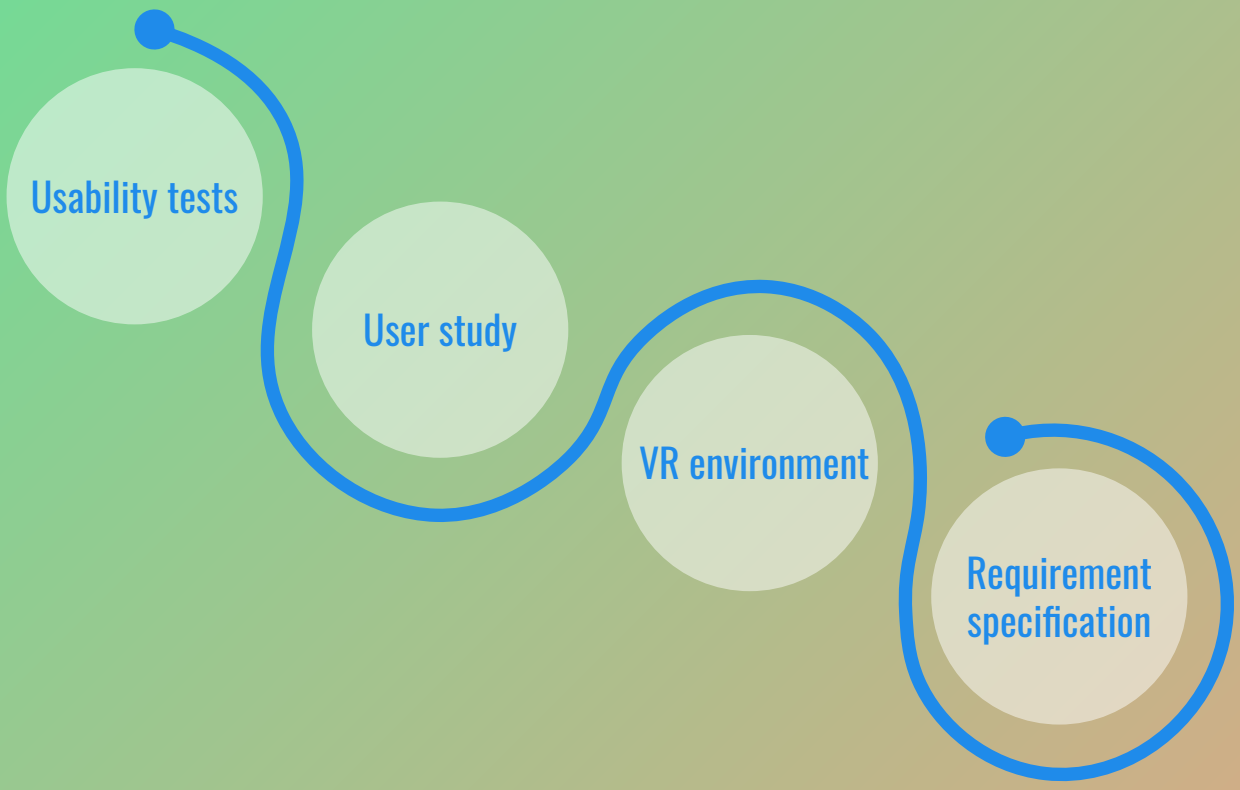
PHEA was also used on the results after the usability tests were conducted, to evaluate and analyze the problems that occurred during the tests. All errors that occurred with every participant for each task were combined together and analyzed thereafter. The tests were also analyzed of whether the participant achieved the task or not. This could later be compared to the first CW and PHEA, to see resemblance or new outcomes that were not found in the pre-analysis.

Requirement specification

From all the analyzed data, requirements were formed according to the findings in the study. Since the implementation of VR in Swedish courts has different use areas, one specification was made for general requirements, affecting all use areas, and separate specifications were made for each use area. The requirements in the general specification were categorized.

4. Results

This chapter will present the results from the implemented methodologies. The results are based on the analysis conducted on all the information given during the project



4.1 User study

From the user study that was performed findings could be analyzed. Findings were found through both a KJ analysis and observation notes.

4.1.1 Interviews

The results from the interviews were put into seven categories. They cover the user's knowledge, thoughts and feelings towards the judicial system and process today and potential change and future development with a focus on VR. Finally, the analysed data resulted in use areas for VR in Swedish courts.

Evidence value

The user study showed that the more evidence one could collect the better it was for everyone included since the evidence would play a big part in giving a good understanding of what had happened. It was also appreciated if it included different kinds of evidence such as texts and pictures since they often complemented each other. Further it was mentioned that the behavior one was showing in court could have an effect at the trial itself. The judges would often take the behaviour in consideration. It was important that one would speak with a clear and loud voice, and to face the judges while speaking since the judges would be the ones that are in need of an understanding of the incident. The judges are also those who need to interpret whether what one is saying is the truth. It is therefore important to keep everything disciplined in the courtroom, to ease for the judges to receive the information and process it.

"Something that I find important when it comes to the actual trial is order in the courtroom."
- *Lay judge*

Law and order

The results also showed that the participants had a high trust towards the Swedish judicial process and it was mentioned that if any country could implement new technology, it would be Sweden thanks to its low corruption. The trust towards NFC and technical evidence was shown to be generally high. However, there are still some aspects to be considered before implementing it. One struggle is how to separate real evidence and information from theoretical. Due to the high trust towards NFC there is a risk that the judges will interpret everything shown to be the truth and investigated facts. There are also ethical issues in what should be shown and not, and how the information may affect personal feelings.

"One can not try something for the first time without thorough investigations before."
- *Lay judge*

"A defense attorney is, of course, very biased."
- *Defense attorney*

Both parties need to be treated equally during the trial since no one is guilty until found guilty. It is important that the trial is fair and is examined from both parties' sides and stories. Use of VR should also be used beforehand, during the investigation, so that the users of VR in a trial are not first-time users as their behavior could affect the outcome of the trial. By introducing the users to VR in advance, the risk of the technology becoming a barrier will be lower.

Resources

As for resources it was often mentioned that resources and good evidence were dependent on one another. Important resources would often be time and money and had a great effect on the length of the investigation of the case. Time resources were one of the biggest challenges in having a viewing as evidence within a trial. It would be complicated to find a time suiting everyone involved but could also implicate a safety risk. Apart from financial and time resources, equipment was also mentioned as a resource that could affect the trials, depending on what equipment was present in the courtroom.

"Legal security is determined by access to resources."
- *Prosecutor*

Use-perspective

The importance of being transparent, objective and professional when handling the information or presenting the evidence was often mentioned. Everything has to be done with a certain quality to ensure a high quality trial. It was mentioned that it was difficult to keep track of all details in bigger cases, and sometimes even to differ between the different people involved. The judge and prosecutor are the ones that have the responsibility to explain difficult terms and words. It was important that they knew how to describe new information to increase the understanding of the information presented. To increase the desired characteristics in a trial it is important that the aids that are used are easy to maintain, reliable and easy to use. New technology should be used from the beginning of the pre-trial if it is to be used in the main hearing. Language differences could also be a threat to the wanted characteristics. Most importantly, everyone needed to get to partake of what was presented, and those who were to judge and discuss a sentence had to have the same experience.

"A recurring thing during the whole judicial process is that no one has enough information."
Lay judge

Emotions

It is important to take the human into consideration since it was often mentioned that there is a fear of being a witness and participating in a trial. There is a fear of committing perjury, which is a crime that is committed if one lies or does not tell everything they know during a hearing. There is also a fear due to the inexperience of how a trial is performed but also the

feeling of being threatened or the feeling of putting themselves at risk. Lay judges mentioned that the witness often seems nervous and that it often is very personal for the witness to testify.

> *"Sometimes a witness is so badly affected by what they have seen that they almost break down and then it becomes hard to judge their statement"*
> *Lay judge*

Unfortunately, it has also been shown that there is a trend among witnesses not wanting to admit that they need support. Among those that do seek support, a bigger part is women. Support before a trial is important since it prepares the person for the upcoming trial. This is especially recommended since few people have knowledge and experience of the Swedish legal system, and there is a tendency to base their expectations on what they see in the media.

Cognitive affect

It is argued that people are unreliable when it comes to trustworthiness. This is influenced due to the long period of time between the incident and the trial. This influences the person's memory, by information either being forgotten, being repressed, or being affected by others. It is therefore important to not provide witnesses with the information they do not have from the beginning since it may affect their statements. Questionings during trials are today most often initiated by the judge but led by the prosecutor since the prosecutor has to be objective. The questions asked should in no way be leading or guiding the witness in one direction, the witness must speak freely which adds to the unpredictability in each hearing.

User acceptance and development

As for the acceptance of new technology within Swedish courts, it is mentioned that it is a rather conservative and slow institution. Implementation of new equipment is not always acceptable. It is therefore important that the equipment is a useful choice and does not disappear after being used in a couple of trials. It has to be professional and easy and should in no way resemble a game or be scary. The technology has to be trustworthy, be of good quality and it has to contribute to better support than other options.

In order for it to be accepted, it is believed that it has to be shown in a real trial to show the potential of the tool and awaken inspiration for future trials. To include all potential users the equipment should be used in cases where there is a conviction but also a verdict of not being guilty. By doing so the equipment will be attractive to both prosecutors and defense attorneys.

> *"Make use of the technology, it exists to help us"*
> *Defense attorney*

Having access to VR could also include the possibility of involved people to participate from other locations which can ease the management around the trial. It was mentioned that having a VR option could ease the trials with defendants that are detained, by reducing the need for staff in the trial since the person would not have to be physically in a courtroom. However, remote use has its limitations and many of the participants have had first-hand experience of this during the Covid-19 period. Covid-19 has forced more remote participation due to the difficulties in gathering people in one room.

Use areas

From the interviews and the collected information five potential use areas for VR in court were found;

1. Giving pre-trial support
2. Viewing of object
3. Viewing of scene
4. Reconstruction of incident
5. Reviewing material

There was also found a sixth use area of having a remote trial which was mentioned by some of the participants. However this was not included any further due to the low acceptance shown from lay judges towards VR, as well as the lack of developed technique for this purpose.

4.1.2 Surveys

From the surveys more information was found about the potential users and the potential use.

First survey

The first survey had a total of 109 participants. 64 out of 109 had tried VR before and 47 had not. Among the participants that had previously tried VR it appeared that more than 65% would be comfortable using VR equipment alone. More than 40% would feel more uncomfortable than comfortable using VR equipment in front of strangers, see Figure 4.1. Of the participants that had not tried VR it was shown that more than 80% would feel more comfortable than not using VR equipment alone, see Figure 4.2. More than 80% would feel more uncomfortable than comfortable using VR equipment in front of strangers.

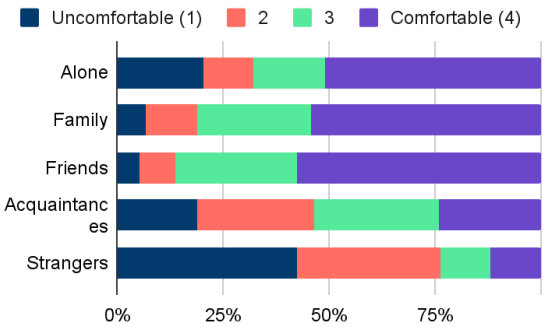


Figure 4.1 Have tried VR.

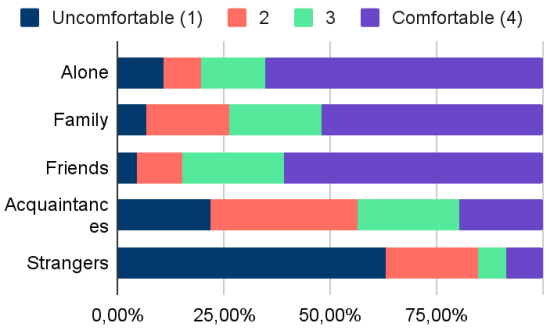


Figure 4.2 Have not tried VR.

50 participants answered that they had been on a trial before, whereas 61 answered that they had not. Of those that had not been in a trial before it was shown that more than 60% would be more comfortable testifying in front of their family, friends or alone, see Figure 4.3. More than 55% would feel more uncomfortable than comfortable testifying in front of strangers. Out of those that had not been on a trial before, more than 60% answered that they would feel more uncomfortable than comfortable testifying in front of familiar people, strangers or alone, see Figure 4.4.

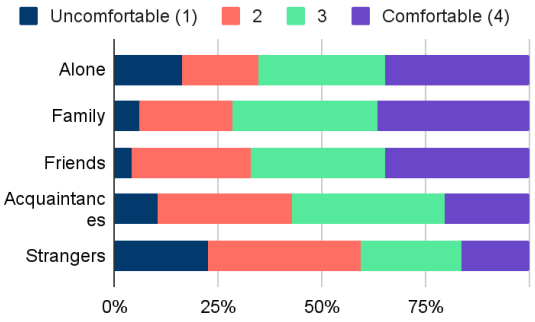


Figure 4.3 Have been to a trial.

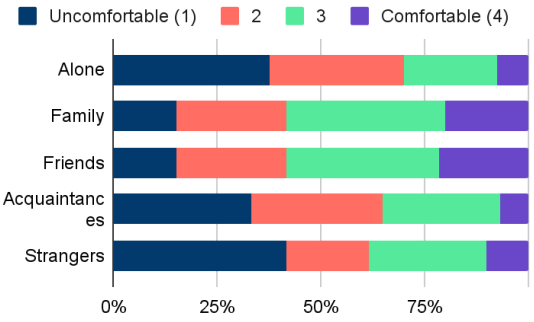


Figure 4.4 Have not been to a trial.

Survey participants in court

The survey was based on five use areas and resulted in findings for each area. The use areas are giving pre-trial support, viewing of objects, viewing of scenes, reconstruction of the incident and reviewing material. All participants were asked to grade their attitude towards using VR as a complement in each area and if they would prefer physically conducting it.

The first use area is *giving pre-trial support*. The participants mentioned that it is important to be clear about the different roles that are participating and to be flexible and accommodating to the needs of the person that the support is given to. It is important to listen, evaluate the needs and adapt to the person. This is believed to also increase the success of support. It was also said that aids used today are pictures, movies, brochures, maps and physical contact and communication. They mentioned that important information about the judicial system and trials should be given to the person in need of support. Furthermore information about the method of communication in court and how one should behave should also be given. They often also inform about financial compensations. The participants mentioned that it is important that the solution of VR for support allows physical contact and acts as a complement and not a replacement. VR as a complement to witness support is believed to give the users a perception of what a courtroom looks like and would tone down the false perceptions. However, it has to be as true as possible in order to not create confusion. It was also mentioned that it may enable quicker accessibility to get support. However, there is a risk that it may be too time-consuming and therefore not being used. The biggest issue mentioned was that today it is difficult to give support to someone at a distance or meeting up with people in need of support multiple times due to lack of time. The mean value for the attitude towards implementing VR as a tool for support was 4, and the mean value whether they believed it would be used as support was 3.5, see Appendix E.

> *"A good mediating tool that could help for further communication."*
> - *Witness support*

The second use area asked about is *viewing of objects*. When asked for what information is needed the participants answered that weight, size, material, color, quality, characteristics of and in what condition the object was in is important. They also mentioned the location where the object was either found, placed or used. Why the object is shown and how it is connected to the trial as well as what should be observed and taken into consideration was also mentioned. The importance of presenting any sources of errors of the differences from then and now was also mentioned. The participants wrote that the aids and tools used today include the object itself, references for colors, ruler or measuring aid as well as maps. It was mentioned that they would like the possibility to watch the object from different perspectives and to be able to change between different perspectives. It was also mentioned that they wanted to be able to see more of the details and have easier accessibility to the objects. The cons mentioned were the risk of details not being included or the technology not functioning properly. It would imply that someone needs to learn to handle and use the technology and that there is a risk of increased time of trials due to complications with the technology. The participants mentioned the risk of motion sickness as well as their low trust towards the

solution. The mean value for their attitude towards viewing an object in VR was 4, and The mean value of how likely they would use it instead of physically conducting it was 3.

> *"A reason to have it through VR would be if it is inappropriate to bring the object to the courtroom due to safety risks, or if it is inaccessible."*
> - *Prosecutor*

The third use area is *viewing of the scene*. The participants answered that descriptions of what is shown and when and by whom the environment was created was important information that should be included. They also mentioned the time, date, year and external conditions in regards to the environment were important. Any sources of errors were once again important information needed, as well as distance, size, color, quality and characteristics of objects and the environment itself. They also wrote that how the scene was documented and differences from then and now were important as well as what should be observed. Aids and tools mentioned to be needed during a viewing of a scene were a ruler or measuring aid, a map and the possibility to change between light or darkness in the scene. It was mentioned that VR could minimize flight, health and safety risks while enabling visiting locations that are no longer accessible. It was also said that VR may increase the number of viewings performed. The participants would want to be able to see from different perspectives and to change between these perspectives as well as see more in detail. However it was also mentioned that there is a risk of fewer details being included, the technology not functioning and that it would be difficult to clean the equipment in between uses. The motion sickness induced by using VR was also mentioned as a drawback. The participants did however mention that VR could result in a better understanding of distances, time and details in a cheap and easily accessible way. The mean value for their attitude towards viewing a scene in VR was 4.5, and the mean value of how likely they would use it instead of physically conducting it was 4.5.

> *"An advantage with VR could be that you can simulate the correct light conditions that were present during the incident."*
> - *Lay judge*

The fourth use area is *reconstruction of the incident*. The required information mentioned by the participants was when the environment has been created and any sources of error along with whether anything has been changed from the original environment. Additionally, information of the time of the day, date and season the environment had been based on was also something mentioned. The participants also said that the information of how the questioning would be documented, whether it was under oath and what scene that is shown, as well as the sequence of the incident is information they would want. It is important to know what the questioning is about and who is questioned. They also mentioned that there was a risk of low or no acceptance, but that they would appreciate the tool since it would imply that one could easily see details in small areas without disturbing the environment. It would also mean higher safety and that they would be able to see the person in the correct environment. When asked what tools they use today they mentioned pictures, videos, printed material, microphones, translator, maps, phones and computers. The participants said that

they would like to see the scene or incident, to be able to replay it and to see the questioned person pointing at directions while presenting. The drawbacks that were mentioned were sources of errors, doubts whether VR is accessible to everyone and the technology. The mean value for their attitude towards a view of a reconstruction of the incident in VR was 5, and the mean value of how likely they would use it instead of physically conducting it was 4.

"It would be easier to interpret details when seeing them in VR."
Lay judge

The fifth use area is *reviewing material*. The participants say they use paper, notes, events from the trial, pictures and all info given during the trial as their tools and aids for deliberation. They also say that VR could be an aid to see the material that has been presented and would like to be able to see each other during deliberations. However they also mention the cons of the technique being new and has to be learned, the difficulty in interpreting the other's reactions as well as the hygienic part of sharing a VR set. They also mention that there is a risk of them reviewing material in VR since it may give them more material or knowledge than the material that has been presented during the trial.

"Gives an opportunity to look back at material which can be helpful."
Lay judge

4.1.3 Observations

From the observations, the atmosphere and the technology used in courtrooms could be observed. In total three observations were conducted.

Trial of assault

The first trial observed was a trial of assault with witnesses which gave a good understanding of how important witnesses may be in a trial. It seemed that if a person knew how to describe figuratively they would receive higher reliability. To be able to describe figuratively it was important that the one witnessing noticed and remembered details from the scene. In this trial, the witness that did speak figuratively and described with details was the one that the prosecutor claimed had the highest evaluation of evidence.

The event had happened more than a year before the trial. The case did not involve any pictures of the scene where the event occurred. Overall the trial gave an understanding of the importance of witnesses and the way a witness could confirm or disprove the story from the defendant or the prosecuted.

Trial of serious narcotics crime

During the second observation, a bigger trial was visited. In the corridor waiting for the trial to begin, a picture was found outside the door. This picture visualized what the courtroom looked like which was discovered as misleading when entering the courtroom as it was much bigger in reality. The second case had more visual footage and used this footage to describe the happenings to the court. The prosecutor used both a PowerPoint and booklets, which were shared with the defendant and the jury. The prosecutor read from the booklets, the PowerPoint was mostly for the audience. The pictures that were presented during the trial were often taken at one place and later stated that the objects visualized in the pictures were found in another place. It showed how important it is to not mislead with pictures.

The trial showed how difficult it is to present loads of information in a pedagogic way. The trial included new concepts and a need of getting acquainted with new situations. Describing incidents without visual information was shown to be difficult to interpret.

A tour of a courtroom in Gothenburg, Sweden.

The tour in a courtroom in Gothenburg resulted in measurements for the VR model. The measurements were taken on all furniture and how they were placed, see Figure 4.5.

