

Advantages of using Virtual Reality as a financial instrument

How risk and opportunities can be visualized when making investments

Gustav Ryrlén

DEPARTMENT OF DESIGN SCIENCES
FACULTY OF ENGINEERING LTH | LUND UNIVERSITY
2018

MASTER THESIS



Advantages of using Virtual Reality as a Financial Instrument

How risk and opportunities can be visualized when
making investments

Gustav Ryrlén



LUND
UNIVERSITY

Advantages of using Virtual Reality as a Financial Instrument

How risk and opportunities can be visualized when making investments

Copyright © Gustav Ryrlén

Published by

Department of Design Sciences
Faculty of Engineering LTH, Lund University
P.O. Box 118, SE-221 00 Lund, Sweden

Subject: Interaction Design (MAMM01)

Supervisor: Joakim Eriksson
Examiner: Johanna Persson

Abstract

In recent years, the phenomenon of Virtual Reality has been highlighted by most technology-interested persons around the world. The technology allows visualization and interaction with environments, which in real life would be too costly to recreate. At the same time, the banking sector's ways of presenting financial information are relatively old fashioned and still consist of lists and 2D graphs. This study will examine whether VR can be used by financial actors as an instruments and what the technology can contribute to in economics. The present work will lay the foundation for a VR test environment that will be tested and evaluated by potential users. The design process of the environment will include 1) Investigation phase – flaws in current systems will be identified, meetings with bank representatives and end user identification will be conducted. 2) Idea-generating - through brainstorming, ideas on the design of the environment will be developed. 3) Prototypes - In this phase, prototypes from sketches will be forwarded into 3D simulation which will be developed and evaluated. The prototypes will form the development of the final creation of the environment. 4) Final phase - The final part of the process will include testing on the developed environment and present conclusions as to whether VR has a future in the banking system. The testing will be conducted in two different groups, one with people with financial experience and one with people without economics knowledge. The test embraces a scenario-based model with physical and analytical tasks ending with a feedback survey.

Keywords: Financial Technology, Data Visualization, Virtual Reality, Portfolio Management

Sammanfattning

Fenomenet Virtual Reality (VR) har dom senaste åren uppmärksammats av de flesta teknikintresserade världen över. Tekniken möjliggör bland annat visualisering och interaktion med miljöer och som i verkligheten skulle bli för kostsamma att återskapa. Samtidigt så står bankernas sätt att presentera finansiell information förhållandevis stilla och utgörs fortfarande av listor och 2D-grafer. I studien kommer det undersökas huruvida VR kan användas av finansiella aktörer som instrument och vad tekniken kan bidra till inom ekonomi. Föreliggande arbete kommer lägga grunden för en VR-testmiljö som kommer att testas och utvärderas av tänkta användare. Designprocessen av miljön kommer att innefatta 1) Definierande fas – då kommer brister i nuvarande system identifieras, möten från bankrepresentanter och identifiering av slutanvändare att genomföras. 2) Idegenererande – genom brainstorming kommer idéer på utformningen av miljön att tas fram. 3) Prototyper –I denna fas kommer prototyper i form av skisser vidare fram till 3D-ritningar att tas fram och utvärderas. Prototyperna kommer att lägga grunden till utvecklingen av det slutgiltiga skapandet av miljön. 4) Slutfasen – Sista delen av processen kommer att innehålla testning på den framtagna miljö och presentera slutsatser huruvida VR har en framtid inom bankväsendet. Testningen kommer att genomföras på två olika grupper, en med personer som har ekonomisk erfarenhet och en med personer utan ekonomierfarenheter. Testet anammar en scenariobaserad modell med fysiska och analyserande uppgifter som avslutas med en feedback-enkät.

Nyckelord: Finansteknologi, Datavisualisering, Virtuellt verklighet, Portföljsteori

Acknowledgments

I've would like to thank Joakim Eriksson at Lund Faculty of Engineering for supervising me through the thesis process. Without your guidelines and the access, you've provided me with to the Virtual Reality-lab nothing would have been possible.

I also want to address a special thanks to Pierre at iZave and Erik at Handelsbanken for letting me interview you and giving me a good picture of how financial advisory works today.

Finally, a big thanks to everyone who participated in the brainstorm meeting, the design iterations and the experiment.

Gothenburg, January 2018

Gustav Ryrlén

Table of contents

List of acronyms and abbreviations	13
1 Introduction.....	14
1.1 Background	14
1.2 Virtual Reality today	15
1.3 Virtual reality in finance.....	16
1.4 Previous Works	17
1.5 Purpose and Goal.....	17
1.6 Study design	18
1.7 Limitations.....	18
2 Theory & Technology.....	19
2.1 Immersion & Presence.....	19
2.2 Cyber sickness	20
2.3 User-centered design	20
2.3.1 Usability	20
2.3.2 Design Principles	20
2.3.3 Code information with colors	22
2.4 Data visualization and its impact.....	23
2.5 Risk in investments	24
2.6 Banks existing data visualization	25
3 Method	28
3.1 Literature Study	28
3.2 Design Process of the environment	28
3.2.1 Defining Phase	29
3.2.2 Idea generation	29
3.2.3 Lo-Fi.....	30

3.2.4	High-Fi	30
3.2.5	Conclusion Phase	30
3.3	The experiment design	31
3.3.1	Before the simulation	31
3.3.2	The simulation.....	31
3.3.3	Feedback	32
3.4	Material	32
4	Design	33
4.1	Defining Phase	33
4.1.1	Survey	33
4.1.2	Meeting with financial advisors.....	37
4.1.3	Conclusion	38
4.2	Idea generation	39
4.2.1	Brainstorming.....	39
4.2.2	Affinity diagram.....	40
4.3	Lo-fi.....	41
4.3.1	System requirements	41
4.3.2	Prototypes.....	42
4.4	High-Fi	47
4.4.1	The valve.....	47
4.4.2	Holdings	48
4.4.3	Steering	50
4.4.4	Value	54
4.4.5	Evaluation of requirements	56
5	Result	57
5.1	Test persons	57
5.2	Today's system	57
5.4	Feedback.....	61
6	Discussion	70
6.1	Results	70

6.2	Pre-knowledge	72
6.3	Choice of method	73
6.4	Problems in the process	73
6.5	Proposals for improvement work	74
6.6	Conclusions	75
7	Reference List	76

“It amazes me how people are often more willing to act based on little or no data than to use data that is a challenge to assemble.”

— **Robert J. Shiller**

List of acronyms and abbreviations

Cognition – The mental process of acquiring understanding or knowledge

Eye Gazer – A point in the middle of the view which works as a mouse for eyes

Field of view – The visible view in the virtual environment

Immersion – Physical presence in a artificial digital world

Portfolio – A group of financial assets, e.g. Stocks or funds

Visualization – How information can be mapped to visuals

1 Introduction

In this chapter the background to the chosen subject will be presented as well as the goal of this study.

1.1 Background

Virtual Reality-technology has since the 1930s fooled the human brain and is to some people described as the biggest technical development since the moving image. Virtual Reality, enables physical presence in artificial environment. The technology promotes for instance that users can interact with imaginary objects and enhance training virtually before entering the real world. New technology always seeks its identity but right now gaming and entertainment has been the most mentioned area of use and has proven that the technique works technically and economically. It is too early to define exactly what we can do with the technique although it's clear that the technique is growing in areas of education, therapy and communication. What is sure is that virtual reality will face some opposition before it's fully accepted.

At the same time financial data and portfolio management is an area that stands relatively still. The numbers and distributions that the bank provides us with have been presented in 2D graphs and excel tables for a long time. Everyone with a bank account has interacted with all kinds of platforms and numbers in the name of finance. Studies show that these statistics are often hard to interpret and difficult to relate to reality when it comes to risk and opportunity; especially when you're unfamiliar with economics. This data presentation is missing out what virtual reality and 3D can offer; presence, the feeling of being there, and a relation to reality.

Recent research in this area focus much on how the techniques are used in the financial sector from an economic perspective. Since I have had direct contact with financial advisor and private bankers on some of

Sweden's most notable banks, this report was able to focus more exactly on what banks want to achieve technically with virtual reality (hereby referred to as VR) usage. Based on these facts, measurements can be made from different VR implementations to see what suits the financial systems best in different categories such as making investments, showing risk and making data easier to interpret. So why use data visualization for this area? It's the fastest way to communicate.

1.2 Virtual Reality today

VR let the user interact with virtual objects mainly with the motivation of cost-reduction and the fact that the 3D-space gives you better interaction and easier targeting of object (Maad et al., 2010). As mentioned, virtual reality is today mostly associated with gaming and entertainment. However, the technique is also a million-dollar industry for education and simulation. For example, both doctors and pilots can practice tough situations associated with their occupation and thus learn to handle them. The National Institutes of Health Vaccine Research Center lets hospital staff use VR to find weak spots on viruses. This has been tested at Children's Hospital LA leading to savings around \$430.000 (Jolly, 2017).

Lately research in recovering situations for recalling information has been a trend as well. The German federal office was able to rebuild the entire Auschwitz in order to bring justice in the trials against old war criminals. The prosecutors could now see the scene through the eyes of criminals and make observations on how much they've actually witnessed (Chang, 2016).

All these areas of use works best with the highest possible immersion. Higher immersion makes the user act more realistically and lifelike. This is of course a matter of a well developed VR-environment and its interaction possibilities but also of the equipment in use. Right now it's a competition between the headset brands with HTC, Playstation and Oculus on the leading edge with a tethered, computer- or console-based

system. On the smaller price tag area, we find phone-driven headsets by Samsung, Google and Carl Zeiss (Chapman, 2017).

The phone-driven VR-headset (regardless of brand) succeeded in becoming the Christmas present of the year 2016 in Sweden and this would also become the year when the technique was described to have its own break through despite its age (HUI Research, 2016). VR has raised investments of \$2.3 billion in 2015-2016 with a revenue up to \$5 billion (DigiCapital, 2017a) and is expected to make as much as \$25 billion in revenue by 2021 according to branch forecasts (DigiCapital, 2017b).

1.3 Virtual reality in finance

Bank's digitizing process can often be extended due to the strict regulations of person and bank data. Most banks haven't implemented the technology but it's a hot topic on most innovation labs, even though noone is sure that VR is needed in the finance sector. Even though it's hard to find a perfect area of use, it's clear that the banks are interested as long as the public likes the technique. Right now it's really a matter of attract and retain.

Already in 2001, University Warwick designed a VR trading environment for the purchase and sale of shares. With very different instruments and tools from today they succeeded in creating the first finance tool in VR. Using a seated position and pinch gloves, you negotiated and took the role as an animated broker. The trade was made by moving arrows and other 3D-objects from the floor to the table. Apart from the interaction with hands, the environment and situation were not considered realistic (Maad, Beynon & Garbaya).

If we take a look at the current state of VR in terms of finance, we have to highlight The French Bank BNP Paribas who has developed a VR-app for the overview of the account balance and transaction actions. This has been the first official financial instrument in VR developed by a bank in favor of its customers. Retail Banking Leader at Genpact, Raja Bose, supports the project and shows his interest by stating the problem *"Virtualizing is a good tool for visualizing data. If you can come up with a way of showing how the \$100 you save today turns into a big pile of*

money in 20 years it might make it easier for people to grasp the concept” (Macheel, 2017). He does not only give hope for VR as a tool but stresses the importance of data visualization in finance.

One minor actor, GMO Click Securities, has made VR-applications for visualizing finance data. The application is made for iPhone and Android and uses a simple eye gazer as control and publish their data in 2D in a 3D world. GMO’s app is only available in Japanese and publishes nothing but currency indexes in a manga themed news room (FXVRTrade, 2016).

1.4 Previous Works

In the study “Virtual and augmented reality in finance: State visibility of events and risk” from 2010, Maad et al discuss earlier attempts to use VR and AR in finance and the dimensions of problems with the techniques. The authors highlight the importance of succeeding in visualizing risks especially in times of financial crisis and are open for 3D technology to facilitate this. On the other hand, they are critical of the VR and AR-instruments at the time of the study and believe that most of the improvements circles around the phenomenon visibility (Maad et al, 2010).

1.5 Purpose and Goal

The aim of this Master thesis work is to understand how Virtual Reality can be used by financial actors and how the technique can simplify how you interpret financial data.

- Can virtual reality make today’s banking and investing easier and more entertaining?
- How can financial actors apply the technique to show their data?
- Will people be able to see risks in their investments and portfolios?

1.6 Study design

The thesis project will be based on theoretical knowledge and will feature real-world experiments. I will define reasonable improvement areas in today's bank data visualization. Based on these flaws a test environment in VR will be developed, which will allow the user to have access to financial and investment data. The experiments will be carried out with the test environment conducted on people with minor experience of doing investments and on people who work with finance. The study will focus on two scenarios. First the users will use the prototype to interact with stocks and funds data for potential investments and then they will interact with an existing portfolio of stocks. The given environments will be compared to regular data visualization that the banks give the investor.

1.7 Limitations

I have chosen to focus on the stock and fund investment area only. All other types of investments will be avoided. The study will only process data available for everyone with a bank account.

2 Theory & Technology

The second episode of the current study will present theory necessary to understand how the process and result have been formed.

2.1 Immersion & Presence

Immersion is very important in the progression of the artificial environments. Immersion relies heavily on the quality of the technology and its advantages to make the user absorbed by the environment. It's about tricking the user into feeling he's really there. When developing the test environment it's important to attach great importance to this phenomenon since the project strives for realism in the data visualization. To achieve high immersion, the technology needs to focus on parameters like tracking, stereoscopy, image quality, sound quality, user perspective and field of view (Cummings & Bailenson, 2015).

Presence is closely related to immersion but still quite different. Presence is about tricking the user to the point he's acting like he would in reality. To enable this behavior, the environment needs to embrace natural mapping and lifelike social interaction. This will cause the user not to divide reality and the virtual world and thus make the user act more normally (Mestre, 2005). This present study will focus more on achieving high immersion since the environments will be more of a fictive candy land of data rather than a, for the user, recognized environment.

2.2 Cyber sickness

Dizziness and disorientation with a big chance of nausea is the definition of cyber sickness according to Lisa Rebenitsch's article "Managing Cybersickness Virtual Reality". There are many different theories why cyber sickness may appear. The biggest theory is that the user's eyes and ears sense of mind doesn't match and results in disorientation. This phenomenon can appear when the user moves in the virtual world and not in reality or when the virtual world controls the user's movement. Cyber sickness is therefore important to study when developing virtual environments (Rebenitsch, 2015).

2.3 User-centered design

2.3.1 Usability

Usability is according to the ISO-9421 definition, in what degree a user achieves goals with a product in terms of efficiency, effectiveness and satisfaction in a given situation. The product is labeled to be hardware, software or a service. ISO-9241 not only describes usability but also provides us with explanations on how to evaluate and specify the product's usability quality (International Organization for Standardization, 2010).

2.3.2 Design Principles

Donald Norman has broken down years of research in design in his acclaimed book "The design of everyday thing". Here is stated what

is believed to be the 6 principles of human interaction with digital products designers and developers should consider.