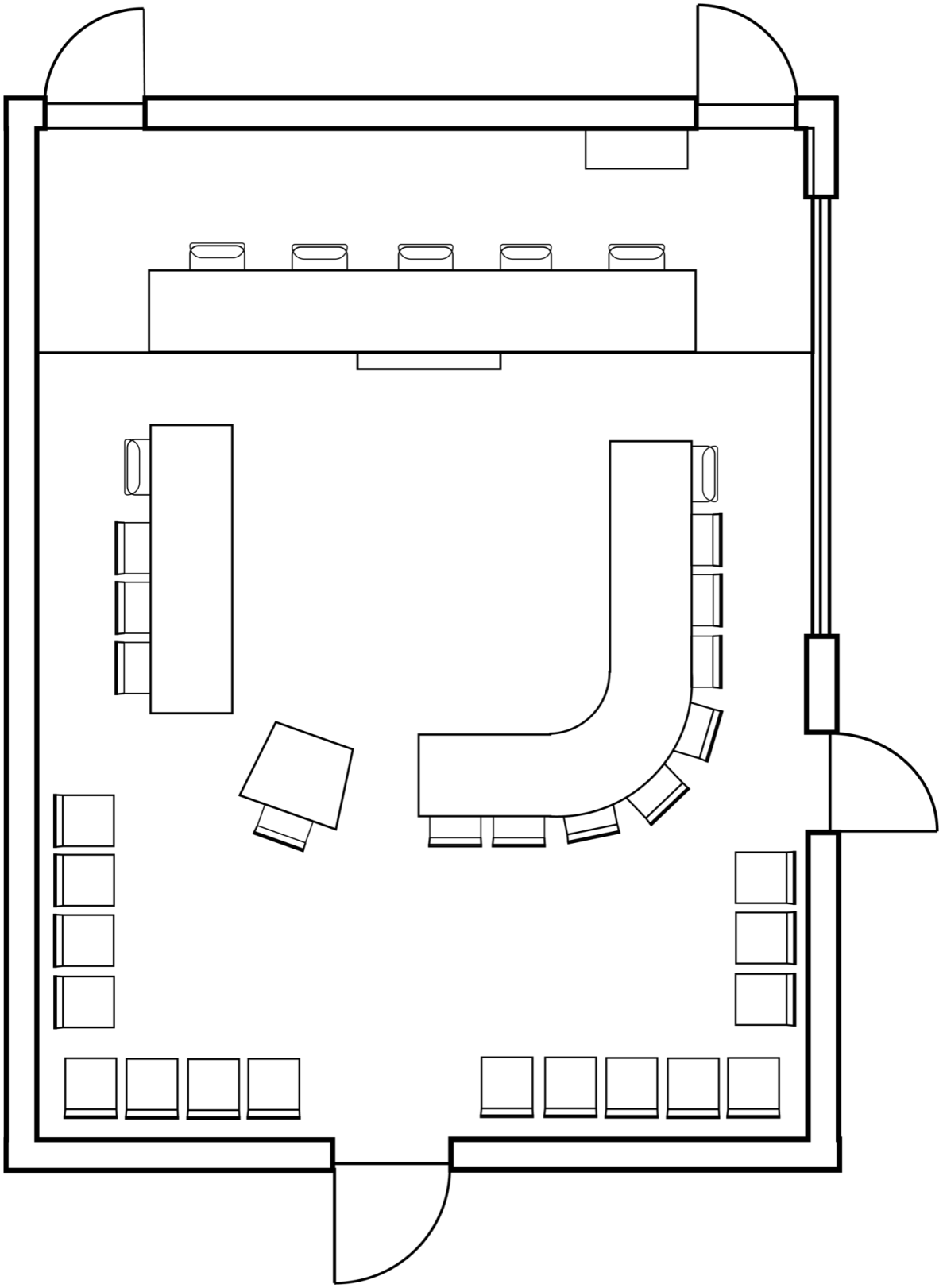


Figure 4.5 The layout of the courtroom.

4.2 VR environment

The design of the VR environment was based on previously mentioned results. The aim was to create an environment that was true to what it looks like today. The VR environment was later used for tests. The VR development consists of the environment, how to navigate in the environment and instructions for the usage of the VR environment.

4.2.1 The 3D model

The model's furniture and placement are based on the courtroom from the observation. It consists of five swivel chairs behind the judge's table, one swivel and four static chairs behind the injured party's table, one static chair behind the witness' table and one swivel chair and eight static chairs behind the defendant party's table, see Figure 4.6.

Behind the judge's table the judge is seated in the seat in the middle, lay judges on the sides and the clerk next to the judge. The defendant is seated behind the table in a horseshoe shape, see Figure 4.7. The swivel chair is assigned for the defense attorney.

The victim is seated on the short table close to the witness table, see Figure 4.8. The swivel chair is assigned for the prosecutor, the chairs next to the swivel chair are for the victim and their attorney, see Figure 4.9. Microphones have been placed at regular intervals on all tables.

At the back of the room, there are nine chairs lined up towards the rear wall, see Figure 4.10. There are three respectively four additional chairs lined up with the side walls. These chairs can be assigned to guards or for the public. Details such as projectors, cameras, screens, napkins and plastic cups have been added to the environment.

Figure 4.6 Overview of the environment in VR.

Figure 4.7 Perspective from the defendant's chair.

Figure 4.8 Perspective from the witness's chair.

Figure 4.9 Perspective from the victim's chair.

Figure 4.10 Perspective from the judge's table.

4.2.2 The experience

The UI guides the user to correct use. The user must first read and accept the instructions given to be able to use the product. The first instructions guide the user in how to use the controllers and how to move on to the next slide, see Figure 4.11. The user has a red laser pointer out of the right controller helping them to see where they are pressing. The next slide shows the user how to use the equipment in a safe way, see Figure 4.12.

Then the user gets instructions on how to adjust the headset correctly, see Figure 4.13. Additionally, the instructions show how to adjust the visual acuity on the headset, see Figure 4.14. Lastly, the instructions inform how to move in the environment using the touch controllers, see Figure 4.15.

The main menu has four different environments the user can enter depending on what purpose they will have, see Figure 4.16. The four different environments are based on the perspective of a witness, defendant, victim or to explore the room. The user has the red laser pointer to guide where they are pressing.

When the user enters the environment by pressing the button “I am a witness” they are placed in the witness chair in the environment. The witness environment does not allow the user to walk around, but to just sit on the assigned chair and look around. There is a menu button placed on the table that the user can reach with their hand holding a controller, to go back to the main menu. The environments for the witness, victim and defendant are similar just that the user is placed on the respective seat.

The environment where the user can explore allows the user to walk around in the environment. The user can transport themselves either by teleporting or by locomotion with the joystick. The right joystick allows them to rotate left or right while the left joystick allows them to move in four directions. The user can also teleport by using the pushing down on the joystick or X/A button. The user exits the environment by going through any of the four doors available in the environment.

Figure 4.11 First slide gives information on how to use the controllers.

Figure 4.12 Second slide gives information on how to use VR in a safe way.

Figure 4.13 Third slide gives information on how to adjust the HMD.

Figure 4.14 Fourth slide gives information on how to adjust the HMD.

Figure 4.15 Fifth slide gives information on how to move in the environment.

Figure 4.16 First slide gives information on how to use the controllers.

4.3 Usability tests

From the usability tests, findings could be analyzed. Findings were found from both the CW and PHEA conducted before the tests and the tests with the participants.

4.3.1 Theoretical evaluation of the test

When conducting a CW and PHEA it was shown that how well the participants would receive the use instructions would imprint on the usage thereafter. Restricting the users from receiving information or functions will have an impact on the usage. The CW and PHEA also implied that it is important that the users follow and adjust the equipment to not affect the user experience due to bad comfort.

If the action of choosing something is confirmed to the user, it will increase feedback and allow a higher feeling of user control. It is also important to allow high user control for all users, even the users with physical impairments. To keep the user control high even within the environment it is important to keep giving the user feedback. By informing the user in which environment they are present in, both feedback and visual clarity will be increased. The analysis also shows that it will lead to a smaller risk of misunderstanding the interpretation of the environment. The pictures found in the menu increase the probability of the users understanding what it is they will be seeing once they are in the environment.

The biggest issues may occur when the user is asked to move around in the environment. This is because the instructions have been presented approximately 5-10 minutes before this part of the test and the probability of the users forgetting how to move in the environment is high.

4.3.2 Usability during the test

The rate of participants completing the task was high in all tasks except for task eight, asking the participants to find who is seated at the judges' table. The lowest score of completed tasks per participant was seven. It was found that the participants that did not follow the instructions in the first task, did not pass two additional tasks during the test, thus completing the fewest tasks, see Table 4.1.

Table 4.1 Scores on tasks from the usability test

	Scoring on each task (Pass/Not)										
Participant		1	2	3	4	5	6	7	8	9	10	
	1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	10
	2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Not	Pass	Pass	9
	3	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Not	Pass	Pass	9
	4	Not	Pass	Pass	Not	Not	Pass	Pass	Pass	Pass	Pass	7
	5	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	10
	6	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Not	Pass	Pass	9
	7	Not	Pass	Pass	Pass	Not	Pass	Pass	Not	Pass	Pass	7
	8	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Not	Pass	Pass	9
	9	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Not	Pass	Pass	9
	10	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Not	Pass	Pass	9
	11	Pass	Pass	Pass	Not	Pass	Pass	Pass	Not	Pass	Pass	8
		9	11	11	9	9	11	11	3	11	11	

Task 1 - Follow the instructions

During the first task, it was found that the users struggled to adjust the equipment according to the instructions. The first instructions showed the user how they should hold the controllers, which seemed to be most difficult to understand. From the test, it was found that the participants that chose to follow the instructions more often held the controllers correct than the ones that did not.

Three out of eleven participants pressed the wrong button when trying to move on to the next page of instructions, which required the test leader to intervene and restore the environment. When asked why they chose the button they did, the test participants were certain that this was the button that should be used, in spite of the instructions showing otherwise. In one of the cases, it was due to the participant holding the controllers upside down.

A few participants chose to adjust the headset once the instructions for the headset were shown. It was mentioned that they did not understand how the straps should be adjusted and could therefore not perform the task. The next slide instructed the user how to adjust the visual acuity which had a better effect, where most of the participants chose to readjust the headset towards their face creating a better visual image.

> *"It is very clear with the pictures in the menu, showing what to expect once you enter the chosen environment."*
> *participant #1*

Task 2 - Enter the witness environment

During the second task some participants were hesitating whether they were allowed to continue and press on an environment. The same participants that hesitated had a tendency to do so during the whole test and ask questions before conducting any action.

Task 3 - Identify emergency exits

During the third task, participant #1 and #11 waved with their hands, resulting in the menu-button being pressed and them getting sent back to the main menu. Both participants had to be asked to be still with their hands since it was repeated three times. The menu-button's placement was one reason for the participants' accidental exit from the environment, and the low feedback of why they were sent back made the participants unaware of their mistakes. Participant #2 tried to awaken the laser that had been present in the main menu as a tool for pointing, but failed since this was not a function that was available in the environment. This may argue for a low consistency within the environment.

Task 4 - Identify seats for audience

During the fourth task it was noticeable that it was difficult to understand where different people were to be seated without any indications or leads. However all participants were able to point correctly, but some hesitated and did not know whether they were pointing in the right direction.

Task 5 - Exit the environment

During the fifth task it was obvious that the participants did not realise that walking was not an option in all environments. Four participants tried walking physically out of the door, which was not allowed since they were to be seated during the whole test. The button was not an obvious choice for some of the users since the users had not been introduced to it before entering the environment. Some users also performed the test on a swivel chair. This made them frustrated since they had a tendency to roll back from the origin geographical point they started the test, meaning they distanced themselves from the menu button. One user kept looking at their hand searching for a button as others tried to use the navigation functions that had previously been explained, in order to move closer to a door.

Task 6 - Enter the exploring environment

The sixth task had no bigger problems. The participants were familiar with the menu and knew what actions had to be performed in order to gain the wanted result.

Task 7 - View the courtroom from the judge's table

Once the participants were asked to move to the judges table in task seven, four of them had issues remembering how to navigate. Once they managed to find how to move in the environment, the next challenge was for the participants to figure out how to walk around the furniture. Two of the participants never managed to get around since they got too close to the furniture and had to aim higher to get over it.

"You never really get to the judge's table, no matter how you do."
participant #2

Task 8 - Identify the roles at the judge's table

During the eighth task the participants had difficulties in finding the signs displaying who is seated where. Since the indication of who is seated where is only visible from the front of the desk and very small it increases the difficulties in finding them and interpreting them correctly. Some participants tried to guess from earlier knowledge, and asked the test leader if it was correct.

Task 9 - Identify seat for the witness

Thanks to the well familiar environment, and that the users had the ability to look around in the witness perspective during earlier tasks, there were no bigger problems with identifying where the witness is seated. One issue that was present was that the participants did not know how to point at the witness table to show the test person.

Task 10 - Exit the environment

The last environment, allowing the users to explore the district court, had an exit through the door. In 10 out of 11 cases the users understood the task. All ten went for the door and reached out for the door handle to exit to the menu. In one case, the participant searched for the menu button placed on the table, since this was where it was in all the other three environments. When moving in the environment participants chose different methods. Since it had been a couple of minutes since the users last saw the instructions when reaching this point of the test many had forgotten or never learned how to move. Therefore some users tried or asked if they should physically walk to move around in the environment. All users eventually figured out how to move through trial and error. Some participants only used teleportation to move, some only used locomotion and some tried or actively used both. What was found was that all participants who used locomotion felt some level of motion sickness during and after the test, it was not as common among the users who used teleportation.

"I guess I will just exit through the door then..."
participant #8

4.3.3 User experience during the test

The results from the survey show that the experienced knowledge of a district court in Sweden increased for all participants. On a scale from 1 to 5, where 1 equals very little and 5 equals very much, the mean value increased from 2,64 to 4,80 and the median value from 2 to 5, see Appendix H. All participants' opinion was that they got a better understanding of what a Swedish court looks like after their participation. It was mentioned that it was not what they thought it would be and that it looked more like a classroom than their mental model of a courtroom. Some mentioned that they did expect the view they got, but not the size of the courtroom and that it was small. Many referred to American courtrooms, which often appear in movies.

All participants were asked for the likelihood that they would contact witness support before witnessing in a trial, and to grade the likelihood from 1 to 5. The average results were that all participants, after being present in a VR environment, chose a higher likelihood of asking for

support in all scenarios. It was however mentioned that it also depended on who the prosecuted person is, and whether there is a threat towards themselves as witnesses.

Since all participants were asked to fill in their physical symptoms and to what degree they were feeling each symptom this data could be gathered and summarized, see Appendix H. From the surveys, it was found that there was a more present feeling of nausea, headache and vertigo. However, it was also found that some symptoms were felt less present after the test in VR. Two participants graded lower on sweats, two participants graded lower on difficulties in concentration and one participant had less headache, tiredness and blurry vision.

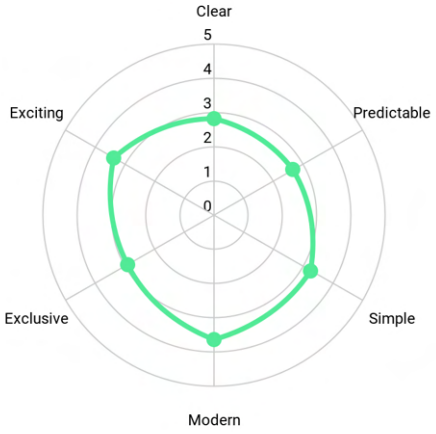


Figure 4.17 Results of the semantic scale

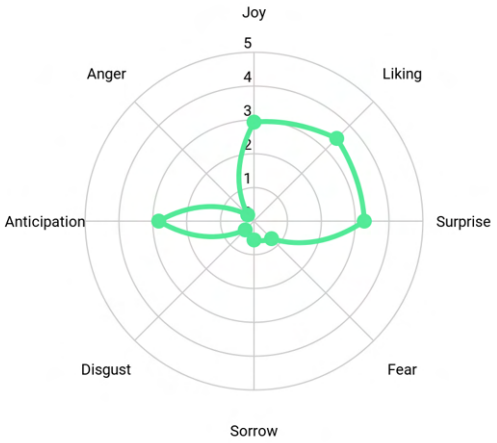


Figure 4.18 Results of Hesselgren's scale

As for the mean value of the semantic words describing the experience, the values for predictability, excitement, clearness and exclusiveness were relatively high, see Figure 4.17. The mean result for modernity, excitement and simplicity had the highest value.

As for the semantic scales of Hesselgren, the experience evoked joy, liking, surprise and anticipation with the participants, whereas the remaining emotions had a low value, see Figure 4.18.

4.4 Requirement specification

This section will present the requirement specification that has been developed during the literature study, user study and usability tests.

*The solution = VR-experience within Swedish courts
*The scene = a location connected to the trial, often but not always the crime scene
*The incident = the sequence of happenings during the event of the crime

4.4.1 Functionality

The functionality requirements describe how a solution of VR within Swedish courts should function.

NO.	Requirements	Origin
1.1	The solution should enable incremental implementation	Interviews
1.2	The solution should be adaptable to multiple use areas within the Swedish Judicial System	Interviews
1.3	The solution should be adaptable to the available equipment in the courtroom	Interviews
1.4	The presented information from the solution should be available for everyone in the courtroom	Interviews
1.5	The solution should allow smooth and easy transitions between different information	Interviews
1.6	The solution should allow for quick and easy transitions between Virtual Reality and reality	Interviews
1.7	The solution should allow the user to start, pause and exit	Literature
1.8	The solution should be able to be set up within a maximum of 1 hour	Observations
1.9	The solution should be able to be used during short, long and repeated sessions	Interviews
1.10	The solution should be usable by the Swedish courts	Literature
1.11	The solution should not be restricted to a geographical location	Literature
1.12	The solution setup should be mobile and portable	Literature
1.13	The solution should be used in situations when information can not be presented in another way or where it is less resource-demanding than other options	Interviews

4.4.2 Accessibility

The accessibility requirements describe what VR within Swedish courts needs in order to be accessible.

NO.	Requirements	Origin
2.1	The solution should be able to support users with different native languages	Interviews
2.2	The solution should be adaptable to the user's cognitive ability	Interviews
2.3	The solution should be adaptable to the user's physical ability	Interviews
2.4	The solution should be adaptable to the user's technical ability	Interviews
2.5	The solution should enable use by users with visual impairments	Interviews/Literature
2.6	The solution should enable use by users with auditory impairments	Interviews/Literature
2.7	The solution should enable use by users with mobility impairments	Literature
2.8	The solution should enable use by users with cognitive impairments	Interviews/Literature

4.4.3 Ergonomics

The ergonomics requirements describe how to keep an ergonomic use of the solution of VR within Swedish courts.

NO.	Requirements	Origin
3.1	The solution should aim to minimize the risk of physical pain or discomfort	Literature
3.2	The solution should encourage a natural sitting or standing posture	Literature
3.3	The use of the solution should be limited to a maximum of 20 minutes per session with at least 10-15 minute breaks in between sessions	Literature

4.4.4 Interaction and form

The interaction and form requirements describe how the solution of VR within Swedish courts should be designed.

NO.	Requirements	Origin
4.1	The solution should be user-friendly	Literature
4.2	The solution should use a language that is easily understood by all users	Interviews
4.3	The solution should instill trust in the user	Literature
4.4	The solution should communicate in a way that is clear and understandable for the user	Literature
4.5	The interface should be compatible with the user's mental models	Literature
4.6	The solution should give the user realistic and accurate expectations	Literature
4.7	The solution should match the expression and expectations of Swedish courts both visually and functionally	Interviews/Literature
4.8	The solution should introduce the user to the experience	Literature
4.9	The solution should allow for independent use	Interviews
4.10	The solution should provide support for the user during use	Interviews
4.11	Information about the presented object, scene or incident should be given during use or in connection to the use of the solution	Interviews
4.12	The solution should use UI fitting for the light conditions	Literature

4.4.5 Hygiene and safety

The hygiene and safety requirements describe how to keep a safe use of the solution of VR within Swedish courts.

NO.	Requirements	Origin
5.1	The solution should guide hygienic use	Literature
5.2	The solution should encourage safe use	Literature
5.3	The solution should allow use between users with no risk of transferring diseases	Literature

4.4.6 Use areas

Each use area has specific requirements based on the use of VR in each area. The requirements are separated into common requirements followed by requirements only relevant for each use area.

Common requirements for Area 1-5:

NO.	Requirements	Origin
6.0.1	The solution should not enable users to edit the original virtual environment	Interviews

Common requirements for Area 2-4:

NO.	Requirements	Origin
6.0.2	Use of the solution should be able to be recorded and documented	Interviews
6.0.3	The solution should enable casting and/or linked screens	Interviews
6.0.4	The solution should provide information about casted/linked screens	Interviews
6.0.5	The solution should allow having multiple users in the same virtual environment	Interviews
6.0.6	The solution should allow marking observation points	Interviews
6.0.7	The solution should allow displaying annotations	Interviews

Common requirements for Area 2-5:

NO.	Requirements	Origin
6.0.8	The solution should enable co-use	Interviews
6.0.9	The solution should allow for communication between all users	Interviews

Area 1: Giving pre-trial support

The requirements of Area 1 describes how the solution of VR within Swedish courts should be adapted in relation to giving pre-trial support.

NO.	Requirements	Origin
6.1.1	The solution should enable switching between different perspectives (audience, witness, victim, prosecuted)	Interviews
6.1.2	The solution should enable viewing the environment with and without people	Interviews
6.1.3	The solution should enable use without support from an external person	Interviews
6.1.4	The solution should enable viewing the environment with different abstraction levels	Interviews
6.1.5	The solution should give basic information about trials	Usability test

Area 2: Viewing of object

The requirements of Area 2 describe how the solution of VR within Swedish courts should be adapted in relation to viewing of objects.

NO.	Requirements	Origin
6.2.1	The solution should enable non-destructive scaling, translation and rotation of objects	Interviews

Area 3: Viewing of scene

The requirements of Area 3 describe how the solution of VR within Swedish courts should be adapted in relation to viewing of scenes.

NO.	Requirements	Origin
6.3.1	The solution should enable non-destructive scaling, translation and rotation of objects	Interviews
6.3.2	The solution should enable an illuminated version	Interviews

Area 4: Reconstruction of incident

The requirements of Area 4 describe how the solution of VR within Swedish courts should be adapted in relation to reconstruction of incidents.

NO.	Requirements	Origin
6.4.1	The solution should enable users to add, remove or move additional objects that are not included in the original environment	Interviews
6.4.2	The solution should allow multiple statements of the incident to be visualized in the scene	Interviews
6.4.3	The solution should allow multiple statements/versions of the incident to be shown in the scene	Interviews
6.4.4	The solution should enable an illuminated version	Interviews

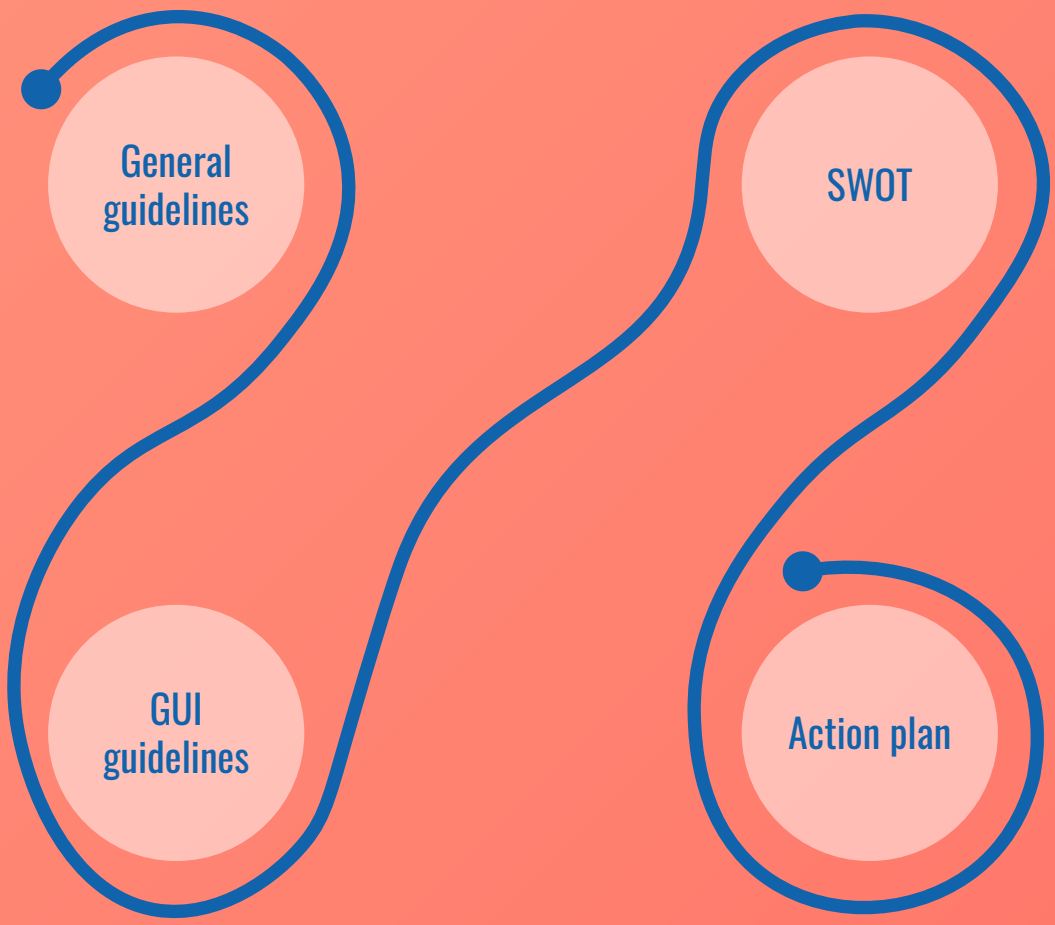
Area 5: Reviewing material

The requirements of Area 5 describes how the solution of VR within Swedish courts should be adapted in relation to reviewing material.

NO.	Requirements	Origin
6.5.1	The solution should allow multiple statements/versions of the incident to be shown in the scene	Interviews
6.5.2	The solution should allow showing simulations of the incident	Interviews

5. Guide

This chapter presents the guidelines for development and use of VR within Swedish courts. It also presents a SWOT analysis and an action plan.



5.1 General guidelines

The general guidelines are divided into five use areas, see Figure 5.1. Each use area has guidelines specifically concluded for that area.

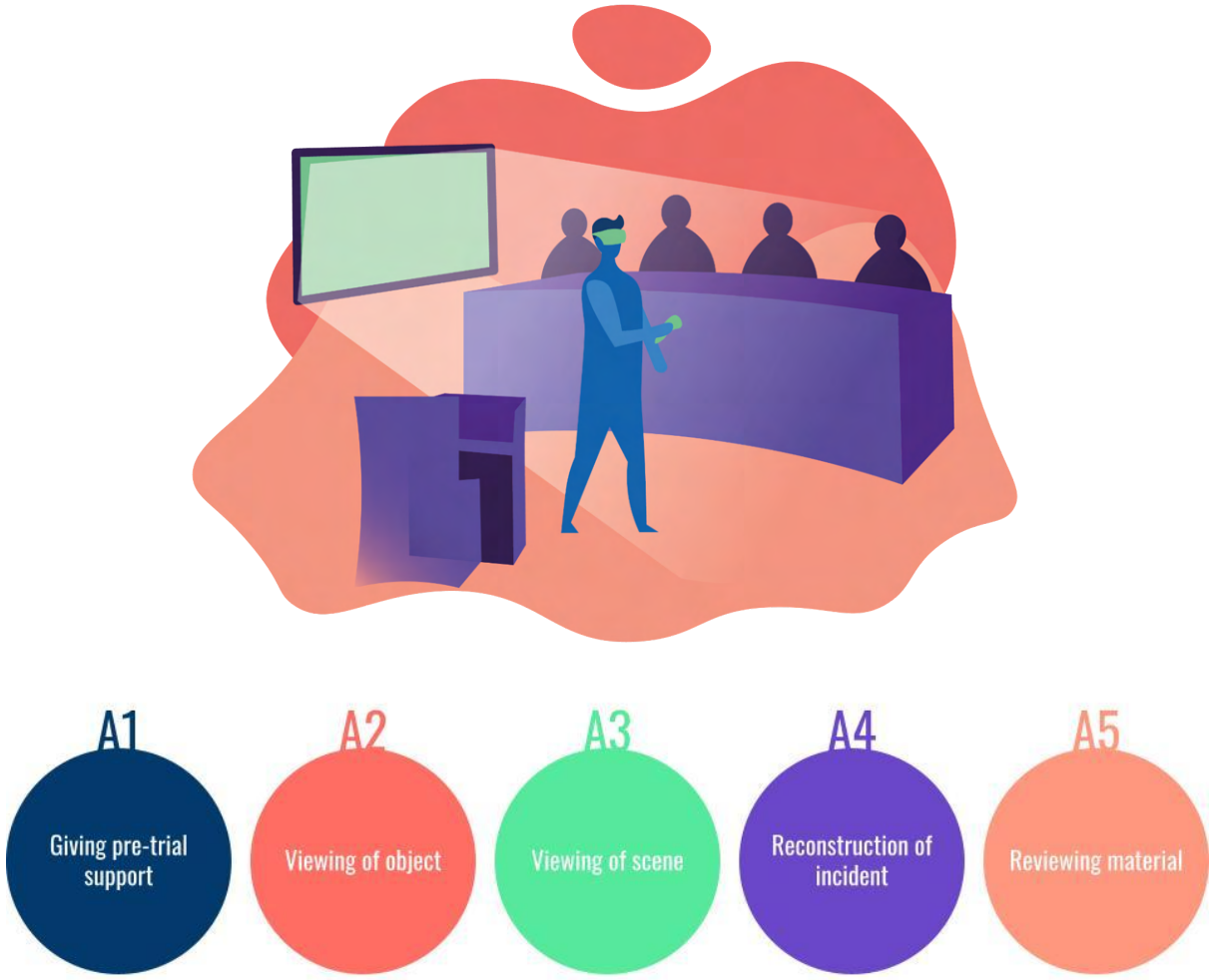


Figure 5.1 The five use areas for VR within Swedish courts.

5.1.1 Guidelines for Area 1 - Giving pre-trial support

VR can give the users a virtual tour inside a courtroom, see Figure 5.2. By doing so, VR can be a tool to help prepare witnesses, victims or accused before a trial.

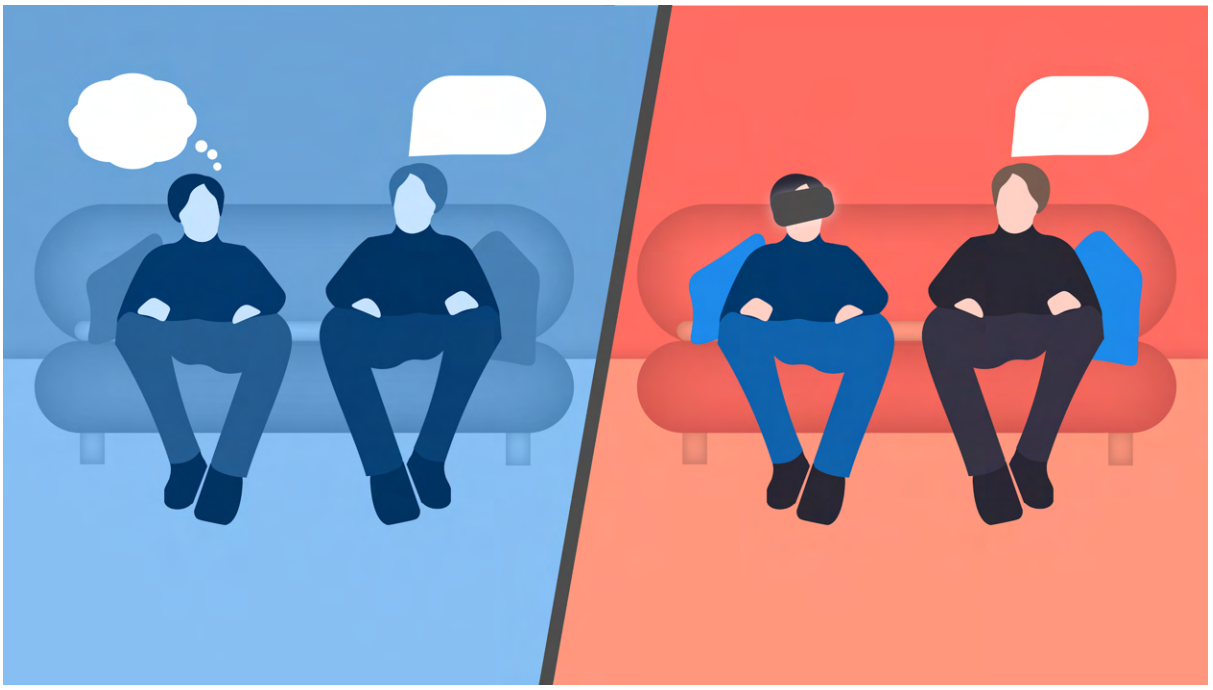


Figure 5.2 Illustration of Area 1 - Giving pre-trial support.

Why should Virtual Reality be used for giving pre-trial support?

It will contribute by minimizing false expectations of a courtroom and at the same time give information about the trial. It can be used as a mediating tool during meetings with witness support or to be used as standalone support. VR can help by giving the user visual information in a way oral communication can not. The user can see where everyone will be seated, go through the process and get useful information and guidance before the trial. VR is a tool that aims to answer users' questions before a trial and make them more prepared.

When would Virtual Reality be used?

VR for pre-trial support will be used in between a commencement for prosecution and the actual trial.

How would Virtual Reality be used?

VR will be used either in connection to meeting witness support or alone from any location. It will be available either by the user asking for support or through given material.

Who would be the user?

The user will be any witness, victim, accused or other people affected by a trial in need of information. VR will be most useful for inexperienced users.

5.1.2 Guidelines for Area 2 - Viewing of object

VR can be used as a tool for viewing objects that have a connection to the trial. By doing so, VR can replace the current methods of viewing an object, see Figure 5.3.

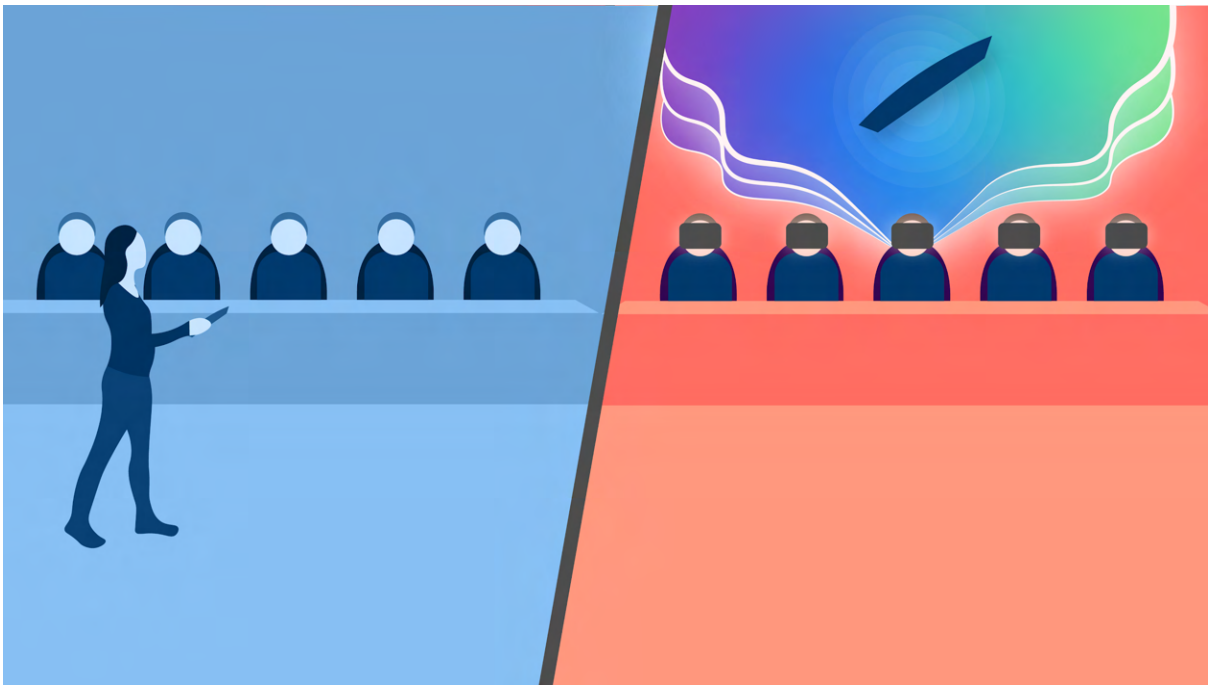


Figure 5.3 Illustration of Area 2 - Viewing of object.

Why should Virtual Reality be used for viewing of object?

VR is an alternative that is resource-saving compared to the current alternatives of viewing an object. The object can be viewed through VR without compromising safety or risking destroying the object. Viewing of objects through VR will contribute to a better understanding. The option of VR will also increase the possibility of implementing a viewing of objects in more trials.

When would Virtual Reality be used?

VR for viewing of objects will be conducted during trials. It will be an alternative to use when an object is to be presented but is not possible to present physically in court. It is also an alternative to reconsider if there are any safety risks with bringing specific objects.

How would Virtual Reality be used?

When conducting viewing of objects through VR the use should be led by one person.

Who would be the user?

The users should at minimum be the judge and lay judges. The ones not using VR equipment should be able to see the information through a computer screen or projector screen.

5.1.3 Guidelines for Area 3 - Viewing of scene

VR can be used as a tool for viewing scenes that have connections to the trial, see Figure 5.4. By doing so, VR can replace the current methods of viewing a scene.

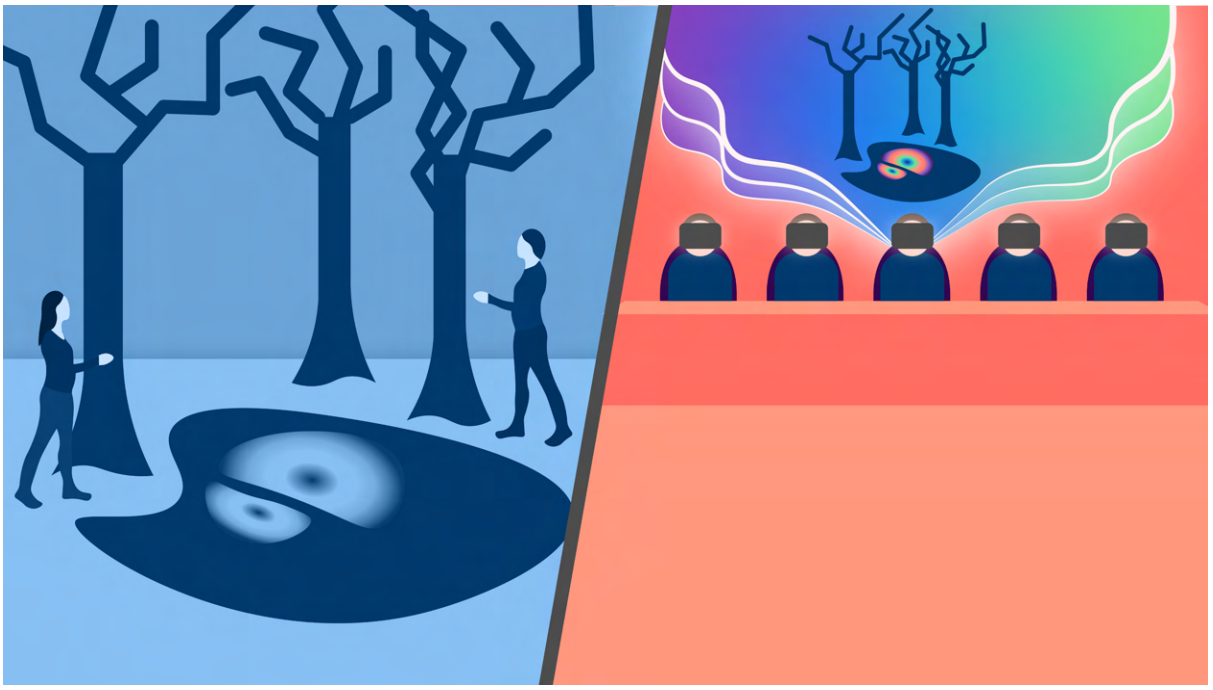


Figure 5.4 Illustration of Area 3 - Viewing of scene.

Why should Virtual Reality be used for viewing of scene?

By implementing viewing of scenes through VR the accessibility of viewing scenes will increase in trials. It is a solution that will be resource-saving and increase the possibility of finding time slots that suit everyone. Having a viewing of a scene in VR will increase the correct interpretation of the scene. It will also minimize the safety risks that a physical viewing may imply.

When would Virtual Reality be used?

VR for viewing a scene will be used during trials. It will be used when wanting to see a scene virtually instead of physically. It is an option that can be used when the scene is not reachable.

How would Virtual Reality be used?

The use of VR for viewing of a scene is led by one person.

Who would be the user?

All participants in a trial, except for the public, will be users of the VR equipment during viewing of a scene. The people of the public can see the information through projector screens or computer screens.

5.1.4 Guidelines for Area 4 - Reconstruction of incident

VR can be used as a tool for reconstruction of incidents that have connections to the trial. It can be done both based on theoretical facts and on statements given by witnesses. By doing so, VR can enable reconstructions during trials, see Figure 5.5.

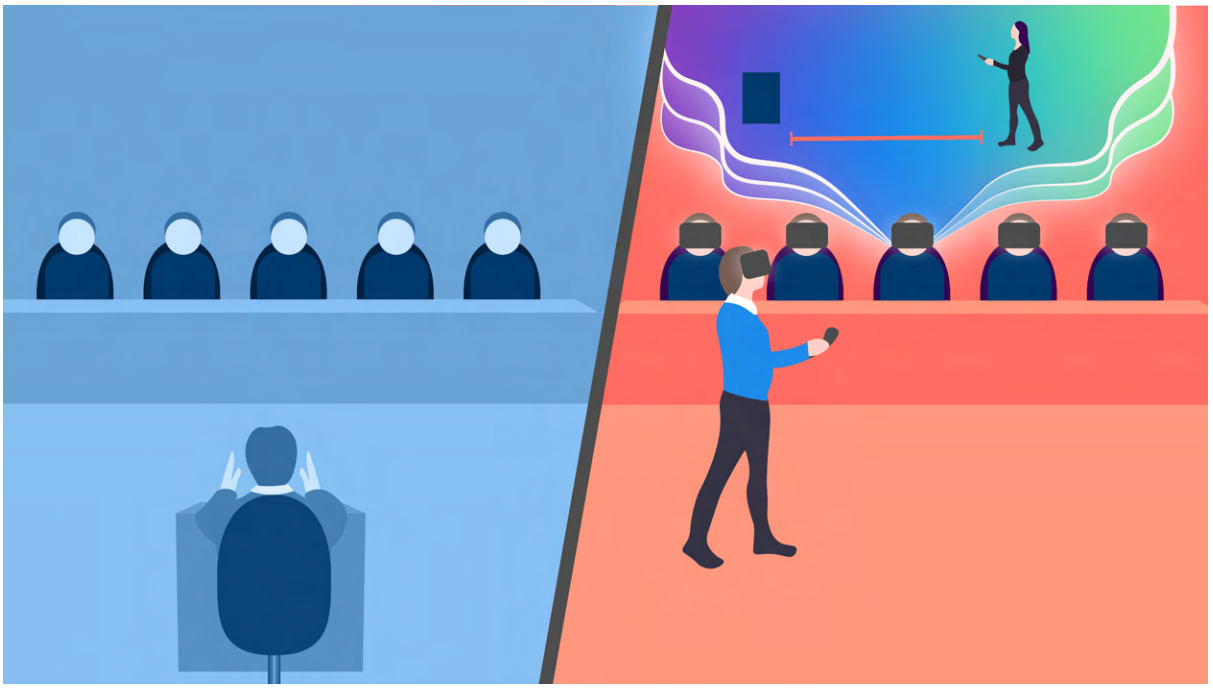


Figure 5.5 Illustration of Area 4 - Reconstruction of incident.