2.3.2.1 *Affordance*

Strong affordance is when an item clearly mediates how it is used. This can be a button, which clearly shows that it's clickable and what its purpose is.

2.3.2.2 *Visibility*

The idea of visibility is that all options and functions should be displayed. Better visibility means greater chance for a user to actually use the function and get a better overview of what is possible with the system.

2.3.2.3 *Feedback*

Feedback is the system's answer to a user action which will lead to awareness of what has been done. The feedback can come in the form of tactile, graphic or audile.

2.3.2.4 *Constraints*

It is important not to make a system more complicated than necessary and leave the user confused. Constraints is about limiting the functionality leading to easy and clear interaction.

2.3.2.5 *Mapping*

A system has good mapping when the design explains the functions' purpose. In figure 1, we see a good example of mapping. It's Spotify's volume slider which clearly shows what's happening if it's dragged left or right.

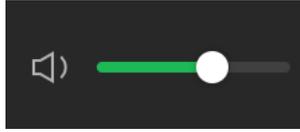


Figure 2.1 How Spotify mapped their volume slider

2.3.2.6 Consistency

Strong consistency is all about using similar design and operations for similar tasks. This does not only refer to the actual interface but for most interfaces used by the users together as a group. This will ease the learning process.

2.3.3 Code information with colors

Colors can easily trigger different feelings to users when used in systems. Below some of the most common perceptions of how colors are interpreted by users are listed (Preece et al., 2015).

Black Power Death Formality	Grey Stability Security Maturity	Blue Peace Calmness Affection
Green Life Growth Money	Pink Romance Friendship Compassion	White Simplicity Freshness Hope
Purple Luxury Passion Magic	Yellow Joy Caution Energy	Red Danger Loss Urgency

Table 2.1 Colors and their message

2.4 Data visualization and its impact

Graphics is essential for presenting data and has been the body of displaying statistics for a long time. In statistics you draw graphics to compile large amount of data along with the description of the colors or variables in use. Graphic representations of quantitative data can include for example pie, bar or dot charts (Chen, Härdle & Unwin, 2008). Type of chart depends on situation and these guidelines, on how to avoid ambiguity. This has been discussed in the work of Edward R. Tufte. His book “Visual Display of Quantitative Data” from the 70s has been used as a guideline for statisticians when to use or when to avoid different type of diagrams (Tufte, 2001).

Tufte also describe the importance of remembering that graphic display should always:

- Show the data
- Avoid distorting what data want to communicate
- Encourage the eye to compare different sets of data
- Serve a clear purpose: description, exploration, tabulation or decoration

Data visualization has many similarities with graphics display but circles more around the area of letting the readers or users see the structure in the data. This will facilitate learning and understanding. Data visualization is not used for staying away from numbers or 2D representation but clarifying the underlying message. It's hard to say when the representation is considered as a good example of data visualization since it depends on the interpreter's cognitive ability. What you can say is that factors like colorblindness and the readers culture and age differences may be considered when designing the data environment.

If you take the representation one step further and combine data visualization with interaction you let the user understand how the data is affected by changes (Chen, Härdle & Unwin, 2008). It encourages the interpreter to explore the information in ways static images cannot. The greater the interest leads to clearer messages and better impact. The interaction moment of the visualization is considered perfect for an audience with lack of interest or knowledge about the subject (Murray, 2017).

2.5 Risk in investments

There are several risk indicators in portfolio theory, which are important to study when placing money. The relationship between return and risk is matter of fact fundamental in financial analysis. The present thesis will break down these to the most commonly mentioned by financial advisors today. When you talk about risk in investing, you talk about the chance of harmful consequences on the economic return of the investment, which is often synonymous with a chance of high reward (Investopedia, 2017a).

2.5.1 Volatility

Volatility indicates on how much a price of a stock varies. The greater the increase or loss means higher volatility as well as fluctuation of the price curve. High volatility equals the chance of dramatically changed price, which makes the investment riskier. Lower Volatility will on the other hand describe the security as more stationary. Volatility is displayed in percent, based on the daily trading of the stock or fund (Investopedia, 2017b).

2.5.2 Diversification

“Don’t put all eggs in the same basket” describes this phenomenon best. The goal is to create at portfolio that includes different kinds of investments in order to minimize risk. Picture a portfolio containing only oil-company stocks and the oil industry takes a major loss and so would this portfolio’s stocks and values. How the spread of assets shall take place depends on the risk profile that wants to be achieved (Jacob, 1974). So how many stocks shall a portfolio contain for good diversification? Its hard to say but investing in for example 50 large-cap companies will make the portfolio stagnant –not letting the positive results of one company having effect on the portfolio growth. The portfolio should include stocks with impact on the portfolio value

and also demonstrate a journey from lower risk- to higher risk alternatives (Investopedia, 2017c).

It's of course not only a question of number of stocks but also on diversification in industries and countries as well. Some industries are associated with more risk since they're cyclical and affected by political decisions such as the oil industry and medical area. The same principles apply to countries where inflation, political decisions and the weather can be seen as risk factors (Johnson & Markel, 2017).

2.5.3 Assets Allocation

Assets allocation means that portfolio should include different equity investment choices such as funds, stocks and bonds. The assets allocation is strictly based on the aim of the saving. If the aim is to save for a new kitchen, private investors would probably recommend a more classic and defensive allocation between stocks and funds. If the goal is to save for retirement, a more aggressive stock portfolio which have the time to straighten out the cycles and fluctuations in the market would be preferable.

2.6 Banks existing data visualization

If you look at the banks visualization of data we almost only find 2D-representations. We will now look further into one of the more "innovative" banks. The Swedish bank Nordnet is one of the biggest banks in Scandinavia when it comes to saving and investing. Nordnet is a modern bank, who consider itself to be in forefront of technology. The idea of Nordnet is to give the individual control over his or hers savings and investments independently and with the guidance of Nordnet (Nordnet, 2017).

This study will, as mentioned, focus on one scenario: when a user is looking at his current portfolio. Below are clippings from Nordnets

interface in a given situation but also when looking at one particular stock/fund.