Why should Virtual Reality be used for reconstruction of incidents?

Using VR to create reconstruction of incidents gives a possibility to see sequences of an incident and increase the understanding by visualizing it. VR can also give the opportunity to see the difference between statements of witnesses, the ability to compare the information and to value the evidence with more information.

When would Virtual Reality be used?

The use of VR to perform reconstruction of incidents would be used either during questionings or during presentation of evidence. VR can be a tool to use during questioning of witnesses, the defendant or the victim.

How would Virtual Reality be used?

When using VR to create reconstruction of the incident only one person can lead.

Who would be the user?

Depending on what the purpose is with the reconstruction of the incident, different actors may be the user. If it is used during a questioning, the questioned is the user and others can follow from a screen. If it is used based on theoretical facts everyone except for the people of the public should have the equipment on. The people of the public can see the information through a screen.

5.1.5 Guidelines for Area 5 - Reviewing material

VR can be used as a tool for reviewing material that has been presented during the trial, see Figure 5.6.

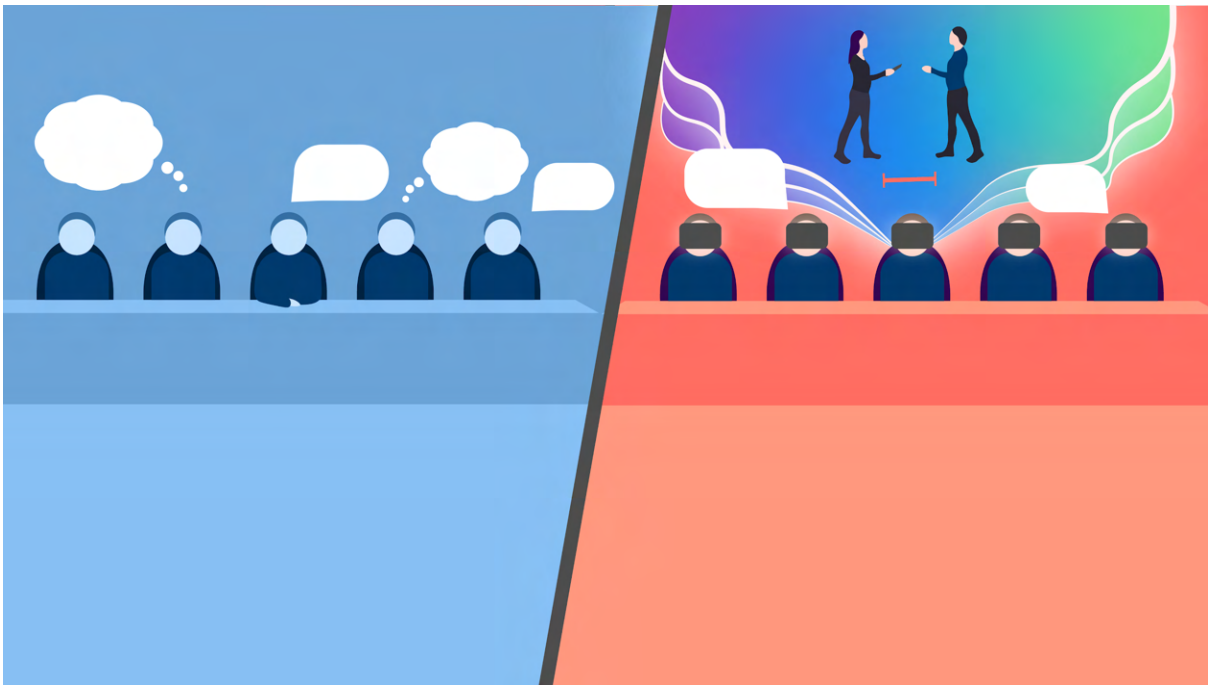


Figure 5.6 Illustration of Area 5 - Reviewing material.

Why should Virtual Reality be used for reviewing material?

Reviewing material through VR allows the user to look back at the material. It can be used as a way to compare statements, or to get a better understanding.

When would Virtual Reality be used?

Reviewing material through VR is used either during trials or during deliberations.

How would Virtual Reality be used?

Depending on when reviewing materials is used, it will be either dependent or led use. If material is reviewed during the trial there will be one that leads the use. If the material is reviewed during deliberation there should be an independent use, where each user has control for themselves.

Who would be the user?

If reviewing material through VR is used during trial all people within the courtroom except for the people of the public are the users. The people of the public can see the information through computer screens or projector screens. If reviewing material through VR is used during deliberations the users will be all the lay judges and the judge.

5.2 User experience guidelines

VR within Swedish courts must support and guide the user before, during and after use. In order to do this, user experience guidelines will follow below. Development and use of VR should also follow the requirement specification, see Appendix C.

5.2.1 Usability

Before the use, the user needs to be given instructions on how to fasten the HMD and the touch controllers correctly. Users who wear glasses should also be given the option to use a spacer which adjusts the space in order for the glasses to fit. These instructions should be easily accessible by the user through either printed instructions placed on the HMD or displayed close by. Giving the user information about how to place and fasten the equipment during the use is not suitable. This is because the user then has to take the equipment off in order to follow the instructions and therefore will not be able to read them simultaneously. Safety instructions regarding the use environment should also be presented to the user before use to give them the possibility to make sure that the environment is safe.

During use, the user firstly needs to be given instructions on how to use the touch controllers in order to navigate in VR. This will make sure that the user understands the instructions as they otherwise can not move on to the following instructions. The user should also be given information about safe use. This includes how to move in an ergonomic way and how to avoid injuries. Next the user should be instructed on how to move in the virtual environment if that is included in the use. At all times during the use the user should be able to access the instructions in a way that does not require a lot of effort or experience.

After the use, the user needs to be given instructions on how to end their use. This includes turning off their HMD and how and where to put them down.

5.2.2 Hygiene

Since the VR equipment will oftentimes not be personal and therefore will be used by many people, hygiene becomes an important factor for safe use and a positive user experience. A proper routine of how to take care of the equipment will also ensure the longevity of the equipment. Before and after use the HMD and touch controllers should be cleaned in order to ensure sufficient hygiene for the user. It is important to clean all parts that are in direct contact with the user including the HMD, the HMD lenses and the touch controllers. When cleaning the HMD and the touch controllers it is important to use non-abrasive, alcohol free, and anti-bacterial liquids or wipes. The outside of the HMD should be cleaned with a dry cloth. The HMD lenses should be cleaned with a lens cloth, liquids should not be used. Preferably the user should also wash and disinfect their hands before and after use.

5.3 GUI guidelines

To gain trust from the users and to create an experience that is coherent with the Swedish National Courts Administration the color scheme aims to include the same colors as the authority uses, see Figure 5.7.

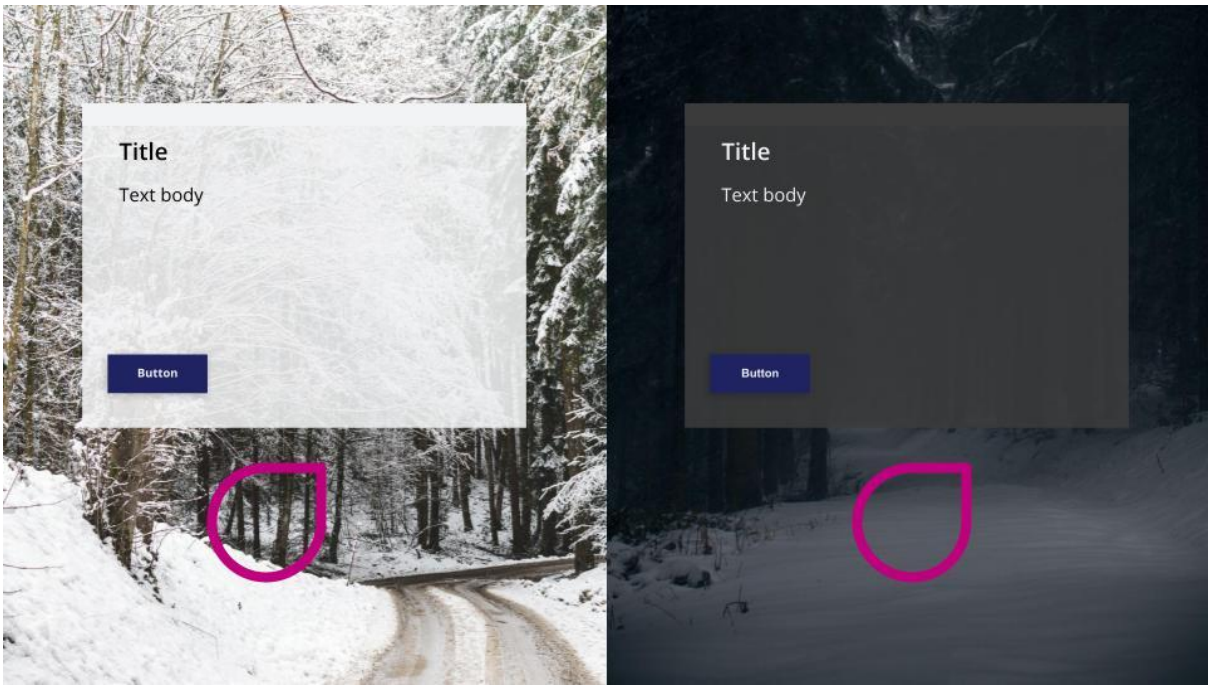


Figure 5.7 The GUI guidelines placed on a light environment and a dark environment.

5.3.1 Light mode

The light mode should only be used for light environments to maintain the same light level and reduce eye strain between transitions, see Figure 5.8. If the light mode is used in a dark environment the contrast between the two will be hurtful to the eyes. Best readability is achieved when placing dark text on a light background and the button is in a contrasting blue color with a discrete shadow to stand out and guide the user. It is important to use contrasting colors to keep readability for users with visual impairments. The background is set to 90 % opacity to desaturate and lower the importance of the background. This also enables the user to see the background while using the interface.

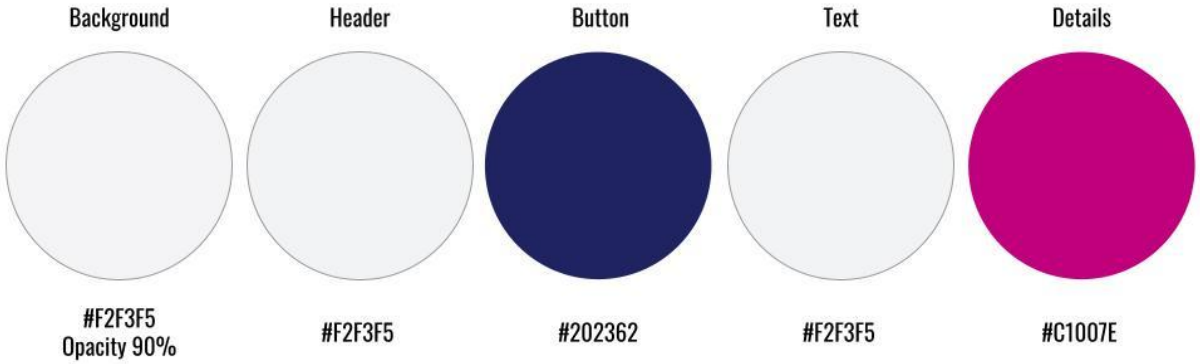


Figure 5.8 GUI colors for light environments.

5.3.2 Dark mode

The dark mode should only be used for dark environments to maintain the same light level and reduce eye strain between transitions, see Figure 5.9. If the dark mode is used in a light environment the contrast between the two will be hurtful to the eyes. Good readability is achieved when placing light text on a dark background and the button is in blue color with a discrete shadow. The background is set to 90 % opacity to desaturate and lower the importance of the background. This also enables the user to see the background while using the interface.

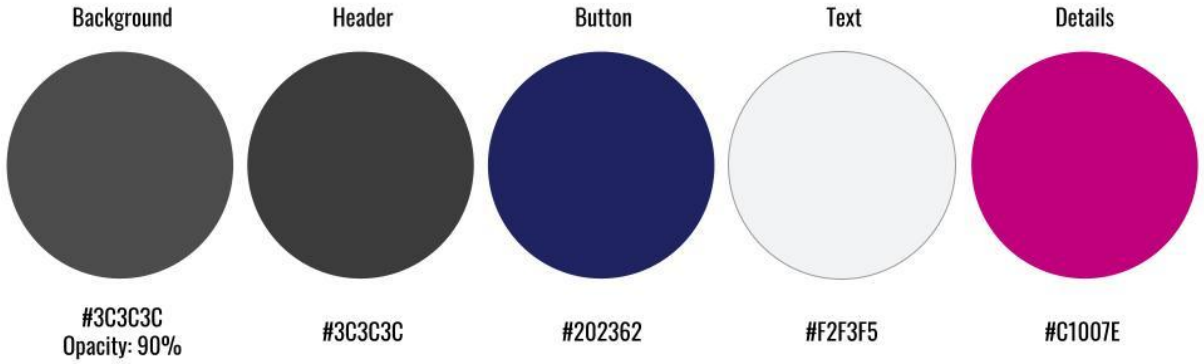


Figure 5.9 GUI colors for dark environments.

5.3.3 Information

Once entering a scene the user should always have the ability to see what scene it is that they are seeing. Information about who has created the environment and from what date, time and season of the year it is should easily be reachable. If one person is leading within a scene the other users should be informed of that and guided through the use.

Information about use should always be accessible to rewatch during use. When needed, the user should be able to pause the VR application. Information about changes in the environment should always be present so that the user understands what is happening, for instance when changing environments. The menu should always be easily reachable for the users.

5.4 SWOT

In order to minimize potential risks and take full advantage of the potential of VR within Swedish courts a SWOT analysis was made on the potential of VR within Swedish courts, see Figure 5.10. The SWOT is based both on the user study and the literature study.

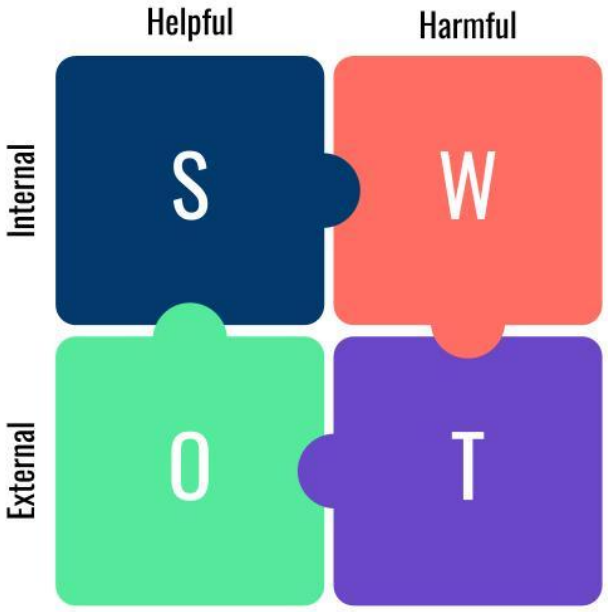


Figure 5.10 Illustration of the SWOT analysis.

5.4.1 Strengths

- Adaptable
  The technology can be used in many ways and be adapted to many kinds of user needs. It will only get easier as the technology is developed and more options become available.
- Gives new opportunities
  The technology will enable including evidence that otherwise can not be included or are difficult to present in an efficient and effective way.
- Saves resources
  The technology will save resources when used for areas that otherwise would need extra security, travel or support.
- Can be applied to multiple areas
  The technology is very versatile and can be used for many areas within the Swedish courts.
- Modernizes the process
  The technology will help to update and modernize the Swedish courts. It will bring new opportunities and make the process more efficient and effective.

5.4.2 Weaknesses

- Technology can be unreliable
  Technology can fail to work and if that were to happen during a trial it will affect the proceedings if it can not continue without the technology.
- Low experience of technology
  The implementation of new technology within courts is rather slow and to what degree technology is used varies between different courts in Sweden. The majority do not have experience of using VR or anything similar.
- Demands staff
  The development of VR environments and managing of the technology when used within Swedish courts will require staff.
- VR is not usable by all
  The technology is usable by many but not by all. Certain impairments will make it difficult or impossible to use it.
- Costs
  The development of VR environments can be time-consuming and costly.
- Motion-sickness
  The technology can cause motion sickness in users if the experience is not designed carefully. The users can also get motion-sick if they are biologically easily motion-sick or if the user is new to VR and immersive experiences.
- Hygiene
  The technology is directly placed on the face of the users. Since the headset is not personal it will switch users between each use which can be unhygienic.

5.4.3 Opportunities

- Expected to be a trendy product
  The technology will become more common among the Swedish citizens and will thereby get increased user acceptance.
- Accelerating development of devices
  As the technology is still being developed at a rapid pace this will create more effective and efficient products that will ease the use.
- Development reduces costs
  Newer and better technologies are decreasing the prices of VR products which makes VR more accessible for more users.
- Criminal cases
  The need for the technology is largely dependent on the frequency of relevant criminal cases.

5.4.4 Threats

- Non-accepting users
  Far from all people are positive about new changes and new technology. Some users can and will refuse to use the technology.
- Keeping up with new technologies
  As the development of new technologies continues this can imply that new innovations in the future will be created that are more effective and efficient than VR.

- Laws and regulations
  Since VR has not been used in Swedish courts before there are no laws in place for use of the technology. New laws can arise that will affect the potential of the technology.
- Criminal cases
  The need for the technology is largely dependent on the frequency of relevant criminal cases.

5.5 Action plan

In order to successfully implement VR within Swedish courts certain steps need to be followed, see Figure 5.11. The following action plan is based on the feedback from the users during the project and the SWOT and includes action steps, resources needed, main responsibility, outcomes and estimation of time. The goal of the action plan is to successfully implement VR within Swedish courts.

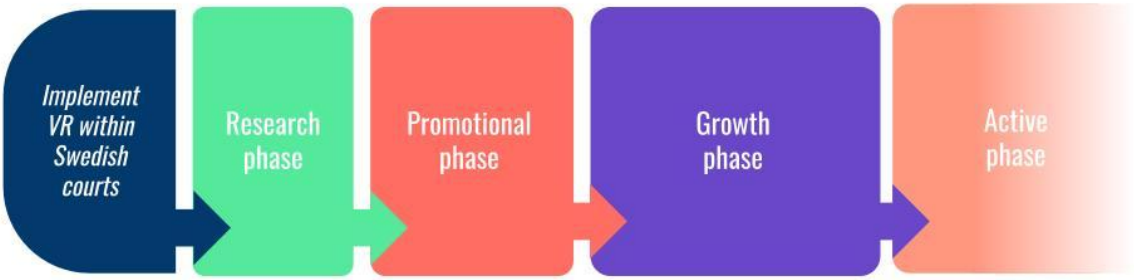


Figure 5.11 Illustration of the action plan.

5.5.1 First phase - Research phase

The first phase is the ongoing phase which is called the research phase which will continue for an estimation of 1-2 years from today. The main responsible of this phase will be NFC.

The phase will include the following actions:

- User tests
  It is important to base the implementation of VR in courts on future users to include their needs and demands for the solution to be accepted. By conducting user studies with future users and involving them in the process the acceptance towards the solution will increase. When conducting user tests the choice of users will be an important factor as well as the equipment. It is important to test all potential VR equipment to analyze and continue with the most suitable for court. It is also important to include all roles that are present in courts to find a solution that will be accepted by all. The user studies should include different use areas and exploit each of these to find realistic future use areas of VR in Swedish courts.
- Market analysis
  A market analysis will increase the knowledge of how VR equipment can be used and what type of use that is efficient. It will give information on how VR has been implemented in other countries or by other professions.

- Skill development in VR and trials
  Knowledge of VR and trials must be increased. Increasing the knowledge of how VR can add value to a trial will increase the knowledge of what should be seen in VR. There is a need to increase the knowledge of how environments should be developed to gain and fulfill the purpose of the use. A system for creating environments in the form of guidelines should be considered and created for future phases.
- Development of the technology
  Gain knowledge through user and literature studies of what hardware and software should be used for VR in Swedish courts. These decisions should act as requirements for future developments.