2.6.1 Stock Quote representation

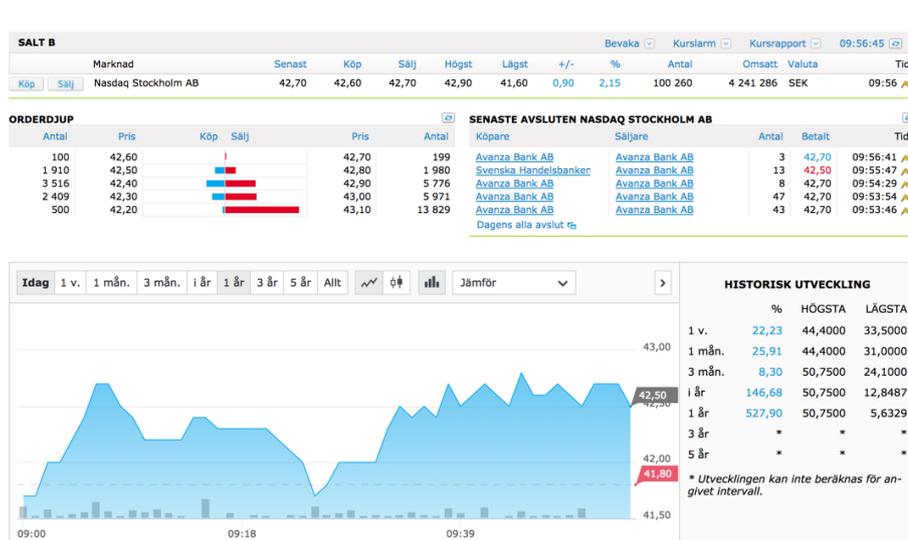


Figure 2.2a Nordnet stock market quote for SaltX

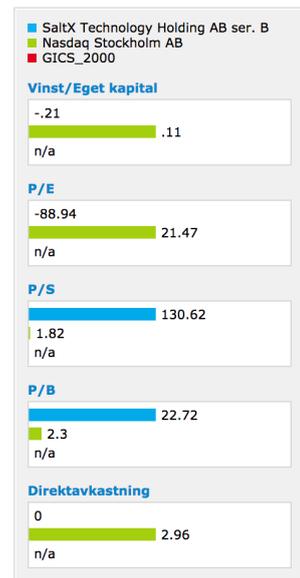


Figure 2.2b Nordnet Key figures for SaltX

In figure 2, we find the course data when searching for SaltX AB, a company listed on Nasdaq Stockholm. This precise view is for logged in customers only, otherwise the order depth (visualized with a lying bar chart) as well as the historical growth would not be available. The red bars in the order depth is the selling amount at a certain price and the blue bars represent the buying amount. We find a blue interactive chart of the price historically. Figure 1 displays the key figures for this company; it is compared to Nasdaq Stockholm figures in a bar chart.

2.6.2 Portfolio

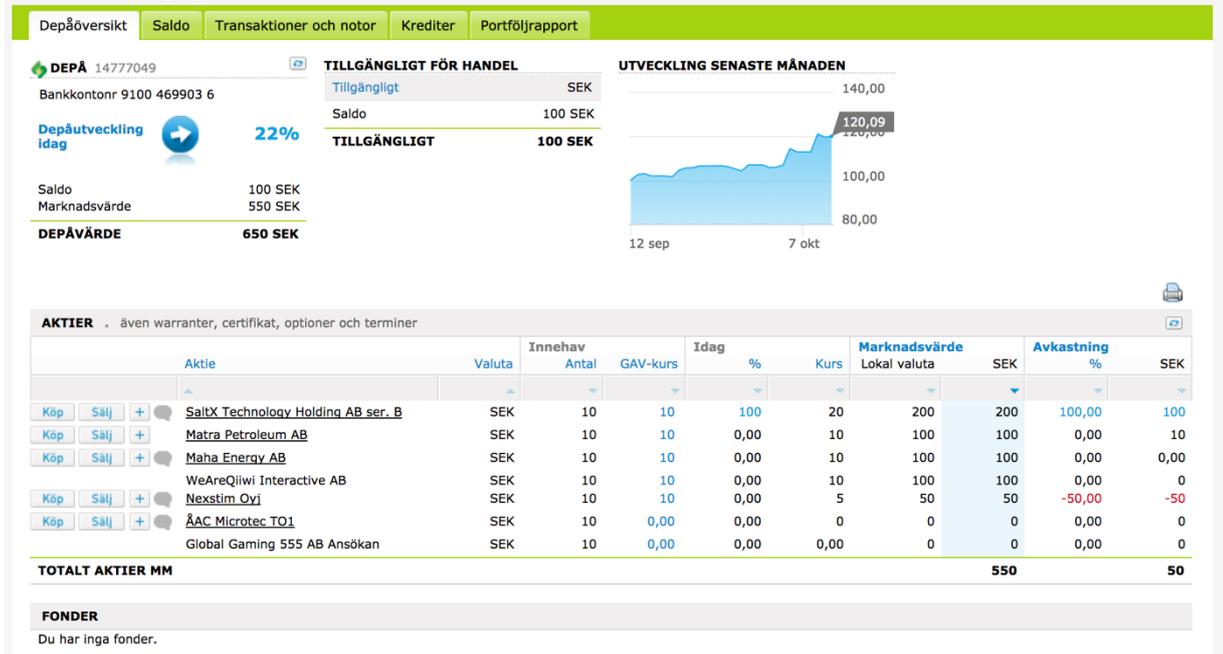


Figure 2.3 Nordnets portfolio visualization (made up figures)

This is how Nordnet display a customer's portfolio. No graphs or charts but for the percentage of growth of the portfolio. The holdings are a simple list-based visualization of the securities. For each security we find: amount, the paid price, the daily progress, market value and return. Marked with blue if a positive result and red if negative. No indication of diversity, volatility, industry or country can be found.

3 Method

The third section defines the plan on how the work proceeded during the study and more profoundly how the prototype was made.

3.1 Literature Study

I started the work with a literature study to get in the subject data visualization and virtual reality. An overall picture of which areas was dealt with and what literature could be referred to was created. Authors whose work has been used are all referred to in the bibliography

3.2 Design Process of the environment

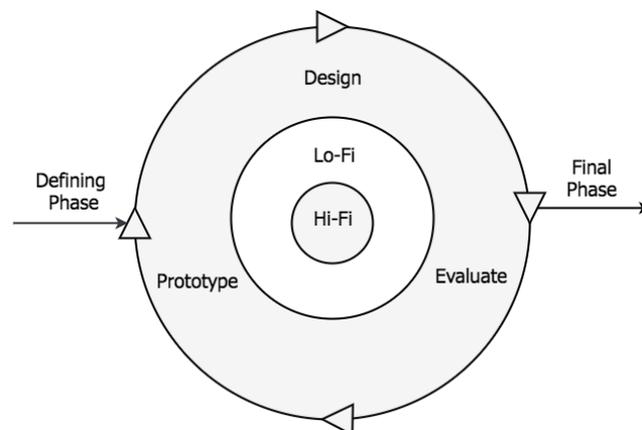


Figure 3.1 The design process

The design process is an iterative process, meaning that decision and analysis are made repeatedly until the planned environment reached the desired result. As can be seen in Figure 3, the process starts with the defining phase which will lead to the iteration of the design. This round of analysis and changes will lead to a lo-fi prototype which will later on lead us to the last step of the circle, the hi-fi result of the environment.

3.2.1 Defining Phase

In this phase I will focus on identifying the end users and their problems with and opinions of today's banking system. It's a common phenomenon that software developed by the end user themselves lack key features (Scaffidi et al., 2005). Therefore, all thoughts will be welcomed, noted and saved for the prototyping.

3.2.1.1 Survey

To identify what was the current perception of the investment data a survey was made consisting of 7 questions. The survey was intended for private individuals who had been in contact with savings accounts. The questions and answers are shown in Appendix A.

3.2.1.2 Interviews with financial advisors

An interview was carried out with two financial advisors from two different banks. It was important for the project to identify what data to really focus on when developing the environment and to hear the banks representative's opinion on the virtual worlds today.

3.2.2 Idea generation

During this part of the design process ideas are generated using brainstorming, body storming or other forms of ways to communicate ideas, which are abstract or concrete. In this study, brainstorming will

be used. It's important to encourage and welcome all ideas since the quantity of ideas often leads to quality (Michalko, 2006).

The result will later on be systemized and grouped -not only the brainstorming but the interviews and notes from the defining phase. The grouping and systemization will be visualized in affinity diagram.

3.2.3 Lo-Fi

A low fidelity or lo-fi prototype is a sketch on paper or whiteboard of the product or environment. It's done in the early stages with limited effort in time and preciseness. Low-fi prototyping lets the designer explore and breakdown ideas and thoughts. The method requires no or little programming experience, which makes it ideal for communicating in teams (Alcantra et al, 2012).

3.2.4 High-Fi

High fidelity prototyping is the next step where interactive moments and functionality are added to the model. Unlike lo-fi, hi-fi requires computer tools for prototyping and sometimes programming experience. This prototype should act and feel like the end-product. It lets the user try how the product works, which open doors for relevant improvement and user feedback (Filimowicz & Tzankova, 2017). Tests on the environment will be carried out on people with different experience in economics.

3.2.5 Conclusion Phase

This final step in the process will consist of analyzing and evaluating all user reactions and information collected during the design process.

Possible improvements, deficits and error sources will be presented as well as a discussion.

3.3 The experiment design

3.3.1 Before the simulation

First out, the participants were informed how and why the test are carried out. There were two groups of test persons, people with and without experience in economics (work or studies). The group who had less experience in economics had a little brief about a few basic economic terms used in the environment and normal portfolio management systems.

Before the simulation the test persons were shown today's present portfolio management visualization at Nordnet.

3.3.2 The simulation

The simulation was piloted with a HTC Vive equipped with headphones and two controllers in a 3x3 m green room. The simulation was video and audio recorded.

The study used a scenario-based setup with different tasks for the participants. Every task was time-controlled and evaluated with results and comments by the test person. The form used can be found in Appendix B. The tasks was announced in sequence after the previous one was accomplished.

3.3.2.2 *The portfolio in use*

The portfolio, which the test persons will navigate around, analyze and interact with, was set up by one of the financial advisors

participating in this study. He was asked to design an aggressive portfolio, which is risky on different levels. The financial assets can be found in Appendix C.

It is important to remember that how risky a portfolio is being -is a personal assessment. The compiled portfolio was, however, by the banker described to have:

- Assets with very high volatility
- Monotonous country diversification
- Disproportionate distribution in the assets
- Invested in industries known to be risky
- Big changes of high reward/high loss
- Few funds and much stocks, discussable asset allocation

3.3.3 Feedback

After the study the test person filled in a, so called, system usability scale paper (Jordan et al., 1997). It's a 13 question long sheet with questions about the experience when using the system. They are all answered with a Likert scale from 1 to 5, with 5 being synonymous with fully agree. The sheet is found in Appendix B.

3.4 Material

The environment and it's scripts were compiled in Unity 5.5.0f3 Personal. Some particular objects were made in Autodesk Maya 3D 2017. HTC Vive combined with Steam Home VR Beta was used for testing and for the experiment simulation.

4 Design

This chapter will present and interpret the results from the design process different steps. Finally, each listing will lead to the final experiment design.

4.1 Defining Phase

To define the problem and the end users, great focus have been made on the online survey and the conversation with the financial advisors which will make the greater part of this phase.

4.1.1 Survey

The survey was carried out online with Google forms and answered by 73 persons in the ages 16-68. All participants are familiar with bank accounts and have access to a saving account. The results from the questions are presented below.

4.1.1.1 “Do you have experience in economy? (Investment, studies or work)”

As we can see, a large majority of the respondent consider themselves experienced in economy, even though the case study only reached a small proportion with economist education.

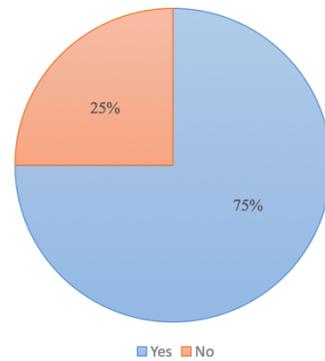


Figure 4.1 Experience in economy

4.1.1.2 “Which word/words best describes how the share and fund data are visualized on your bank?”

In this more open question, we see scattered sheds in terms of perception. As much as 23.1% has never looked at how their banks show stock and fund data even though 75% have experience of economics. This applies to the 28,8% group who describes it as boring and the difficult group of 21,2% as well as the group of 7,7% categorizing it as incomprehensible. However, we can see a certain curiosity in economics among the participant since 23,1% thinks it’s interesting and 19,2% describes it as stripped. Clearly, there is a room for improvement when it comes to how banks visualize their data.

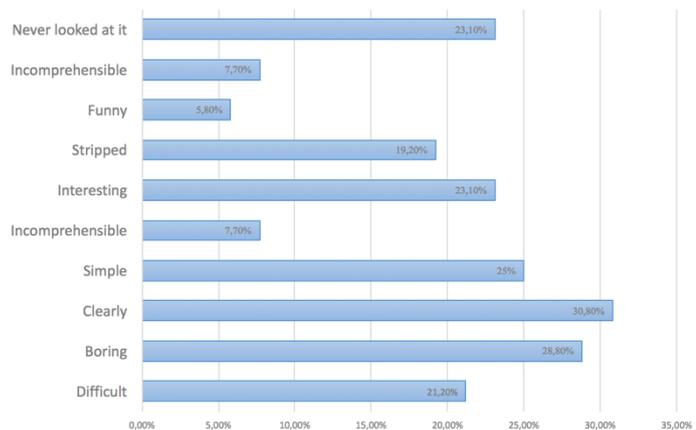


Figure 4.2 Words describing banks data visualization

4.1.1.3 “Would you like to understand more of investment data? (key ratios, balance sheets or income statements)”

As for the interest of understanding more about the investment data we find a big group of persons.

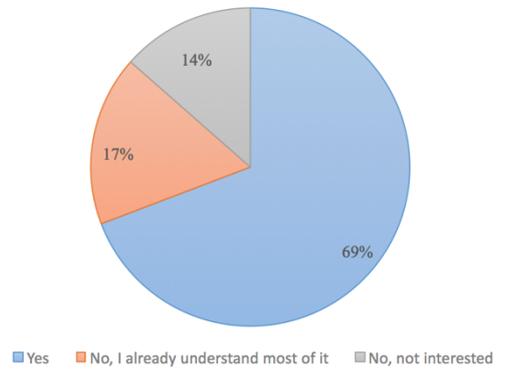


Figure 4.3 The will to understand the data

4.1.1.4 “Do you often analyze your stock and fund portfolio?”

Even tough the high confusion on how the data of stocks and funds are visualized, the vast majority still analyze their portfolio. Its interesting and in someway alarming that 25% don't event reflect on their securities.

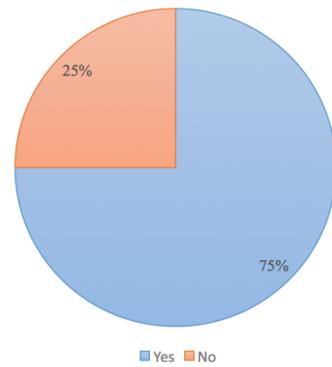


Figure 4.4 The analyzing distribution

4.1.1.5 *“Do you think the visualization of your holdings in your equity or fund portfolio gives a good picture of risk / opportunity?”*

There is only 23% who thinks the banks succeed in showing an image of risk and opportunity. This not only confirms that the thesis fills a purpose but gives space for research in this area.

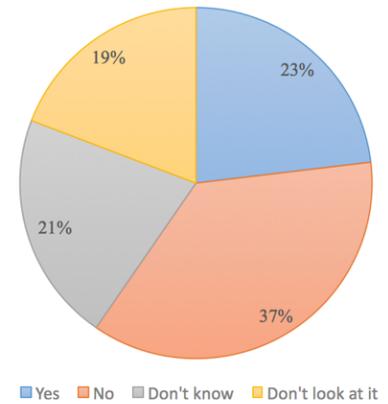


Figure 4.5 The view on if banks is succeeding with risk-visualization

4.1.1.6 *“To what extent do you feel that the visualization of your holdings gives you a sense of reality rather than just number?”*

This question was answered with a Likert scale from 1 to 10, with 10 being as close to reality as possible. According to the result, the present perception of the portfolio is considered more of a number than reality.