In order to perform the steps the following resources will be needed:
- Users
- VR equipment
- Experts in VR technology, design, psychology and the judicial system

The action steps shall result in the following outcomes:
- Requirement specification
- Guidelines for development
- Potential use areas

Bottleneck: Before going into the next phase an evaluation of the potential use area needs to be done. This will act as a basis for the upcoming phases and ensure that the implementation is formed after the users.

5.5.2 Second phase - Promotional phase

The promotional phase will aim to increase the awareness of VR within Swedish courts and the judicial system. The phase will last for about 2-3 years. The actions will be performed mostly by NFC but with additional support by the Swedish National Courts Administration.

The phase will include the following actions:
- Mock trials in favor of both parties
  To increase the knowledge of how VR can favor both parties it is important to perform mock trials that show the possibilities for both. They will result in demos that can be referred to when wanting to implement it in a trial or as marketing material. Mock trials should include realistic trials and be performed with real users. By conducting mock trials it can act as inspiration for real future trials. To conduct mock trials it is important to have information from the earlier step and to base the mock trials on potential use areas. The mock trials will result in good marketing for the use. To create a realistic experience and to evaluate the potential use of VR in Swedish courts it is important that they are performed in a courtroom.
- Introduce VR in legal education
  To share the knowledge of VR and its potential, it should be introduced to new legal students during their education. By doing so, these students will have the knowledge of VR when starting to work with legal work. This will increase the acceptance of VR among new students and increase the willingness of implementing it in future cases. This will require teachers at legal educations that have knowledge of VR.

- Advertisement
  Advertisement has been shown to be an effective way of spreading the word of VR in court within the country and has been tried in Schweiz. By doing so, the knowledge of VR will increase further among all active in Swedish courts. Advertisement in the form of news will get the word out to the public, making VR within courts a topic and trendy. Presentations at conferences or within the authorities will increase the discussion of the topic from within. Events showing how VR can be used will also add to the topic being spread, as well as allowing people to try it.
- Improved competencies in VR
  All steps included in this phase will demand competencies within VR. IT is important that NFC equip their department with VR competence to match supply and demand and to prepare for future demands.

In order to perform the steps the following resources will be needed:
- The results from the previous phase
- Access to a courtroom, professionals within Swedish courts, VR equipment and VR environment
- Legal teachers skilled in VR
- Presentation material, presenters, a platform
- Increased staff and skills within VR

The action steps shall result in the following outcomes:
- Demos
- Knowledge and awareness of VR in legal students
- Interest from the judicial system and more opportunities

Bottleneck: Before going into the next phase VR will have to be used in a real trial with high media coverage. This will reach a wide range of potential users across Sweden and a solid starting point for the next phase. It is important to not move on to the next phase until the technology is fully functional and fulfills the user needs. Otherwise, the probability of low user acceptance will be high and result in a failed implementation.

5.5.3 Third phase - Growth phase

The growth phase will aim to increase the availability of VR within Swedish courts. The phase will last for about 5-10 years. The actions will be performed mostly by the Swedish National Courts Administration but with additional support from NFC.

The phase will include the following actions:
- Incremental increase of VR headsets within Swedish courts.
  The use of VR in Swedish courts should be done with an incremental increase to increase the acceptance of it. By doing so the users within a trial will get time to get used to the equipment and learn how to use the equipment. It will also act as a guide as to how much VR can be used in trials. An incremental increase of use will favor both the Swedish National Courts Administration that will have to provide the equipment, as well as NFC that will have to provide the material to be seen in the equipment.
- Incremental increase of competent staff
  With the increasing use of VR, there will have to be an increase of competent staff that can provide material for the use. There will also be a need for competent staff that can prepare the equipment for a trial.

- Active collection of feedback
  Feedback will be an important factor for the success of VR in courts. By collecting feedback, drawbacks of VR can be analyzed and adjusted for more proper use. Through feedback, continuous improvements can be made regarding the material that is used.

In order to perform the steps the following resources will be needed:
- VR equipment
- Staff
- Collection methods

The action steps shall result in the following outcomes:
- Increased availability
- Streamlined process
- Continuous improvements

Bottleneck: The next phase will be the active and final phase. Therefore VR needs to be highly available and fully developed for use in Swedish courts. The growth phase will ensure an effective and efficient process from the start of the need to deliver a product.

5.5.4 Fourth phase - Active phase

When VR is fully implemented within Swedish courts it will reach the active phase. This phase will continue until new technologies arise that are more efficient and effective for the intended use. During this phase, it will be important to perform continuous improvements through evaluations and collections of feedback from the users. It will be important to continuously improve the technology to keep up with needs and requirements that may change or arise.

6. Discussion

This chapter discusses the scope of the project, the chosen methodologies and produced results, the implementation guide as well as ethical and sustainability aspects to consider.

6.1 The scope of the project

The aim of the Master's Thesis is to contribute to the implementation of VR as a visualization tool that will improve the judicial system in Sweden. Since the thesis investigated VR in Swedish courts which is a rather new and unexplored area the project had to start with exploring fundamental factors. An initial idea of focusing more on GUI turned into a wider exploration, with GUI as a smaller part of the project. The five use areas for VR in Court can act as inspiration for future development. The further explored area of giving pre-trial support has given a solid base for what such an experience could look like. Before using it in real situations the experience should both be improved based on the feedback from the evaluation and extended to include informative and illustrative material about the trial and the participants within. The area should also be tested in a real situation before being implemented. The developed VR environment can be further developed or used as inspiration for other VR environments.

The objective is to gain knowledge of the judicial system in Sweden, VR technologies and VR development through empirical and theoretical research that will result in a requirement specification and guidelines that shall act as inspiration for future development and implementation. The user study, literature study and usability test were performed during the project. Thereafter the analysed data was categorized and concluded into a requirements specification and guidelines. The requirement specification was developed continuously during the project while the guidelines were established at the end to conclude the project and the findings. The requirement specification and the guidelines are independent of each other but can and shall both be considered when doing future work.

The project was limited to virtual reality and therefore no conclusions can be made about how AR, MR and VR compare. The project instead focused on what virtual reality can be used for, and should not be used for, without considering if another technology would be more effective or efficient. The project was also limited to Unreal Engine and Oculus Quest which meant that the environment and testing were based on them. Although the results of this project are partly affected by Unreal Engine and Oculus Quest that does not mean that these are the two technologies that need to be the ones used in court.

The project was executed during Covid-19 and this both limited and created opportunities. The pandemic affected the judicial system by having to include more technology during trials when people had to participate remotely. The users were exposed to more technologies in a short amount of time which either made them more accepting or less accepting of new technologies being introduced. Professionals within the judicial system were also very busy during the time of the project, partly due to the pandemic. Almost all contact with users related to the judicial system was done remotely. The remote aspect made it harder to explore the users' requirements and needs due to the flexibility and depth of the communication being affected. The usability test was also adapted and in some aspects limited to apply to the general guidelines from The Public Health Agency of Sweden.

6.2 User study

The discussion of the user study is divided into three parts; interviews, surveys and observations.

6.2.1 Interviews

The interviews had more lay judges as participants due to the high workload for judges, prosecutors and attorneys in Sweden. However all roles were included in some way during the project. When sending out information about the interviews asking about potential participants, the description mentioned VR and its implementation into Swedish Courts and was performed through Zoom. Therefore it is believed that the people that volunteered to be interviewed in some way had the interest to contribute to the purpose of implementing VR. Potential participants that were not comfortable with Zoom or do not know what VR is may have been discouraged. This is a reason why the participants included cannot be argued as a representation of all professionals within Swedish courts. Nonetheless, the results from the interviews are still important aspects that need to be considered for the purpose.

All interviews were conducted remotely due to both Covid-19 and the difficulty for the participants to find a free time slot. Half of the interviews were conducted through Zoom and half by phone call. The participants could therefore only use their words to describe and answer the questions asked, which may have limited their answers and the perception of them. The interviews were semi-structured which made them differ from interview to interview. During the last interviews it was more and more clear what questions gave the wanted outcome and how to ask them. Because VR is an unknown area to many people it was sometimes hard to extract their own thoughts and visions of how VR could be used without influencing them when trying to guide them in their answers.

From the interviews, it was initially found six processes within a trial that VR could be used for. Some of the users came to the interviews prepared with ideas and some came to learn during the interview. The participants that had thought of it beforehand had diverse ideas, while the ones that had not prepared initially often thought of the idea of doing a trial remotely via VR. The six processes were later on redesigned into five use areas. The redesign was necessary since implementing VR within the six processes would result in another type of evidence. One of the use areas, having a trial remotely, was not further investigated. Because of low acceptance towards new technologies within the judicial system and the potential users, this was not a use area that is considered realistic within the near future. This use area could however be a future potential area when the five others have been implemented.

6.2.2 Survey

The first survey was sent to people of the public by sharing it on different platforms. Since the description mentioned both VR and Swedish courts this may have had an effect on the people that chose to participate. The participants were either very eager about the idea, or very negative. The number of participants was too low to represent the user group and did not give enough opinions to result in statistical conclusions. However the findings could be analyzed as qualitative information.

The second survey was sent to both new participants and previous participants from the user study. The previous participants were already familiar with the study and had a better insight into the areas that were investigated. The survey was not made for statistical information, but for insights from the users that are difficult to get a hold of within the Swedish judicial system. A separate survey was sent out to people working with witness support. It may have been difficult for all participants to get acquainted with each area that was asked about in the surveys, depending on whether they had been introduced to them before or not. The information was difficult to analyze since the survey had a need of being as short as possible, yet including as many insights as possible. Since the survey was sent to all participants it can not be adjusted to each person and therefore loses the personal touch which normally brings out qualitative data in interviews. This resulted in some of the questions being difficult to understand for some of the participants, due to lack of knowledge or experience.

6.2.3 Observations

The pictures outside the courtrooms gave a false impression of what to expect from the room. The footage almost contributed to not visiting this trial, since the perspective created doubts as to whether the audience would fit in the courtroom or not.The picture on the wall had been captured from a low height, creating an illusion of the room being much shorter and wider than reality. This showed how important it is to visualize the environment correctly and to not mislead the user.

During the observations in trials it became apparent that it is difficult to visualize the incidents without pictures. Comparing the two trials, it showed how much a picture can help in putting pieces of words together. However the two trials can not fully be compared to each other, since only four hours of multiple days of the second trial were visited. All observational data in the project are fully based on the district court and trials in Gothenburg. There is a possibility that other courts in other cities in Sweden vary with what technology they use or other specific important details within the courtrooms.

6.3 VR environment

The project group had no experience of VR development before the project. Unreal Engine, Blender, Oculus Quest and the surrounding technologies were all explored and learned during the extent of the project. This allowed for an objective start and a greater opportunity to consider the thoughts and doubts an inexperienced user may have. The low knowledge of VR technologies made the development of an environment challenging. The project members first had to explore what software to use and then how to use them. The development took longer than expected and included a lot of trial and error.

A previously developed environment of a crime scene was provided to the project group by NFC. One initial idea was to use that model to develop a GUI for. A decision was made early in the project to not use the model. The first reason was that it is initially much more difficult to continue developing someone else's model instead of starting from scratch when having no experience in developing for VR. The second reason was that there was a wish from stakeholders to explore the area of giving pre-trial support through VR. It was also a more narrow area with less need for variation. It would furthermore make testing easier since the test participants could be Swedish citizens instead of professionals. Performing tests on a crime scene with participants that are not connected to the crime or never having been the victim, witness or committed a crime would not give a representative and valid result on the user experience.

The finished environment was limited to what the group either had learned during the project or what could be found online. Therefore the design freedom was rather limited which resulted in a compromise between development time and usability of the environment. The level of detail in the environment was also chosen to give a real immersive experience but not include unnecessary details that would take too much time or that could risk overwhelming the users. The GUI for the interface was developed to test how users read and experience instructions as well as how well they absorb information in VR. It was not developed with regards to the area of giving pre-trial support or any other area.

6.4 Usability tests

From the information retrieved from the usability tests, conclusions for VR in court and the first use area of pre-trial support could be drawn. Since the usability test was strongly connected to the environment, the test was also strongly affected by the environment

6.4.1 Evaluation

It was shown that the adjustments did affect the usage of the equipment, however it did not in any test affect the experience of the product noticeably. Just like the evaluation told, the visual acuity could however have a higher impact, but most participants adjusted their headset and thereby also the visual acuity. The feedback was lacking in the model, which was noticeable in the tests. Just like the evaluation showed, the participants were confused

while waiting for the environment to load, which is why a loading page or information needs to be reconsidered while waiting. The lack of possibility to go back to the instructions made it more difficult to use the product. This should be considered as an important factor for future developments.

6.4.2 Usability and user experience

The physical symptoms and the way they were changing during the tests were partially because of the test itself, being in VR, but most probably also because of the testing environment. The environment used had a colder climate, which is believed to be the reason why some of the participants felt less sweat after the test than before. One participant was also late to the test which may have been a result as to why this participant felt less headache after the test and sitting down for 30 minutes. Difficulties in focusing were graded lower in the second survey in two test results, which is believed to be a result of the test having a high grading on joy and liking. It was a test that the participants in most cases enjoyed partaking in, and wanted to focus to achieve high scores. The second survey was sent to all participants immediately after the VR part. The physical symptoms may have increased with time after the test but this was never investigated.

The participants were chosen according to the least risk of transmitting and being affected by Covid-19. This affected the different impairments that were included in the tests. However, it was found that most participants had some sort of impairment, yet not one of the participants mentioned any hindrance due to their impairment.

6.5 Requirement specification and guide

The requirement specification was developed during the literature study, user study and usability tests. It was divided into sections that covered all needed areas for use of VR within Swedish courts. The requirements acted as inspiration for the content of the environment for the usability test but the test did not evaluate the requirements. This was not the purpose of the usability test due to the developed VR environment not being a true representation of what a finished VR environment for giving pre-trial support would be.

The guide was developed to give an overview of the potential use areas and what to consider when developing and implementing VR within Swedish courts. The guide does not cover every aspect of VR in Swedish courts and should not be treated as the only source of information. The requirement specification is also important to consider but it focuses more on what a solution needs to fulfill and contain while the guide describes how to use it. The guidelines were mostly based on the second survey, which professionals took part in and included questions about the areas of use. The GUI guidelines were based on the colors of the Swedish National Courts Administration. This will increase trust and acceptance with users as it matches the expectations and is recognizable. The recommendations for placement of information and tools are based on the user study and usability test and will help to develop a VR environment that is easy to use. It is kept general because there are many potential use areas with VR within Swedish courts which all will require different

functions. Finally, the SWOT and action plan was created to give an overview of the future of VR in Swedish court and a strategic plan for a successful implementation. They are both based on the findings from the project but this does not ensure that all user needs and requirements have been identified. VR technology is also developed at an accelerating rate and new laws and regulations can limit or ease implementation. The guide should therefore act as a general guide and not a set plan.

6.6 Ethical and sustainability aspects

Successful implementation of VR within Swedish courts is a complex and big task. The solution has the potential to create positive change and experiences but if not done carefully it could cause negative experiences and even be damaging to the users.

6.6.1 Ethical aspects

Immersive virtual environments have the potential to take the user to a virtual world and provide an amazing and positive experience. This is a best-case scenario but the opposite could also happen. A criminal trial can contain evidence from a serious crime with people who have experienced trauma, abuse or sometimes worse. The use of immersive VR will feel real to the user and therefore a traumatic experience in VR can cause real psychological and even physical trauma. The negative effects will increase with people who find it more difficult to separate reality from virtuality like children and users with certain cognitive impairments. Both the professionals and the affected of the crime can be the users of VR in a trial and it would be unethical to expose users to experiences that give long-term negative effects. The effects on humans from criminal trials in VR will be an important aspect to consider when deciding on where and how to use VR in criminal trials. The power will be in the designers' and developer's hands to create ethical experiences that do not negatively affect the users.

An often discussed ethical aspect of VR in relation to criminal trials is the legal security of the solution. The VR environments need to be developed in favor of both the prosecuted as well as the victim. In Sweden, the prosecutor needs to act neutral and present evidence in favor of both parties. Sweden therefore has a better chance at implementing VR in an ethical way than other countries where the two parties compete against each other and the winner can be the one with the most resources. Although it will require that defense attorneys take responsibility to demand the tool.

Since the judge and lay judges need to have a common ground for evidence all of them have to use VR if that is part of the presentation of evidence. If VR is used during questioning that person can be required to wear the HMD. One consideration to make is what happens when a participant in a trial does not want to use it.

The positive aspects have to outweigh the negative aspects in order for VR to be an option. VR should be treated as an asset to use when evidence can not be effectively or efficiently presented in another way. It should not be used just because it can but it needs to have a

demand and purpose to fulfill. Furthermore, it is important to be transparent with what the technology can and cannot do. If a user expects a flawless environment any flaws will lead to a negative experience and low user acceptance and low trust in the solution.

6.6.2 Sustainability aspects

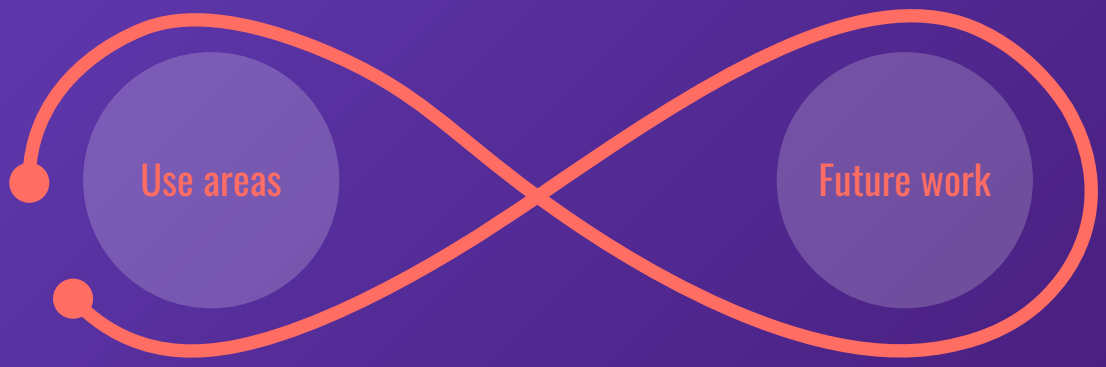
VR within Swedish courts will decrease the need for traveling. The court does not need to travel to a scene during a trial because they can get a close to real experience through VR. It also increases the safety and need of staff since the prosecuted person does not need to leave the courtroom. Visiting a scene connected to a criminal case can be dangerous and feel unsafe, VR will allow all participants of a trial to sit inside the courtroom although virtually being at the scene. By using VR all participants of a trial can get a deeper understanding of the details of the criminal case. Misinterpretations will be reduced as the immersive visual tool will give nuanced and clear information about the case and allow for fewer individual interpretations of the presented evidence.

A highly available solution will also mean a large number of VR headsets and equipment which will require energy both during production and to be charged. How large the effect will be on the environment will depend on the energy source. If the implementation fails because of low user acceptance or no demand it will also generate a lot of waste and a short lifetime. An implementation needs to be based on the users to be successful and gain acceptance.

A factor that could lead to low user acceptance is the hygiene of the HMD. Since the HMD will have to be shared between users the VR equipment can become a source of transmittable diseases. A routine to clean the HMD and protect the user will therefore be needed. Although in the future VR within Swedish courts could allow for an ill participant to take part in a trial and interact with the people in the courtroom through the virtual world.

7. Conclusions

This chapter presents the conclusions from the project. It ends with recommendations for future development and implementation of VR within Swedish courts.



7.1 Identified use areas

Five potential use areas for VR within Swedish courts were identified throughout the project. The areas are based on a user and literature study and were defined to ease the implementation of VR.

- Area 1 - Giving pre-trial support
  Using VR to give a tour of the courtroom and the process of a trial to inexperienced people before partaking in a trial.

- Area 2 - Viewing of object
  Using VR to increase the accessibility to viewings of objects and minimize safety risks that a physical viewing can result in.

- Area 3 - Viewing of scene
  Using VR to increase the accessibility to viewings of scenes and minimize safety risks that a physical viewing can result in.

- Area 4 - Reconstruction of incident
  Using VR to view reconstructions of incidents related to a crime.

- Area 5 - Reviewing material
  Using VR to give the option of reviewing materials to get a better understanding of the incident.

7.2 Recommendations for future work

The developed VR environment is largely dependent on the project prerequisites. Before implementing VR within Swedish courts the following areas needs to be explored further:

- A cohesive and highly functional GUI for all VR use areas within Swedish courts that visually match the Swedish courts to build trust and acceptance with users.

- How to adapt the use to users with different impairments and needs in order for VR within Swedish courts to be as accessible as possible.

- VR within Swedish courts will have to be adapted to the Swedish laws and regulations. Today there are no laws directly connected to VR in the judicial system but the use of the solution needs to follow the current laws.

- Exploration of cognitive and psychological effects of the use of VR during or in connection to a trial with tests with real participants of a trial.

- Exploration of what VR technique and systems will be the most effective and efficient to use. The setup in the courtroom should also be explored for safe, effective and efficient use.

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I. Appendices

Appendix A - Interview Templates

Interview template for lay judge

Section 1 - about the person and their profession

1. Experience
    a. For how long have you worked within the judiciary?
    b. How come you chose to become a lay judge?
2. Preference
    a. What type of cases do you find most interesting?
    b. What type of cases do you feel are most stressful/wearing?
    c. What is the best part of being a lay judge?
    d. Are there moments during a trial when it is hard to maintain focus?
    e. Can it sometimes be hard to understand everything during a trial?
    f. Are there cases which are easier to judge than others?
    g. Are there cases which are more difficult to judge than others?