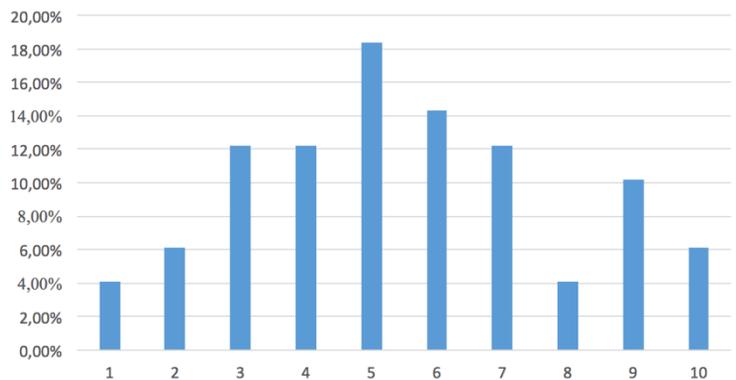


Figure 4.6 Sense of reality in the portfolios value

4.1.2 Meeting with financial advisors

The meeting was conducted with two financial advisors who works at iZave (iZave, 2017) and Svenska Handelsbanken (Handelsbanken, 2017). It was more of an open conversation than an interview to really identify and get the picture of what parameters is important to show from customer perspective.

4.1.2.1 *Portfolio Management*

We talked about how they work when helping their clients to place money. Together we could break down the process of building and setting up a portfolio to a few ground rules.

- The clients experience of investing
- Talk about thoughts the client's thoughts on the market
- Identify the risk profile and saving goals (this outlines the diversification and allocation structure)
- Define the diversification level and the time horizon
- Talk about the market right now and a pitch risk-spreading approach with different volatility percentage
- Recommend industry diversification, identify if the client have any favorite industries
- Collect the best companies/funds from different industries
- Wide the portfolio with foreign investments
- Demonstrate the approach of the portfolio and ideas of the structure

This process can obviously vary from person to person based on much experience and how much the client wants a saying in the placing but usually it looks like this in both iZave and Svenska Handelsbanken.

4.1.2.2 *The view on virtual worlds*

Both advisors agree that banks want to be in the front line when it comes to technology and trends. However, they announce a certain criticism against using virtual reality as a trading or portfolio management tool since they're used to the old systems and do not really see the area of improvement. It is added that this approach only applies to themselves and that it had not hurt private individuals to be more enlightened of what actually is going on with their life savings. "The ignorance of economics and investments has allowed actors to manage money on a culpable basis, look at what is happening with Allra right now" (Nilsson et al. 2017).

But what they do look very optimistic at is using virtual reality as a social dimension service with an avatar representing a real bank representative. "A bank who would be available anytime anywhere would be a trusted bank".

4.1.3 **Conclusion**

After the defining phase and the meeting with financial advisors It was clear that diversification is something that is very important when structuring a portfolio. More closely country, industry and volatility visualization can make the current risk-status of the portfolio much clearer and something that is missing in today's systems. When it comes to the view on the virtual worlds -it is hard to avoid suspecting the advisors feeling a certain fear of being replaced and therefore show a subtle negativity on using it themselves. However, it's positive that they see a need of customer awareness.

From a user-perspective, according to the survey people are interested and have experience in economics yet not really understanding the impact of the current portfolio representation. What else can be said is that the data visualization is in need of:

- Show risk better
- Have better link to reality

- Increase the understanding
- Being easier, funnier and something you look more often at

4.2 Idea generation

After defining the end user and the improvements the idea generation on how to use this information in the VR-environment could begin to take shape.

4.2.1 Brainstorming

Brainstorming is often completed with more than 5 people for best practice. Since this study is a one man show I invited 3 other students from Lund's Faculty of Engineering. With a time limit we all let the creativity flow with both group and single sessions. Even though the majority wasn't even working on the project we managed to produce good ideas. All final ideas could be summed and organized in a affinity diagram, see section 1.2.2.

4.2.2 Affinity diagram

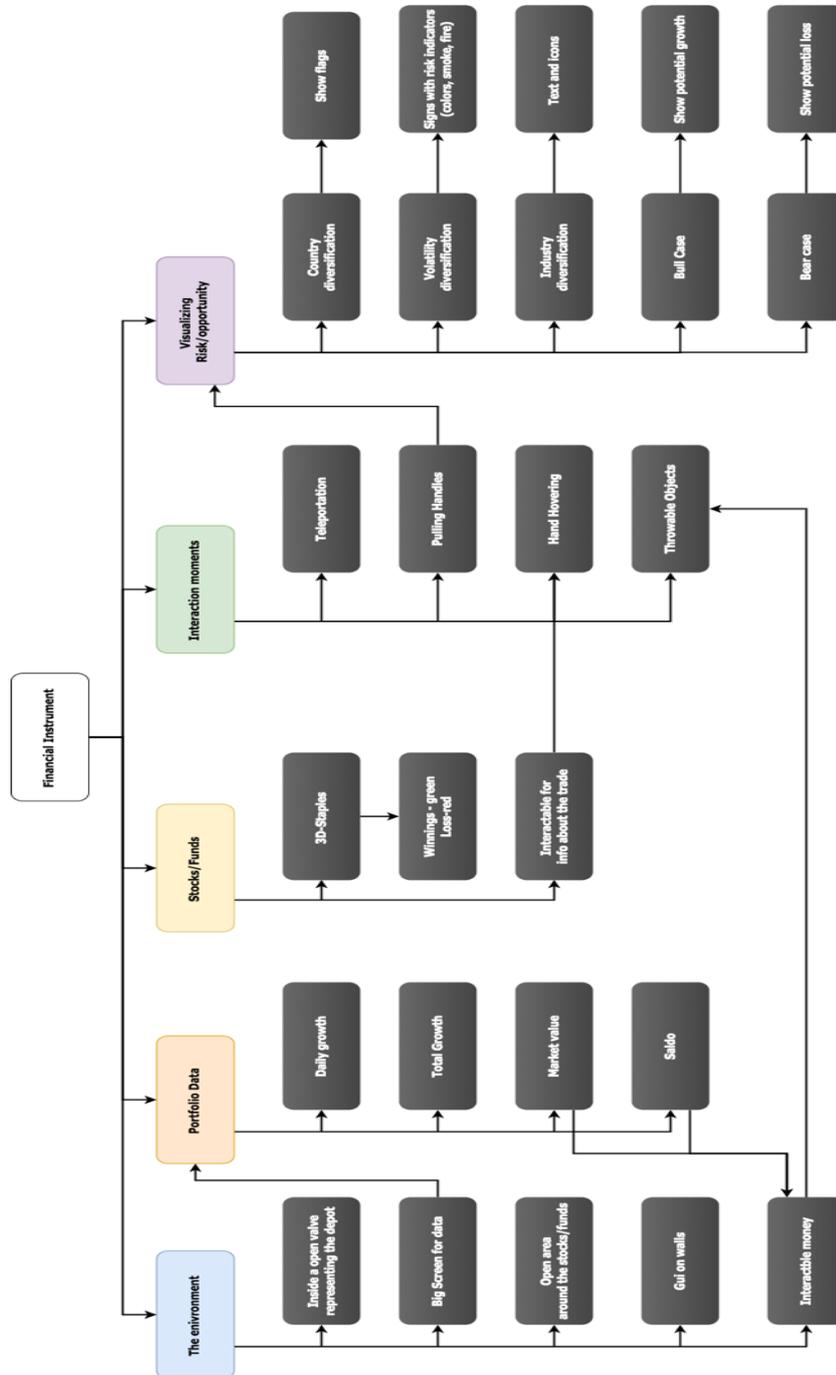


Figure 4.6 Affinity diagram

4.3 Lo-fi

When the idea generation was finished the prototyping phases began to take shape taking into account both the design principles but also the requirements.

4.3.1 System requirements

To make sure the prototype really is designed correctly for this project its important to set up requirements before the prototyping. The requirements will be used as a basis for verifying the system and are evaluated with true or false (Preece et al., 2015).

There are different kind of ways developing and structuring requirements. They can be grouped as functional and non-functional requirements. Functional requirements concern the system's interaction with the user, for example "The user will have the opportunity to change and profile picture". Non-functional requirements treat the subject to what happens within the system without the knowledge of the user. That could be "Uptime of the system should be at least 99.8%".

This study will evolve more around interaction design, and I will only focus on functional requirements.

4.3.1.1 Functional requirements

1. The user should be able to move around in the environment
2. The user should clearly distinguish stocks from funds

3. The securities will unmistakably show loss or winnings
4. The user should be able to interact for further information
5. The securities can be sorted on:
 - a. Industry
 - b. Volatility
 - c. Country
6. Bull and bear market can be visualized on the portfolio
7. All interaction features will clearly show they are interactable
8. The value of the portfolio will be shown In currency
9. The environment will be available for users with HTC Vive

4.3.2 Prototypes

Based on the findings from the investigation phase, two different designs of the environment could be produced. Brief interviews about on how the design looked and what features were included were made with four different test persons. This led to a combination between the three design proposals, presented below.

4.3.2.1 Sketches

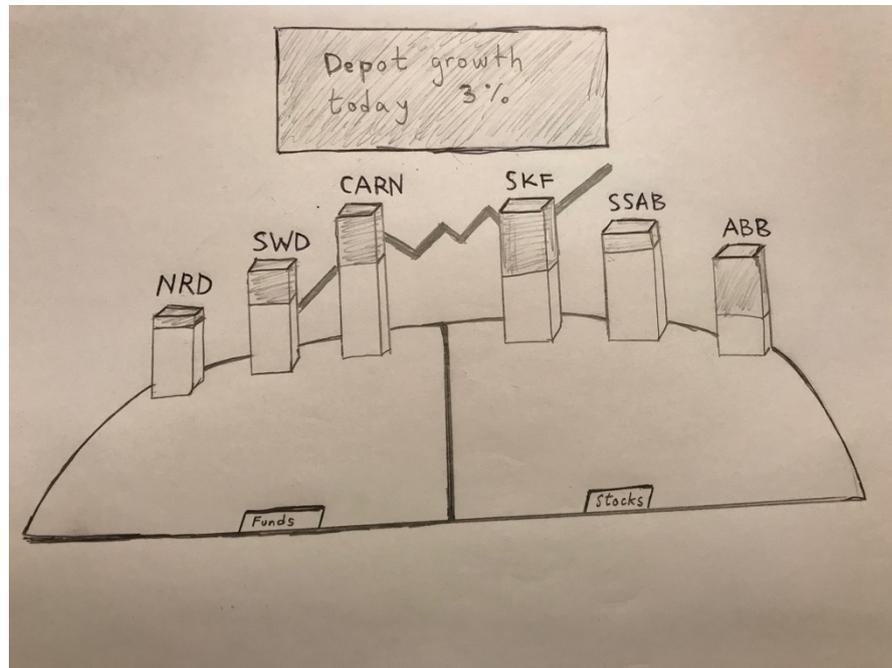


Figure 4.8 Stock and fund start view

In figure 6, we see how stocks and fund will be visualized. The area which holds the securities was chosen to be formed as a half moon instead of a square since the surroundings will have space for information and the floor can easier be considered and used as an observation deck. The length of the staple represents the proportion of the portfolio, which easy gives us the distribution between the investments. The grey upper part indicates on loss or winnings on a trade, this will be discussed later.

The observation deck will be spacious since it will leave room for movements and teleportation. Behind the investments and the deck there will be an information screen, which will be dynamic and show information based on chosen scenario. The initial phase will publish a daily update and provide the user with a graph from the period.

It's a clear demarcation between stocks and funds since the financial advisors says that they should not really be compared to each other.

The stocks and funds, are as stated in the requirements, interactable. The free space and the starting screen behind the deck will be replaced with information about the holding and the trade when touching and moving around with a holding. Roughly the same parameters that Nordnet publish will be used for this inspect mode. Making the staple dragable and portable enables them to be compared to their neighbors.

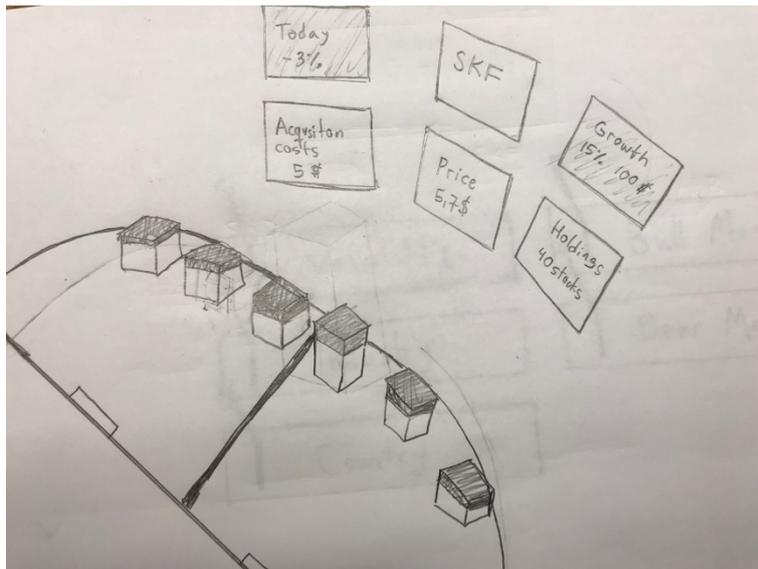


Figure 4.9 Interacting with a security

The survey indicated that people didn't feel good link to reality with their digital money so what was worked out was showing money that is interactable in physical form. Seeing and feeling the money will hopefully lead to higher presence and respect to the value of money. Both the invested market value and the balance will be shown; -the comparison will be glaring about the liquidity distribution contra the investments.

The whole environment will try to use hints and elements from banks that people recognize. For example, the environment will be located inside of a bank valve which according to the test persons may give higher immersion.



Figure 4.10 Representing the portfolio value

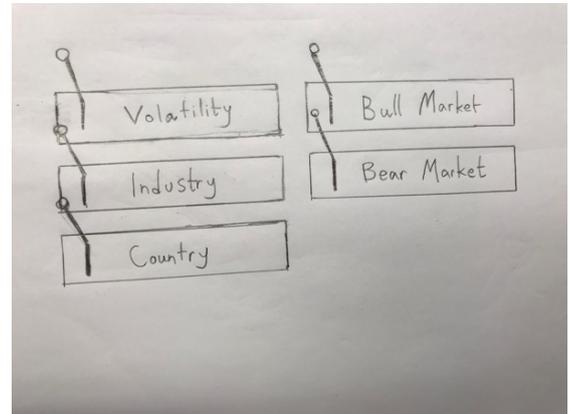


Figure 4.11 Sorting buttons

The sorting menu will strive against good mapping and feedback. The handles are a clearly interactive moment for each sorting mode and the visual drawdown can hopefully be provided with haptic feedback.

4.3.2.2 Digital sketches

Green has been chosen for representing winnings in an investment since, as mentioned earlier, green is synonymous with growth. Red on the other hand reflects loss and danger which will be used when backing on a security. Grey will be the overall environment color since its synonymous with stability and security combined with its subtlety.



Figure 4.12 Colors and their hex-values

Animated flags are the easiest way to show nationality on the placement when getting an overview of diversification. For industry sorting, icons from different industry areas will be used. The volatility indication will be shown in traffic signs with riskier

coloring and smoke for higher volatility. When it comes to activating the speculating into bull and bear market fulmination we will see the stocks move in different directions based on volatility and industry.