Section 2 - Trial

3. Trial and evidence and decision
    a. What is most important within a trial from your perspective?
    b. What are the biggest challenges?
    c. What type of evidence affects your perception of the crime the least/most?
    d. What are the pros and cons with the different evidence that can be presented?
    e. What type of evidence do you prefer?
    f. What type of evidence do you find most difficult to validate/understand?

Section 3 - VR

4. VR
    a. Have you ever tried VR?
    b. What is your attitude towards new technology in general in connection to trials/courts?
    c. Do you believe that VR can be implemented in the judicial process?
        i. What purpose do you see with using VR?
        ii. If it were to be implemented, when during the process do you think that it is most efficient to use (pre trial, during trial)?

iii. Who do you think has the most use of VR? Who will be the user?
iv. Do you think that we in Sweden have the possibility to do it in a legally secure way?

d. Do you think that VR can affect the perception of an incident/crime?
e. What type of evidence would you like to get through VR?
f. Who do you think should look through the glasses?
g. Do you have any doubts about the use of VR?
h. What do you think is important to make it work?

Interview template for prosecutor

Section 1 - about the person and their profession

5. Experience
    a. For how long have you worked within the judiciary?
    b. How come you chose to become a prosecutor?
    c. What type of cases do you take?
        i. In what court instances have you worked?
6. Preference
    a. What type of cases do you get most engaged with?
    b. What type of cases do you feel are most stressful/wearing?
    c. What part of a trial do you like the most/least?

Section 2 - Trial

7. Trial and evidence and decision
    a. What is the most important within the legal process from your perspective?
    b. What are the biggest challenges?
    c. What type of evidence do you prefer?
        i. What type of evidence contributes the most to your perception of the incident?
        ii. What type of evidence influences the most when they are missing?
        iii. What type of evidence do you always try to include? Why?
    d. What are the pros and cons with the different evidence that can be presented?
        i. Is there any type of evidence easier/more difficult to present?
        ii. Is there any type of evidence that is difficult to mediate?

Section 3 - VR

8. VR
    i. Have you ever tried VR?
    j. What is your attitude towards new technology in general in connection to trials/courts?
    k. Do you believe that VR can be implemented in the trial process?
        i. What purpose do you see with using VR?
        ii. If it were to be implemented, when during the process do you think that it is most efficient to use (pre trial, during trial)?
        iii. Who do you think has the most use of VR? Who will be the user?
        iv. Do you think that we in Sweden have the possibility to do it in a legally secure way?
    l. Do you think that VR can affect the perception of an incident/crime?
    m. Who do you think should look through the glasses?

n. Do you have any doubts about the use of VR?
o. What do you think is important to make it work?

Interview template for lawyer

Section 1 - about the person and their profession

1. Experience
    a. For how long have you worked within the judiciary?
    b. How come you chose to become a prosecutor?
    c. What type of cases do you take?
        i. In what court instances have you worked?

Section 2 - Trial

2. Trial and evidence and decision
    d. What is the most important within a trial?
    e. What are the biggest challenges?
    f. What are the pros and cons with the different evidence that can be presented?
    g. What evidence do you like the most?

Section 3 - VR

3. VR
    p. Have you ever tried VR?
    q. What is your attitude towards new technology in general in connection to trials/courts?
    r. Do you believe that VR can be implemented in the trial process?
        i. If it were to be implemented, when during the process do you think that it is most efficient to use (pre trial, during trial)?
        ii. Who do you think has the most use of VR? Who will be the user?
    s. What would you have wanted to show or see through VR?
    t. Do you have any doubts about the use of VR?
    u. What do you think is important to make it work?

Interview template for witness support

Section 1 - about the person and their profession

1. Experience
    a. What is your role in the association?
    b. For how long have you been active?
    c. How come you chose to work with your role?
        i. Why is it important with witness support?
2. Profession
    d. What does the process look like when you act as a support for a witness?
        i. How do you get contacted?
        ii. Do you have any material that you show?
            1. What does it look like?
            2. How does that work for you?
            3. How is it received by the witness?
        iii. When in the judicial process do you get involved?
    e. How often do you act as a witness support?
    f. What is important to keep in mind as a witness support?
    g. In what situations do you feel as most needed?
    h. Are there occasions when it is difficult to support witnesses?

Section 2 - Witnesses

9. Trial and evidence and decision
    i. What issues do witnesses experience during trial?
    j. Do you experience that witnesses appreciate the support?
        i. Do you support more than just witnesses?
            1. Do you think more people would want support?
        ii. Is it a typical type of people that seek support?
        iii. Do many seek support?
            1. Do you think that more people would want to have support but fear receiving help?
        iv. How has corona affected?
        v. Do people know that they can receive support?
    k. Do you think that witnesses are in need of more support than what they receive today?
        vi. In what type of crimes/trials?
        vii. For how long a period of time is the support?
        viii. Is it always people that have never been in a trial before that seek for support, or do they come back?
    l. What trials do witnesses experience as most
        ix. frightening?
        x. least frightening?

xi. important?

m. Do you experience any culture of silence?
   xii. How do you think one can counteract that?
n. What are the biggest challenges within the judicial process according to you?

Section 3 - VR

10. VR
    o. Have you ever tried VR?
    p. Do you think that VR can be used for giving support to witnesses?
        i. Before
        ii. During
        iii. Do you think that it could be used to show the witness the courtroom?
        iv. How do you think it will affect the witness perception of the task of giving their witness statement?
        v. How would it affect your work?
        vi. How do you think that it would ease during hearings of witnesses?
    q. Do you think VR can be used to give support to other groups of people before a trial?
    r. How do you think that VR can be used in the judicial process?
    s. Do you have any doubts about the use of VR?
    t. What do you think is important to make it work?

Appendix B - Survey template 1

First survey that was sent out to people of the public in Sweden.

Introduction

What do you identify yourself as?

- ☐ Woman
- ☐ Man
- ☐ Non-binary
- ☐ Unsure
- ☐ Do not want to answer
- ☐ Else:____

How old are you?

- ☐ Under 16
- ☐ 16-25
- ☐ 26-50
- ☐ 51-75
- ☐ 76+

Have you used VR anytime before?

- ☐ Yes
- ☐ No

Attitude towards VR

If the participant has used VR before

How many times have you used VR?

- ☐ Once
- ☐ Couple of times
- ☐ Many times
- ☐ Everyday

For what purpose have you used VR?

- ☐ Entertainment
- ☐ Education
- ☐ Work
- ☐ Else:____

In what situations do you feel comfortable/not comfortable when you use VR?
(Grade from uncomfortable=1 to comfortable=4)

- Alone
- In front of family members
- In front of friends
- In front of people you know
- In front of strangers

_ _

If the participant has not used VR before

Would you like to try VR?

- ☐ Yes
- ☐ No

In what situations do you feel comfortable/not comfortable when you use VR?
(Grade from uncomfortable=1 to comfortable=4)

- Alone
- In front of family members
- In front of friends
- In front of people you know
- In front of strangers

Courts

Have you ever been in a court before?

- ☐ Yes
- ☐ No

Attitude towards courts

if the participant has been to court

What was the reason you were visiting a court? (you can chose more alternatives)

- ☐ I was there as witness
- ☐ I was there as victim
- ☐ I was there as prosecuted
- ☐ I was there as audience
- ☐ I am/have been a lawyer
- ☐ I am/have been a judge
- ☐ I am/have been a recording clerk
- ☐ I am/have been a lay judge
- ☐ I am/have been witness support

- ☐ I am/have been a prosecutor
- ☐ Else:______

How nervous were you before your first trial?
1 = Not at all
2
3
4 = A lot

How much before the trial did you know about the procedure of a trial in Sweden?
1 = Not at all
2
3
4 = A lot

How did your attitude towards trials in Sweden change?
- ☐ More positive than before
- ☐ Did not change
- ☐ More negative than before

In what situation would you feel comfortable/uncomfortable to witness?
(Grade from uncomfortable=1 to comfortable=4)
- Alone
- In front of family members
- In front of friends
- In front of people you know
- In front of strangers

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if the participant has not been to court

How much do you know about the process of trials in Sweden?
1 = not at all
2
3
4 = a lot

How would you feel to participate in a trial as a witness? (if you have witnessed a crime)
1 = Very uncomfortable
2
3
4 = Very comfortable

In what situation would you feel comfortable/uncomfortable to witness?
(Grade from uncomfortable=1 to comfortable=4)
- Alone

- In front of family members
- In front of friends
- In front of people you know
- In front of strangers

How would you feel to participate in a trial as a victim? (if you have been exposed for a crime)
1 = Very uncomfortable
2
3
4 = Very comfortable

How would you feel to participate in a trial as prosecuted? (if you are prosecuted for a crime)
1 = Very uncomfortable
2
3
4 = Very comfortable

Appendix C - Requirement specification

The requirement specification of VR within Swedish courts and which requirements were implemented in the developed VR environment and how they were implemented.

1. Functionality			
NO.	Requirements	Origin	Implementation
1.1	The solution should enable incremental implementation	Interviews	-
1.2	The solution should be adaptable to multiple use areas within the Swedish Judicial System	Interviews	-
1.3	The solution should be adaptable to the available equipment in the courtroom	Interviews	-
1.4	The presented information from the solution should be available for everyone in the courtroom	Interviews	-
1.5	The solution should allow smooth and easy transitions between different information	Interviews	-
1.6	The solution should allow for quick and easy transitions between Virtual Reality and reality	Interviews	-
1.7	The solution should allow the user to start, pause and exit	Literature	Through the touch controllers
1.8	The solution should be able to be set up within a maximum of 1 hour	Observations	-
1.9	The solution should be able to be used during short, long and repeated sessions	Interviews	-
1.10	The solution should be usable by the Swedish courts	Literature	-
1.11	The solution should not be restricted to a geographical location	Literature	-

2. Accessibility			
NO.	Requirements	Origin	Implementation
2.1	The solution should be able to support users with different native languages	Interviews	-
2.2	The solution should be adaptable to the user's cognitive ability	Interviews	-
2.3	The solution should be adaptable to the user's physical ability	Interviews	Different ways to navigate (move and rotate) in the environment.
2.4	The solution should be adaptable to the user's technical ability	Interviews	Different ways to navigate (move and rotate) in the environment.
2.5	The solution should enable use by users with visual impairments	Interviews/Literature	-
2.6	The solution should enable use by users with auditory impairments	Interviews/Literature	The environment does not rely on auditory cues.
2.7	The solution should enable use by users with mobility impairments	Literature	Different ways to navigate (move and rotate) in the environment.
2.8	The solution should enable use by users with cognitive impairments	Interviews/Literature	-
3. Ergonomics			
NO.	Requirements	Origin	Implementation
3.1	The solution should aim to minimize the risk of physical pain or discomfort	Literature	Safety and use instructions
3.2	The solution should encourage a natural sitting or standing posture	Literature	Safety and use instructions
3.3	The use of the solution should be limited to a maximum of 20 minutes per session with at least 10-15 minute breaks in between sessions	Literature	-

4. Interaction and form			
NO.	Requirements	Origin	Implementation
4.1	The solution should be user-friendly	Literature	Instructions.
4.2	The solution should use a language that is easily understood by all users	Interviews	Swedish text and pictures.
4.3	The solution should instill trust in the user	Literature	-
4.4	The solution should communicate in a way that is clear and understandable for the user	Literature	Swedish text and pictures.
4.5	The interface should be compatible with the user's mental models	Literature	Button color and shape.
4.6	The solution should give the user realistic and accurate expectations	Literature	Text and picture that leads to each environment.
4.7	The solution should match the expression and expectations of Swedish courts both visually and functionally	Interviews/Literature	Digital interface and scene inspired by a courtroom.
4.8	The solution should introduce the user to the experience	Literature	Instructions.
4.9	The solution should allow for independent use	Interviews	Instructions.
4.10	The solution should provide support for the user during use	Interviews	-
4.11	Information about the presented object, scene or incident should be given during use or in connection to the use of the solution	Interviews	-
4.12	The solution should use UI fitting for the light conditions	Literature	Minimal black and white to reduce eye strain.

5. Hygiene and safety

NO.	Requirements	Origin	Implementation
5.1	The solution should guide hygienic use	Literature	-
5.2	The solution should encourage safe use	Literature	Instructions.
5.3	The solution should allow use between users with no risk of transferring diseases	Literature	-

6. Use areas

6.1.0 Area 1: Giving pre-trial support

NO.	Requirements	Origin	Implementation
6.0.1	The solution should not enable users to edit the original virtual environment	Interviews	No possibility to interact with objects in the scene.
6.1.1	The solution should enable switching between different perspectives (audience, witness, victim, prosecuted)	Interviews	4 different environments (witness, victim, defendant and an exploratory).
6.1.2	The solution should enable viewing the environment with and without people	Interviews	-
6.1.3	The solution should enable use without support from an external person	Interviews	Instructions.
6.1.4	The solution should enable viewing the environment with different abstraction levels	Interviews	-
6.1.5	The solution should give basic information about trials	Usability test	Partly, visual information of the appearance of a courtroom.

6.2.0 Area 2: Viewing of object

NO.	Requirements	Origin	Implementation
6.0.1	The solution should not enable users to edit the original virtual environment	Interviews	Not applicable
6.0.2	Use of the solution should be able to be recorded and documented	Interviews	Not applicable
6.0.3	The solution should enable casting and/or linked screens	Interviews	Not applicable
6.0.4	The solution should provide information about casted/linked screens	Interviews	Not applicable
6.0.5	The solution should allow having multiple users in the same virtual environment	Interviews	Not applicable
6.0.6	The solution should allow marking observation points	Interviews	Not applicable
6.0.7	The solution should allow displaying annotations	Interviews	Not applicable
6.0.8	The solution should enable co-use	Interviews	Not applicable
6.0.9	The solution should allow for communication between all users	Interviews	Not applicable
6.2.1	The solution should enable non-destructive scaling, translation and rotation of objects	Interviews	Not applicable

6.3.0 Area 3: Viewing of scene

NO.	Requirements	Origin	Implementation
6.0.1	The solution should not enable users to edit the original virtual environment	Interviews	Not applicable
6.0.2	Use of the solution should be able to be recorded and documented	Interviews	Not applicable
6.0.3	The solution should enable casting and/or linked screens	Interviews	Not applicable

6.0.4	The solution should provide information about casted/linked screens	Interviews	Not applicable
6.0.5	The solution should allow having multiple users in the same virtual environment	Interviews	Not applicable
6.0.6	The solution should allow marking observation points	Interviews	Not applicable
6.0.7	The solution should allow displaying annotations	Interviews	Not applicable
6.0.8	The solution should enable co-use	Interviews	Not applicable
6.0.9	The solution should allow for communication between all users	Interviews	Not applicable
6.3.1	The solution should enable non-destructive scaling, translation and rotation of objects	Interviews	Not applicable
6.3.2	The solution should enable an illuminated version	Interviews	Not applicable

6.4.0 Area 4: Reconstruction of incident

NO.	Requirements	Origin	Implementation
6.0.1	The solution should not enable users to edit the original virtual environment	Interviews	Not applicable
6.0.2	Use of the solution should be able to be recorded and documented	Interviews	Not applicable
6.0.3	The solution should enable casting and/or linked screens	Interviews	Not applicable
6.0.4	The solution should provide information about casted/linked screens	Interviews	Not applicable
6.0.5	The solution should allow having multiple users in the same virtual environment	Interviews	Not applicable
6.0.6	The solution should allow marking observation points	Interviews	Not applicable
6.0.7	The solution should allow displaying annotations	Interviews	Not applicable

6.0.8	The solution should enable co-use	Interviews	Not applicable
6.0.9	The solution should allow for communication between all users	Interviews	Not applicable
6.4.1	The solution should enable users to add, remove or move additional objects that are not included in the original environment	Interviews	Not applicable
6.4.2	The solution should allow multiple statements of the incident to be visualized in the scene	Interviews	Not applicable
6.4.3	The solution should allow multiple statements/versions of the incident to be shown in the scene	Interviews	Not applicable
6.4.4	The solution should enable an illuminated version	Interviews	Not applicable

6.5.0 Area 5: Reviewing material

NO.	Requirements	Origin	Implementation
6.0.1	The solution should not enable users to edit the original virtual environment	Interviews	Not applicable
6.0.8	The solution should enable co-use	Interviews	Not applicable
6.0.9	The solution should allow for communication between all users	Interviews	Not applicable
6.5.1	The solution should allow multiple statements/versions of the incident to be shown in the scene	Interviews	Not applicable
6.5.2	The solution should allow showing simulations of the incident	Interviews	Not applicable

Appendix D - Survey template 2

The second survey was sent out to professionals within Swedish courts.

Survey: All professionals excl. witness support

What role do you have/have you had? (You can choose multiple choices)

- ☐ Lay judge
- ☐ Lawyer
- ☐ Prosecutor
- ☐ Judge
- ☐ Recording clerk
- ☐ Police
- ☐ Witness support
- ☐ Interpreter
- ☐ Else:___

Viewing of object

What information is important to give/have in connection to viewing of object?
Answer:

Which tools/aids can one use during viewing of objects? (mention as many as you can think of)
Answer:

What is your attitude towards viewing of objects through VR?
1 = Very negative
2
3
4
5 = Very positive

How likely is it that you would prefer viewing of objects through VR more than a physical viewing?
1 = Not likely at all
2
3
4
5 = Very likely

Do you have any additional thought of viewing of objects through VR?
Answer:

Viewing of scene

What information is important to give/have in connection to viewing of scene?
Answer:

Which tools/aids can one use during viewing of scene? (mention as many as you can think of)
Answer:

What is your attitude towards viewing of scene through VR?
1 = Very negative
2
3
4
5 = Very positive

How likely is it that you would prefer viewing of scene through VR more than a physical viewing?
1 = Not likely at all
2
3
4
5 = Very likely

Do you have any additional thought of viewing of scene through VR?
Answer:

Questioning of people

What information is important to give/have in connection to questioning people?
Answer:

Which tools/aids can one use during questioning of people? (mention as many as you can think of)
Answer:

What is your attitude towards questioning people “in the crime scene” using VR?
1 = Very negative
2
3
4
5 = Very positive

How likely is it that you would prefer questioning people “in the crime scene” using VR more than a traditional questioning?
1 = Not likely at all
2
3
4
5 = Very likely

Do you have any additional thoughts of questioning people using VR?
Answer:

Survey: Witness support

Introduction

What role do you have/have you had? (You can choose multiple choices)

- ☐ Lay judge
- ☐ Lawyer
- ☐ Prosecutor
- ☐ Judge
- ☐ Recording clerk
- ☐ Police
- ☐ Witness support
- ☐ Interpreter
- ☐ Else:____

Witness support with VR

Are there any routines connected to giving support to make sure it is done correctly?
Answer:

What makes the support given to people successful or unsuccessful?
Answer:

What aids/tools are used when giving support to people? (mention as many as you can think of)
Answer:

What information is important to give/have in connection to giving support to people?
Answer:

How do you adjust the support to different types of people? (e.g. age)
Answer:

What is something you would want to be able to do while giving support that you can NOT do today?
Answer:

What is your attitude towards VR as an aid while giving support?
1 = Very negative
2
3
4
5 = Very positive

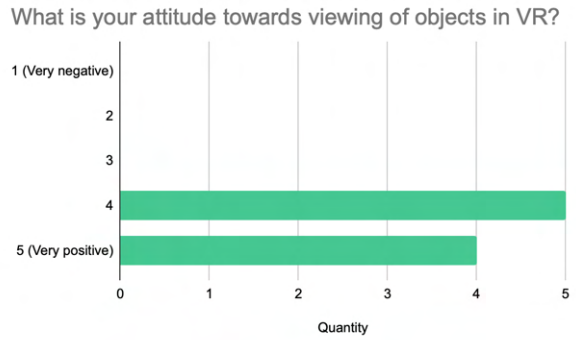
How likely is it that you would use VR as an aid when giving support?
1 = Not likely at all
2
3
4
5 = Very likely

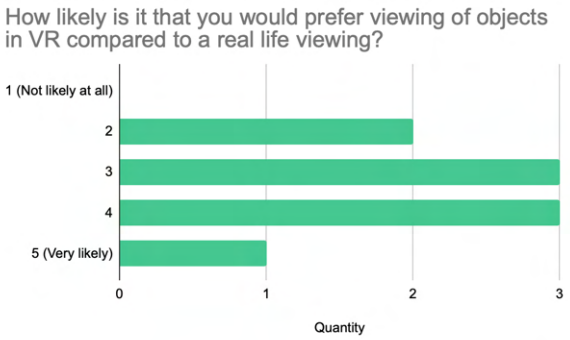
What drawbacks do you see with using VR as a part of the support function?
Answer:

What advantages do you see with using VR as a part of the support function?
Answer:

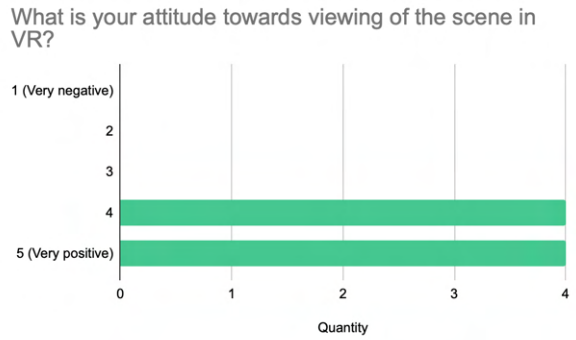
Appendix E - Survey results 2

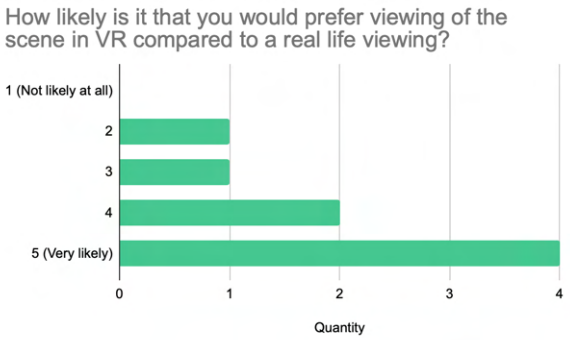
Attitude towards VR for viewing of objects



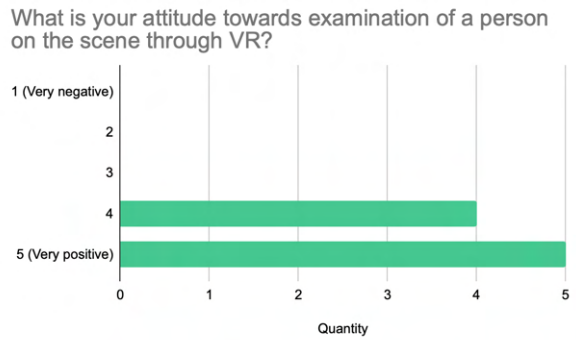


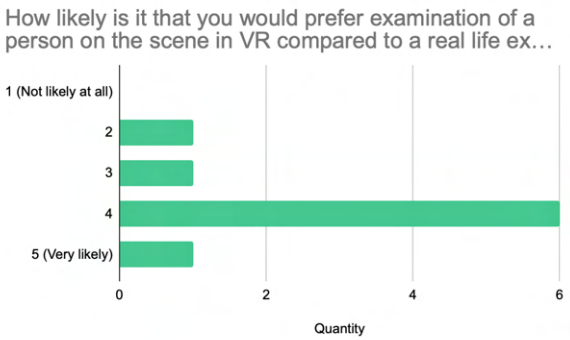
Attitude towards VR for viewing of scene



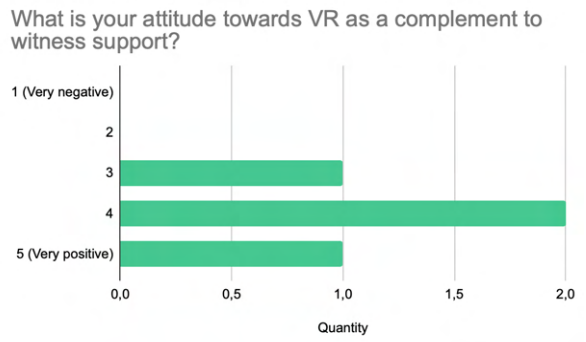


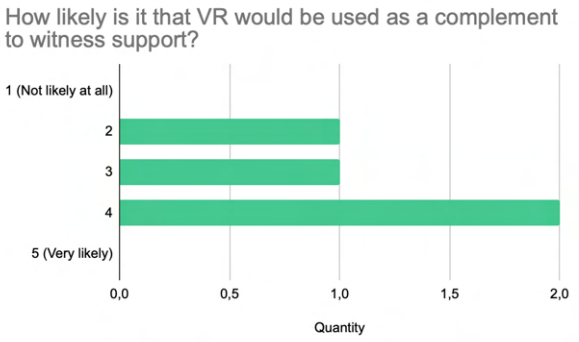
Attitude towards VR for reconstruction of incident





Attitude towards VR for witness support





Appendix F - Usability test template

Survey before test

What is your given number?
Answer:

How well would you say that you know what a Swedish courtroom looks like?
1 = Very little
2
3
4
5 = Very much

Have you ever visited a trial before?

- ☐ Yes
- ☐ No

Have you ever tried VR before?

- ☐ Yes
- ☐ No

If you have, which VR-equipment have you tried?

- ☐ HTC Vive
- ☐ Oculus Quest or Quest 2
- ☐ Oculus Rift or Rift S
- ☐ Oculus Go
- ☐ VR-equipment for the phone
- ☐ Else: ____

How likely would you say that you would contact a witness support before a trial today? (if you are called to witness in a trial of careless driving)
1 = Very unlikely
2
3
4
5 = Very likely

How likely would you say that you would contact a witness support before a trial today? (if you are called to witness in a trial of assault)
1 = Very unlikely
2

3
4
5 = Very likely

How likely would you say that you would contact a witness support before a trial today? (if you are called to witness in a trial of murder)
1 = Very unlikely
2
3
4
5 = Very likely

If you had the opportunity to see a courtroom through VR, would that increase the likelihood for you to contact witness support before a trial?
1 = Reduce the likelihood
2
3
4
5 = Increase the likelihood

Which of the following symptoms do you feel right now and to what degree?
(Not at all, A little, A lot)

- Sweats
- Chills
- Virtigo
- Drowsiness
- Headache
- Fatigue
- Nausea
- Dizziness
- Blurred vision
- Eyestrain
- Difficulty focusing
- Difficulty concentrating

Do you have any visual impairments?
Answer:

Do you have any auditory impairments?
Answer:

Do you have any cognitive impairments?
Answer:

Do you have any physical impairments?
Answer:

Tasks during test

Task 1

You were at Korsvägen when a person chose to physically hit someone. This was investigated and went to court, and the accused is charged for assault. You have been called to give a witness statement in trial. There is a new service where you can see a courtroom through VR which is why you are here today. To get support. You have VR-equipment on the table in front of you, would you like to start the use?

Task 2

First, you want to know where you will be seated

Task 3

If a fire were to break out, do you know where you should exit?

Task 4

Your friend has come with you to the trial, where will this person be seated?

Task 5

Are there any more perspectives that you can see the environment from? Which are these?

- 1st lead: Can you exit the environment?
- 2nd lead: Is there anything in the environment indicating that you can exit the environment?
- 3rd lead: Is there any button anywhere nearby?
- 4th lead: Can you choose MENY

Task 6

Now you want to explore the courtroom and see what it looks like from the judges table

Task 7

What people are seated at the judge's table?

Task 8

Where was it that you as a witness was supposed to be seated?

Task 9

Can you now exit the room?

- 1st lead: Can you exit the environment?
- 2nd lead: Is there anything in the environment indicating that you can exit the environment?
- 3rd lead: Is there any button anywhere nearby?
- 4th lead: How would you have left the room in reality

Survey after test

What is your given number?
Answer:

How well would you say now that you know what a Swedish courtroom looks like?
1 = Very little
2
3
4
5 = Very much

Has your opinion changed after the use of VR?
Answer:

How likely would you say that you would contact a witness support before a trial today? (if you are called to witness in a trial of careless driving)
1 = Very unlikely
2
3
4
5 = Very likely

Has your opinion changed after the use of VR?
Answer:

How likely would you say that you would contact a witness support before a trial today? (if you are called to witness in a trial of assault)
1 = Very unlikely

2
3
4
5 = Very likely

Has your opinion changed after the use of VR?
Answer:

How likely would you say that you would contact a witness support before a trial today? (if you are called to witness in a trial of murder)
1 = Very unlikely
2
3
4
5 = Very likely

Has your opinion changed after the use of VR?
Answer:

I find the experience to be according to the expectations I have/had of Swedish courts?
1 = I do not agree
2
3
4
5 = I agree

What was according to your expectations and what was not?
Answer:

Which of the following symptoms do you feel right now and to what degree?
(Not at all, A little, A lot)

- Sweats
- Chills
- Virtigo
- Drowsiness
- Headache
- Fatigue
- Nausea
- Dizziness
- Blurred vision
- Eyestrain
- Difficulty focusing
- Difficulty concentrating

The experience was:

1 = Clear
2
3
4
5 = Unclear

1 = Predictable
2
3
4
5 = Unpredictable

1 = Complicated
2
3
4
5 = Simple

1 = Modern
2
3
4
5 = Unmodern

1 = Exclusive
2
3
4
5 = Ordinary

1 = Exciting
2
3
4
5 = Calming

To what degree did you experience the following emotions (from 0 to 5)?

- Joy
- Liking
- Surprise
- Fear
- Sorrow
- Disgust
- Anticipation
- Anger

I experience that the instructions:
(Not at all, Partly true, Completely correct)

- are readable and easy to understand
- give me a feeling of trust
- guide my use
- give me the information I need to use
- are pleasant to the eyes
- have pleasant transitions
- enable use without help
- match my previous knowledge

Appendix G - Evaluation of the usability test

HTA of the tasks

1. Get to the main menu
   1.1 Read the instructions
   1.2 Do what the instructions show
   1.3 Continue to next slide
2. Go into the witness environment
   2.1 Find witness environment
   2.2 Press on witness environment
3. Find doors to enter/exit environment
4. Find where audience is seated
5. Exit the environment
   5.1 Find the menu-button
   5.2 Reach for the menu-button with your hand
6. Go into the explore environment
   6.1 Find explore environment
   6.2 Press on explore environment
7. Move to the judge's perspective
   7.1 Press button or use joystick to move in environment
   7.2 Rotate with head or joystick
8. Find who is seated at the judge’s table
   8.1 Press button or use joystick to move in environment
   8.2 Rotate with head or joystick
   8.3 Read signs at the front of the desk
9. Show at the witness table
10. Exit the environment
    10.1 Move to a door
    10.2 Reach for the door

CW and PHEA on the HTA

Påbörja användning	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Vet att testet är med VR. Uppgiften är tydlig.	Vet inte hur man får på sig det. Oklar ordning. Svårt att se kontrollerna med headset på.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Instruktionerna visar. Headset format så att det passar ett huvud. Ser inte remmarna	Förstår inte instruktionerna. Vågar inte dra i headsetet. Kommer inte sitta exakt som det borde.	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Finns bara en utrustning. Går bara att ta på sig på ett sätt	Kontrollernas säkerhetsrem tas inte på, anses inte nödvändigt.	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja	Headsetet är på huvudet. Sitter det löst inser anv att den inte är som den ska	Om den sitter löst, vet inte hur man åtgärdar	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Håller headset mot ögonen, drar inte över huvudet 2. Justerar inte så att det passar mot sitt huvud	1. Förstår inte hur man tar över bandet på huvudet. Tror att det inte går. 2. Ser inte att funktionen finns. Vet inte hur man justerar. Reagerar inte på att det borde gå.	1. Sitter inte på huvudet, kan inte använda kontrollerna. 2. Sitter inte optimalt, för hårt/löst	1. Inser att man inte kan hålla i kontroller och headset samtidigt 2. Inser att den sitter konstigt, konstig skärpa, ostabil	1. Försöker få headsetet fast på huvudet, utforskar headsetet. 2. Tar av och kollar om man kan fixa till den så att det sitter bättre
3. Läser inte instruktionerna	3. Van vid att gå förbi instruktioner, tror man klarar sig utan, jobbigt att läsa.	3. Kommer inte förstå eller veta om alla funktioner.	3. När man väl behöver hjälp och inte kan klara sig	3. Kunna gå tillbaka till instruktionerna
4. Följer inte instruktionerna	4. Vill bara ta sig "igenom" instruktionerna. Förstår inte att det är något som man ska följa, ser inte hur det påverkar ens användande	4. Inte optimalt användande. Försämrar ens experience på grund av komfort, funktioner.	4. Eventuell ingen - kanske om man inser att något inte är som det ska	4. Kunna gå tillbaka till instruktionerna. Uppmaningar till att rätta till ev.
5. Kommer inte ihåg instruktionerna	5. Låser dem, tror att man kan men har inte fått testa de flesta	5. När man väl ska använda kommer man inte ihåg hur det var, bara att det faktiskt går.	5. Kommer ihåg att man kan, men när man väl ska använda lyckas inte välja rätt	5. Fortsätta testa olika knappar, eller att få se instruktionerna igen
6. Vet inte hur man använder glasögon under	6. Den ska mot ögonen, de flesta har inte glasögon, tror att det inte går.	6. Vågar inte ta på sig headsetet optimalt, rätta till. Dra åt..	6. Ingen	6. Bli uppmanad att följa instruktionerna ändå. Ev välja att man har glasögon, få en speciell instruktion?

Var du själv ska sitta	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Kommer ihåg att hen är vittne, tydligt med "jag är vittne"	Om hen inte kommer ihåg att hen är vittne. Om hen flaxar med händerna och kommer åt menyknappen	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Ja, tydligt med att det står "vittne"		
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Delvis. Svårt att avgöra om man klickat.	Om inget indikerar att miljön laddar, anv kmr inte veta vad som händer. Om anv inte kommer ihåg hur man väljer.	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Nej	När miljön väl laddat - delvis. Inget som indikerar att man är i vittne-miljön	Ser inte att man sitter i vittnesbås om man inte vet sedan tidigare att det är rätt. Tar tid för miljön att ladda	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Väljer fel miljö.	1. Råkar klicka på en annan miljö, förstår inte vilken miljö hen ska klicka på.	1. Associerar vittnets plats till fel plats. Blir irriterad.	1. Ev. ingen, eller blir tillsagd	1. Tar sig ut tillbaka till meny
2. Lyckas inte klicka på miljö.	2. Vet inte hur, kan inte fokusera på knappen.	2. Kan inte ta sig in i miljön. Försvårar anv. Dålig experience.	2. Inser att hen inte kommer vidare.	2. Få instruktioner efter ett tag på hur man gör, eller extern hjälp. Kunna välja genom joystick
3. Försöker välja medan miljö laddar.	3. Ser inte att miljön laddas.	3. Förstår inte sina handlingar. Otydligt. Kan ev sega ner programmet. Vet inte vilken miljö man kommer in i tillslut	3. Inser när väl inne i miljön.	3. Bli tillsagd att man ska vänta
4. Vet inte vilken miljö man är inne i.	4. ingen återkoppling.	4. Associera fel miljö till fel plats.	4. Ser i menyn de olika bilderna. Kan också ha något i miljön som indikerar.	4. Ingen.

Om det skulle brinna	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Instinkt att leta efter dörrar/nödutgång	Kabel kort, ev inte kunna rotera fullt ut.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Inser att det går att rotera blicken. Ser dörrar	Kabel	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Direkt återkoppling	-	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja		-	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Vänder inte på huvudet 2. Vet inte att testare ser det de visar.	1. Osäker, försiktig, mår illa. 2. Vet inte hur det funkar. Vet inte var informationen hamnar	1. Kommer inte hitta alla dörrar. Kommer inte kunna utforska miljön 2. Osäker på hur hen ska visa	1. Inser att hen kan vrida när hen kollar åt sidan. 2. Försöker visa med handen, för att vara säker.	1. Testar att rotera.

Kompis sitta	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Letar efter platser andra kan sitta på.	Inte indikerat vem som ska sitta var.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Direkt återkoppling med att rotera.	-	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Delvis, kan endast gissa var kompisar kommer sitta.	-	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Nej	Inget som indikerar huruvida man förstått rätt.	-	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Associerar fel plats till åhörare.	Ingenting som säger vad som är åhörarplatser.	Kan inte veta utan att fråga någon annan.	Ingen om inte någon säger rätt eller fel.	

Fler perspektiv	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Nej	Menyn indikerar inte att det finns fler perspektiv.	Meny associeras till inställningar och annat. Inte endast perspektiv.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Kommer förstå att menyn tar en ut ur miljön.	Kommer inte förstå att hen måste till menyn för att kunna sitta i annat perspektiv.	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Vet att "meny" tar tillbaka till menyn.	Handlingen att sträcka sig mot meny-knappen är inte självklar.	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja	Ser att det laddar.	-	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Vet inte vad meny associeras till. 2. Vet inte hur man klickar på menyknappen. 3. Vet inte att man kan klicka på menyknappen. 4. Tror att man kan se flera perspektiv ur samma miljö.	1. Inget som indikerar att menyn är meny. 2. Ingen förklaring finns. Använder inte samma koncept som tidigare vid klick. 3. Knappen är inte lik resterande knappar. Ser inte klickbar ut. 4. Ingenting som indikerar att det inte går. Står inte ett bestämt perspektiv i miljön (när man väl är inne i miljön).	1. Kommer inte koppla till att det är dit man går om man går till menyn. 2. Tar tid för anv att förstå hur det funkar, kopplar inte rätt handling till rätt effekt. 3. Förstår inte att handlingen finns tillgänglig, kommer försöka hitta andra utvägar. 4. Förstår inte hur man ser ur andra perspektiv.	1. Förstår att det är menyn när man klickar på meny knappen och hamnar där. 2. När väl handen klickar på meny förstår man att det är så man gör. 3. Hittar ingen annan utväg, försöker trycka på den knappen. 4. Inser när man väl är inne i miljön.	1. Kommer därefter koppla meny till menyn. 2. Går på samma metod på resterande menyer också. 3. Inser att knappen funkar genom att den skickar en t menyn. 4. Förstår att varje miljö är ett perspektiv

Domarbordets persp.	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Letar efter miljö som är ur domarbordets persp.	Ingen av miljöerna visar ur dom. persp. Förstår inte vilken av miljöerna det är man ska välja.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Förstå att utforska rättssal ger möjligheten att se ur fler perspektiv än de andra.	Vet inte hur man ska utforska och vad det innebär fullt ut.	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	-	-	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja	-	-	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Vet inte hur man förflyttar sig. 2. Lyckas inte rotera sig. 3. Väljer en av de fasta miljöerna. 4. Ställer sig vid fel bord och fel perspektiv.	1. Kommer inte ihåg från instruktionerna. 2. Sitter på en fast stol. Vet inte hur man gör kommer inte ihåg. 3. Förstår inte skillnaden på funktionerna i de olika miljöerna. 4. Ingenting som indikerar vad som är domarbord, man går på känsla.	1. Tror att det inte går att ta sig till domarbordets perspektiv. Sitter fast. Osäker. 2. Konstiga rörelser och oergonomisk användning. 3. Tror att ingen miljö ger möjlighet att röra sig eftersom de 3 första inte gör det. 4. Vet inte 100% vad som är domarbord, ger ingen förståelse.	1. Ser att det inte går att ta sig fram. 2. Inser att behöver rotera sig. 3. Måste gå till rätt miljö och röra sig för att inse att det går. 4. Eventuell ingen, om inte tillsagd.	1. Testar. Instruktioner igen. 2. Roterar kropp eller testar nya knappar. 3. Instruktioner per miljö kanske? 4. -

Vem sitter vid bordet	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Kommer leta efter svar, eller försöka komma på ett svar.	-	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Kanske. Om hen är övertygad om att det finns instruktioner någonstans.	Indikation finns inte på något annat förutom original skyltarna från miljön.	
Kommer anv att associera korrekt handling med rätt effekt?	Ja/ Nej	Om anv rör sig - kommer se skyltar. Om inte - kmr inte se skyltar.	Kräver att anv är på rätt sida av bordet, sidan man INTE börjar på vid uppg.	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja	Kommer förstå att det står roller där.	-	

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Går inte runt bordet. 2.Ställer sig vid fel bord. 3. Ser inte texten på de olika skyltarna. 4. Förstår inte att det finns något som indikerar.	1. Förstår inte att hen måste gå runt bordet för att se rollerna. 2. Ingenting som indikerar vilket som är domarbord. 3. Förflyttar sig inte mellan de olika skyltarna. 4. Inte tydligt nog, förväntar sig tydligare markering, inget annat är markerat.	1. Kommer inte att få veta exakt vem som sitter där, måste gissa. 2. Kommer inte hitta roller då de är vid riktiga dom. bordet. 3. Tror att hen inte klarar uppg pga dålig syn, får inte veta infon. 4. Vet inte att hen ska leta efter något, tror att det är en själv som testas.	1. Ev ingen upptäckt. 2. Om från rätt persp. kan se skyltar på domarbordet. 3. OM hen flyttar närmare en skylt ser att det syns tydligare. 4. Eventuellt om hen ser skyltarna annars ingen.	1. Ev ingen återhämtning. 2. Går till rätt bord. 3. Testa flytta sig till de olika skyltarna. 4. Eventuellt ingen.

Sitta som vittne	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Vet sedan tidigare var det är man ska kolla.	Inte indikerat, gäller att man kommer ihåg eller har varit i vittnesmiljön först.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Om hen varit vid vittne innan, kommer veta var det är man ska kolla, har lärt sig rotera.	-	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Då de suttit där sedan innan.	-	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja	Konfirmeras att de har utfört uppgiften.	-	

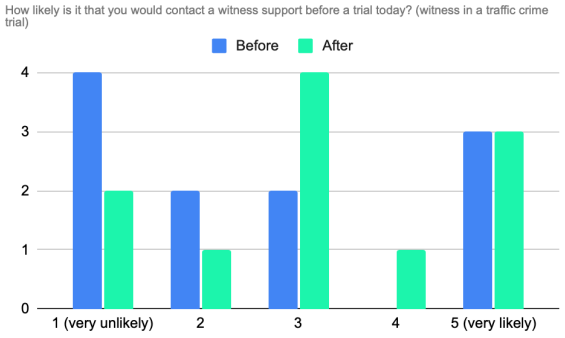
Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Kollar på fel plats.	1. Vet inte vilken plats som är för vittne, inte varit i vittnesmiljö sedan innan, kan inte orientera sig, inget som indikerar.	1. Osäker på om hen har rätt, eventuellt fel bild av var man kommer sitta.	1. Ingen	1. Ingen

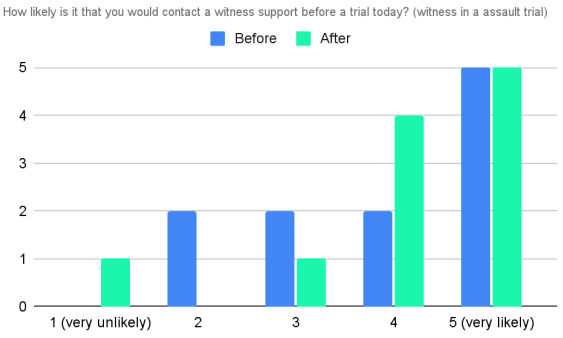
Gå ut ur miljö	J/N	Varför?	Problem	Anteckningar
Kommer anv försöka uppnå rätt effekt?	Ja	Vet att det går från tidigare uppg.	Inte samma sätt som tidigare uppgifter kan vara svårt att förstå.	
Kommer anv att notera att rätt handling finns tillgänglig?	Ja	Vet att det finns från tidigare uppgifter, stämmer med det man hade gjort i verkliga livet.	-	
Kommer anv att associera korrekt handling med rätt effekt?	Ja	Stämmer överens med det man hade gjort i verkliga livet.	-	
Om rätt handling är utförd, kommer användaren att se att handlingen har fört uppgiften närmare målet?	Ja	Ser att menyn laddas.	-	

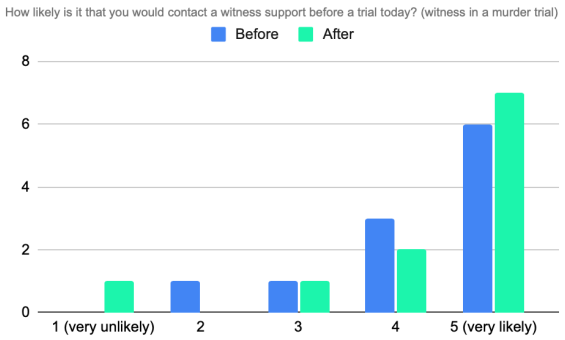
Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1. Tror att det inte går.	1. Går inte nära nog dörren, aktiveras inte.	1. Uppfattar som hen gjort fel trots att det är rätt.	1. OM hen närmar sig närmare, ser att menyn laddas, kan också se menyknappen på svarta dörren.	1. Sträcker sig ytterligare, inser att det går.
2. Letar efter knapp på bord.	2. Så man löser uppgiften i de andra miljöerna.	2. Tror att det inte finns en utväg, förstår inte varför det är olika.	2. Ser menyknapp på dörr, ev ingen.	2. testar dörr istället för bord.

Appendix H - Usability test results

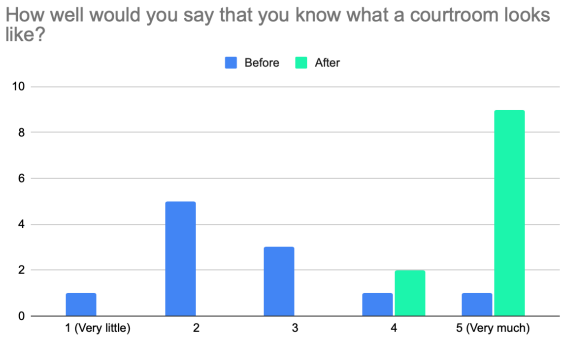
Likelihood asking for witness support



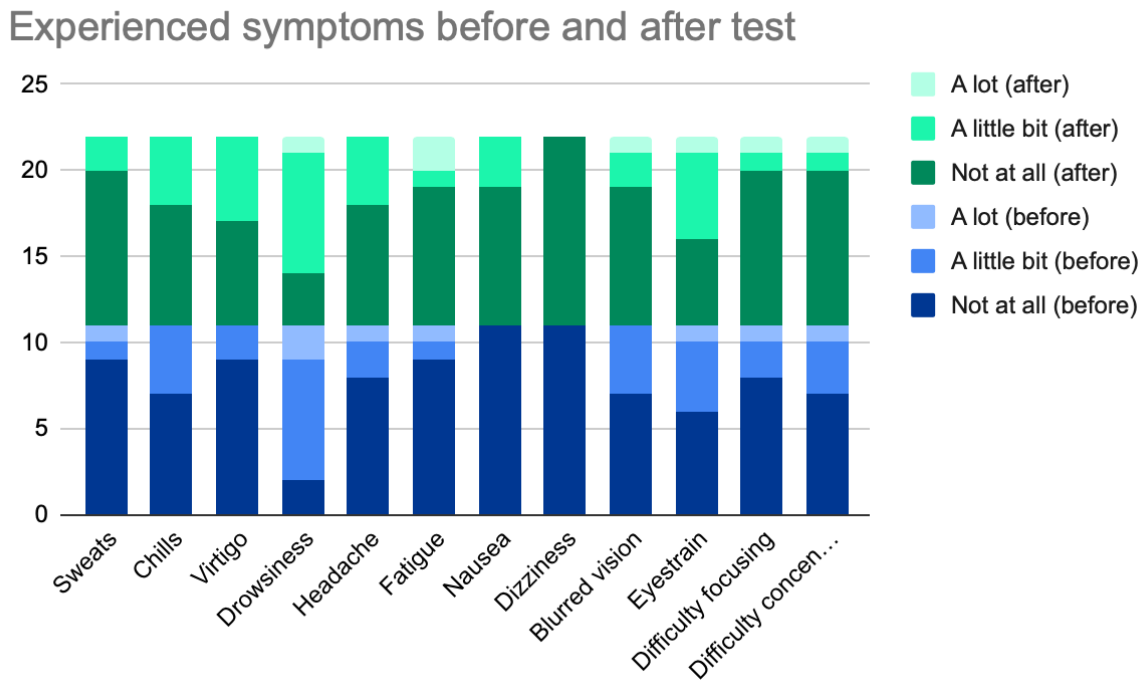




Knowledge of what a courtroom looks like



Experienced symptoms before and after test



PHEA on tasks during test

P.U	Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
1.1 Ja	Osäker på huruvida man ska utföra instruktionerna Frågar hur man kan fixa fokus	Ser ingenting (ser inte handkontrollerna) Osäker på vad instruktionerna menar	Ifrågasättande Vågar inte testa	Försöker se Letar efter knapp	Lyckas trä igenom händer Ändrar avstånd mellan ögon
2.1 Ja	Drar in armarna i ringarna Klickar med fel knapp Förstår inte vad	Vet inte hur hen ska hålla och fästa Läser texten men har inte förstått den, eller uppfattar inte	Händer går åt fel håll Tror att det inte går	Inser att de är åt fel håll Inser att det inte är rätt	Vänder på dem Läser om instruktionerna

	som är baksidan av kontrollen Har inte haft tydlig bild	Inget som förklarar vad som är fram och bak Visste inte vad det berodde på	Förstår inte vad det är hen gör för fel Svårt att läsa instruktionerna	Inser att det inte är rätt och frågar Inser att ändra på headsetet gör det tydligare	Klarar inte av att trycka vidare innan hen får en förklaring Ändrar ytterligare
3.1 Ja					
4.1 Nej	Trycker på menyknappen	Tror att det är knappen som indikeras, eller otydligt	Kan inte lösa problemet själv, iom att menyn kommer upp	Inser att hen inte kommer vidare själv	Måste hjälpa och tillslut berätta vilken knapp hen ska använda för att komma vidare då det upprepas
5.1 Ja	Tappar headsetet (inte på riktigt men håller med händerna) Förstår inte var hand-kontrollerna är Fäster fel band runt fel hand Klickar på meny knapp	Drar inte över bandet över huvudet Ser dem inte med headsetet på, inte upptäckt dem innan hen satt på sig headsetet Håller båda kontroller i en hand och trär över bandet Förstår inte vilken knapp som ska tryckas i	Kan inte ta tag i kontrollerna med händerna för att gå vidare Kan inte följa instruktionerna Kan inte använda kontrollerna med full frihet Behöver hjälp för att komma tillbaka till rätt skärm, kan inte använda	Inser att den faller av från huvudet Inser att hen inte har några hand-kontroller Inser att fel kontroll sitter fast på fel hand (vänster kontroll sitter fast i höger hand) Inser att annan skärm kommit upp Inser att när hen klickar med den igen så funkar det	Ber om hjälp (kan inte klara av det själv utan) och drar ner den över huvudet Frågar vilka handkontroller, kommer inte vidare förrän handkontroller blir tilldelade Tar av bandet från handen Frågar om hen ska klicka på avsluta app, får hjälp för att komma tillbaka till miljön, blir ombedd att kolla

	Har klickat på rätt knapp men inte tagit hen vidare Justerar inte headsetet korrekt (remmarna)	Klickat för svagt eller inte klickat på själva knappen Lyckas inte få ner bandet bakom huvudet	Tror att knappen är fel knapp och väljer därför andra knappar Headsetet kommer inte sitta lika bekvämt eller stabilt		på instruktionerna igen Fortsätter klicka med rätt knapp Väljer att inte göra något åt det
6.1 Ja	Väljer att inte fästa runt händerna	Fästet är längst ut	Mindre säker anv	att det inte går att dra åt	tar på dem som dom är
7.1 Nej	Tar på handkontrollen upp och ner	Förstår inte hur de ska hållas	Instruktionerna kommer inte stämma, svårare att röra sig i miljön Får rikta kontrollerna på ett onaturligt sätt för att välja och “pricka” rätt	-	ingen återhämtning, fortsätter så genom hela testet
8.1 Ja	Klickar två gånger på instruktionerna Ser inte instruktionerna Osäker på om det är rätt	Glider på kontrollen De sitter för långt bort Ser inte hur kontrollerna ser ut	Hoppar över en sida och kan inte komma tillbaka Får anstränga sig för att se Försöker lyfta händerna för att se om det är rätt	Frågar hur hon kommer tillbaka Vet inte om hen gjort rätt	Finns ingen återhämtning Väljer att gå vidare
9.1	Rättar inte till passform på hmd	Orkar inte	Sitter inte korrekt	-	Går vidare med fel passform
10.1	Hittar inte öglorna till handtagen Fäster inte hmd korrekt	Ser inte Förstår inte hur man ska justera	Handtagen inte säkrade Sitter för löst	Lyckas inte Testar	Går vidare utan att fästa kontrollerna Lyckas med sidorna men inte övre

	Går vidare till nästa utan att va beredd	Tolkar knapparna fel	Hinner inte läsa	Går vidare med “annan knapp”	Fortsätter använda “fel” knapp
11.1	Justerar inte något	Orkar inte	Sitter inte korrekt	-	Går vidare med fel passform
1.2 Ja	Frågar om hen ska klicka vidare	Frågar om det mesta, vill inte göra fel	Måste bli uppmuntrad till att klicka	Ledare säger ja	Går vidare/klickar
2.2 Ja					
3.2 Ja					
4.2 Ja					
5.2 Ja					
6.2 Ja					
7.2 Ja	Trycker på menyknappen	Instinktiv reaktion att trycka på menyknappen	Tas tillbaka till menyn, tar tid att ladda mellan miljöer	Inser att den tar till menyn	Går tillbaka till miljön och gör inte om
8.2 Ja					
9.2 Ja					
10.2 Ja					
11.2 Ja	Åker direkt ut	Händerna hamnar förmodligen på MENY	Åker ut, förstår inte	Kommer tillbaka till menyn	Testledaren tar kontrollerna
1.3 Ja	Tar sig själv ut ur miljön Upprepar samma fel	Viftar med händerna	Trycker på menyknappen	Inser att hen är i miljön	Går tillbaka till vittne-miljö Blir ombedd att hålla händerna stilla till en början

2.3 Ja	Försöker få fram laserpekare	Har haft den tidigare i menyn, försöker få fram den igen	Klickar på knappar som kan förstöra eller leda vidare	Ser att inget händer just denna gång	Går vidare
3.3 Ja					
4.3 Ja					
5.3 Ja					
6.3 Ja					
7.3 Ja					
8.3 Ja					
9.3 Ja					
10.3 Ja					
11.3 Ja					
1.4 Ja					
2.4 Ja					
3.4 Ja					
4.4 Nej	Pekar på stolen jämte	Inget som indikerar var	Vet inte helt säkert var, svårt att ha rätt, måste gissa		
5.4 Ja					
6.4 Ja					

7.4 Ja					
8.4 Ja	Kollar inte runt ordentligt	Sitter på en stationär stol	Ser inte alla platser och hur det ser ut	Ingen	Ingen
9.4 Ja					
10.4 Ja					
11.4	Pekar åt höger	Vet inte var	Osäker	-	Gissar
1.5 H1 Ja					
2.5 H1 Ja	Försöker komma ihåg perspektiv ist för att gå tillbaka till menyn	Frågan är dåligt formulerad			
3.5 H2 Ja	Vill ta sig ut ur dörren	Vad man brukar göra	Kommer inte ut		
4.5 H3 Nej	Letade efter en knapp på sina händer, viftade till med händerna klickade på meny	Visste inte hur hen skulle hitta ut-knappen	Vet inte vad som gjorde att händelsen skedde, kommer inte lära sig från den	Visa när hen klickat på något	
5.5 Ja	Tror dörren är en utväg Tror att hen ska klicka på A/X som knapp	Dörr är normalt sätt där man går ut (ev frågan Har blivit introducerad till de knapparna men inte menyknappen	Kommer inte ut ur miljön Kommer inte utföra korrekt handling	- Försöker trycka men inget händer	Frågar Frågar

	Hen rullat bak med stolen för långt	i miljön Försöker få distans mot miljön hen sitter i (stol som rullar)	Sitter för långt från menyknappen och kan inte nå den	-	Blir ombedd att flytta närmare med stolen
6.5 H2 Ja					
7.5	Vill gå fysiskt ut ur miljön Uppfattar frågorna som att man fysiskt ska gå ut ur miljön	Vill gå till dörren, så man vanligtvis hade gjort	Kan orsaka skador och säkerhetsrisk	-	Blir ombedd att sitta ner
8.5 Ja	Hittar inga fler perspektiv Reser sig upp och går ut genom dörren Ser inte menyknappen för att indikera att ta sig ut Försöker välja meny med joystick (laser)	Förstår inte om perspektiven ska vara i samma miljö eller inte Vanligtvis hur man tar sig ut ur ett rum Otydlig, inte tryckbar Det var så man valde i föregående menyer	Klarar inte av uppgiften Utgör fara Kommer inte ut ur miljön. Lyckas inte klicka på knappen	Ser att det inte finns något som indikerar att hon kan välja med joysticken	Följdfråga Ingen Känner att hen inte kan välja knappen
9.5	Ser inte knappen	Kollar inte ner, försöker nå dörren med knappar	Kommer inte ut	Får 2 ledtrådar	Hittar MENY
10.5	Försöker klicka på knappar och nå dörren	Inser inte att MENY finns	Kommer inte ut	Får 1 ledtråd	Hittar MENY

11.5	Åker direkt ut	Händerna hamnar på MENY när hen tar upp kontrollerna igen	Åker ut	Kommer tillbaka till menyn	Accepterar läget och fortsätter
1.6	Står fel i ui-t, går in på målsägande				
2.6	Går in i fel miljö, då det står fel Försöker gå fysiskt eftersom det är i fel miljö och inte kan röra sig	Eftersom det är i fel miljö och inte kan röra sig	Vet inte hur hen ska göra		
3.6 Ja	Står fel i ui-t men väljer rätt ändå				
4.6 Ja/nej	Väljer fel pga fel ui				
5.6 Ja	Står fel i ui-t kopplar inte rätt miljö till frågan				
6.6 Ja	Står fel i UI-t, vet inte vilken miljö hen ska välja				
7.6 Ja	Står fel i UI-t, fel fråga				
8.6 Ja					
9.6 Ja					
10.6 Ja					

11.6 Ja					
1.7 Ja					
2.7 Ja					
3.7 Ja					
4.7 Ja/nej	Tror inte hen kan ta sig till domarbordet Tror inte hen kan ta sig bakom domarborder	Ingenting som påvisar någon skillnad mot föregående Hen har hamnat framför och måste höja handen mer för att komma över “barriären”	Vet inte när man kan och inte kan röra sig Tror inte att det funkar att ta sig bakom		Blir ombedd att testa olika knappar
5.7 Ja	Hamnar framför bordet och kommer inte bakom	Måste höja strålen så hen kommer över bordet	Flyttas bara i sidled	Att hen inte kommer bakom bordet	Väljer att gå runt bordet
6.7 -	-	-	-	-	-
7.7 Ja	Viftar med handen för att ta sig framåt Går runt möbler	Vet inte hur hen ska ta sig fram, testar Tror att hen ska krocka i dem	Kommer inte fram och kan inte utföra uppgiften Använder locomotion mer än vad som behövs	Inser att hen inte tar sig framåt -	Testar andra rörelser blir ombedd att testa kontrollerna Fortsätter på det sättet
8.7	Kommer inte fram till domarbord Klickar på fel knapp	Har inget synligt att välja Gör inte det hon vill (ta sig fram) Vet inte hur man gör	Kan inte utföra uppgiften Tror att det inte går	 Ser att ingenting	 Försöker med nästa knapp

		annars		händer	
	Försöker gå fysiskt	Lyckas inte ta sig fram	Verkar uppgiven		
	Viftar med händerna i ett försök att gå (genom händernas rörelser)	Har för sig att det var det instruktionerna visade	Verkar uppgiven		
	Klickar på trigger-knappen	Ser att det ger något att trycka in	Använder fel knapp och kommer inte vidare	Ser att det inte funkar	Testar andra knappar
	Trycker men släpper inte knappen		Kommer inte vidare	Ser att det borde funka	Testar att trycka igen (släpper och kommer därför vidare)
9.7	-	-	-	-	-
10.7	-	-	-	-	-
11.7	-	-	-	-	-
1.8	Kollar på stolar för att se om vilka det ska sitta där	Vet inte vart hon ska kolla	Får inte svar på frågan	Inser att det inte står något där	Testar med en annan vy
2.8	Gissar vem som sitter	Vet inte om att det finns indikationer,	Får inte kunskapen om vem som sitter	Göra det tydligare	
3.8 Nej					

4.8 Ja					
5.8 Ja	Roterar med stolen för att nå punkten hen vill transportera till	Hamnar “åt fel håll”, 180 grader mot riktningen hen vill gå till, kommer inte ihåg att det finns rotations reglage	Rör sig runt i den fysiska miljön vilket kan medföra skada	-	Fortsätter på samma sätt
6.8 -	-	-	-	-	-
7.8 Nej	Chansar Letar indikation på stolar	Vet inte att det finns utskrivet Det är där hen befinner sig vid frågan	Kommer inte få rätt info Kommer inte få rätt info	- Hittar inget	Blir frågad om det finns något som indikerar Klarar inte av uppg
8.8 Nej	Flyttar sig inte för att se	Osäker på hur hen flyttar sig, tror inte att det går	Kan inte se dem som är för långt bort	Inser att det inte går att gå närmare	Väljer att inte gå närmare
9.8	Kan inte svaret	Inser inte att det finns skyltar	Kan inte svaret	TL: “finns det nåt sätt att ta reda på det?”	Börjar röra sig framåt och läser
10.8	Kan inte svaret	Inser inte att det finns skyltar	Kan inte svaret	TL: “finns det nåt sätt att ta reda på det?”	Börjar röra sig framåt och läser
11.8	Kan inte svaret	Inser inte att det finns skyltar	Kan inte svaret	TL: “finns det nåt sätt att ta reda på det?”	Börjar röra sig framåt och läser
1.9 Ja					
2.9 Ja					

3.9 Ja					
4.9 Ja					
5.9 Ja					
6.9 -	-	-	-	-	-
7.9 Ja					
8.9 Ja					
9.9 Gjorde direkt själv	-	-	-	-	-
10.9 Ja					
11.9 Ja					
1.10	Kommer inte ut	Måste gå närmare dörren	Vet inte om hen gjort rätt	Testar att sträcka sig närmare	
2.10 Ja					
3.10 Ja					
4.10 Ja					
5.10	Ställer sig vid dörren och anser sig ha lämnat rummet Letar efter menyknapp på border	Det var där miljön började Det var där menyknappen var i den andra	Har inte egentligen lämnat rummet Hittar ingen väg ut ur rummet	Blir frågad igen och inser att hen inte lämnat rummet Inser att det inte finns någon knapp	Letar efter menyknapp Letar efter knapp och antar att man kan gå ut ur

		miljön			rummet genom dörren
6.10 -	-	-	-	-	-
7.10 Ja	Går inte tillräckligt nära dörren	Tror hen är tillräckligt nära	Får ingen feedback ang att det går att gå ut genom dörren	Tror att det inte går att gå ut genom dörren	Går mot en annan dörr
8.10 Ja	Klickar i fel knapp	Vet inte vilken knapp man ska klicka för att ta sig fram	Kan inte utföra uppgiften	Inser att hen inte kommer någonstans	Blir bedd att använda en annan knapp
9.10 Ja					
10.10 Ja					
11.10 Ja					

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