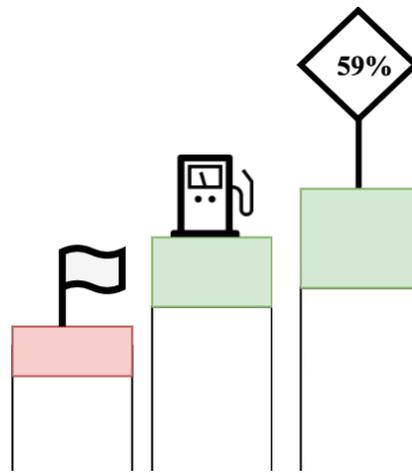


Figure 4.13 Illustrating country, industry and volatility

The environment has after the merge of different designs become a combination of a valve and an observation deck. The bank themed room and entrance is desirable for good consistency and in the process of creating a good metaphor that may lead to normal behaviors in banking.

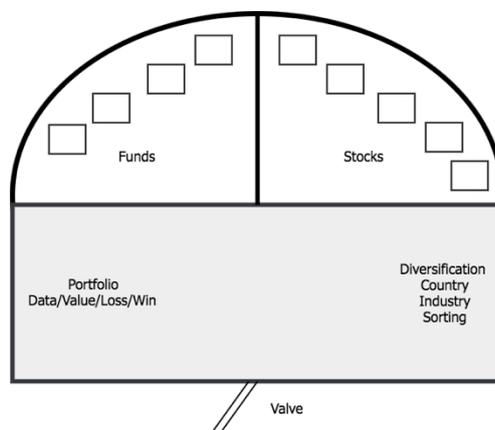


Figure 4.14 Overview of the environment

4.4 High-Fi

With enough sketches, ideas about animations and colors the design process could move on to actually developing and modelling the environment in Unity. The high fi-development was made from the lo-fi-sketches and later tested on four users in two different iterations.

4.4.1 The valve

The entrance to the environment will as mentioned be a valve. The idea was that the user would slide in without steering capabilities with the valve opening up letting the user in to its portfolio.

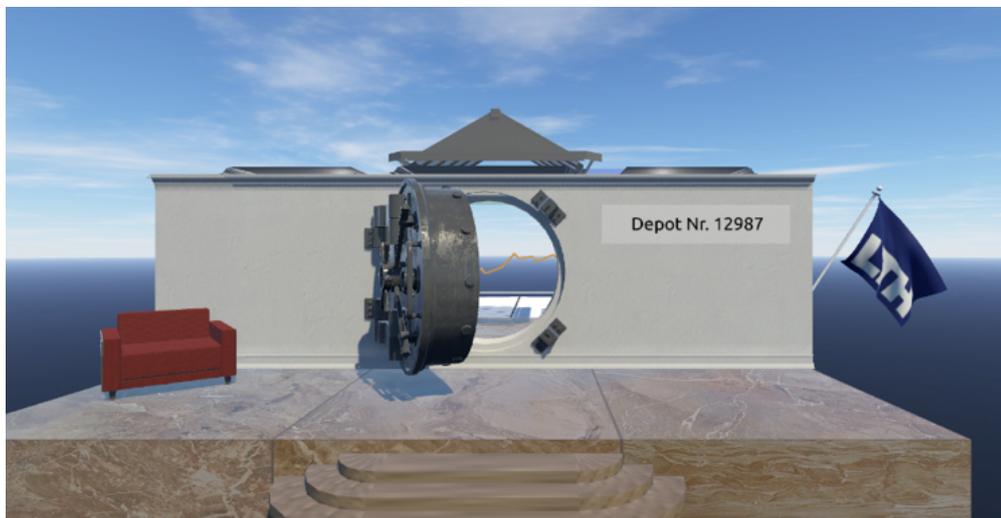


Figure 4.14 The final entrance

4.4.1.1 Improvements after user tests

- The “sliding in”-animation was abolished since it caused tendencies of cyber sickness.
- The valve remained open since its was hard for users to understand how to open it

- Depot Nr were added since some users didn't not really understand that the portfolio was personal
- An LTH-flag as well as an armchair were added to the entrance since it was perceived as being too scaled off

4.4.2 Holdings

This is the first meeting with the portfolio when the user stepped into the valve. The idea about how the holding was about to be visualized was very appreciated on its clarity in the lo-fi testing.

4.4.2.1 Improvements after user tests

- The portfolios total growth panel was added beside today's growth since it couldn't be found anywhere else
- X-axis and Y-axis was drawn to the underlying growth graph
- The staples were a little to large compared to the ground. It was supposed to accommodate more holdings then sketched in the lo-fi
- The holdings were supposed to only be grabable, to make it even easier for the user to see the further information about the trade –hovering with the controller was added as well
- Market Value- information was added on the info-screen and Today percentage and price was combined

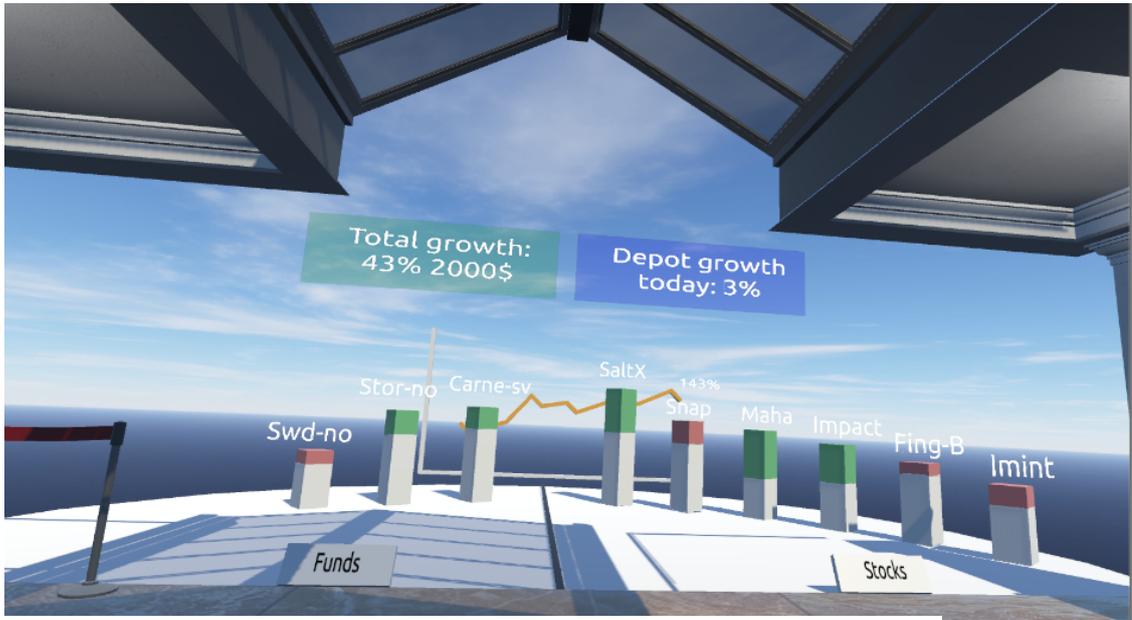


Figure 4.15 Holdings view



Figure 4.16 Pop-up information screen when interacting with a holding

4.4.3 Steering

“The steering wall” with the sorting buttons is supposed to be a very simple and good mapped interface, located on the right side of the entrance.

4.4.3.1 Improvements after user tests

- The handles tensile direction was change from vertical to horizontal since it got to tight between the handles
- Tactile feedback was added to the handles for better dragable feeling
- Sound feedback became a must since many users didn't notice the changes to the left

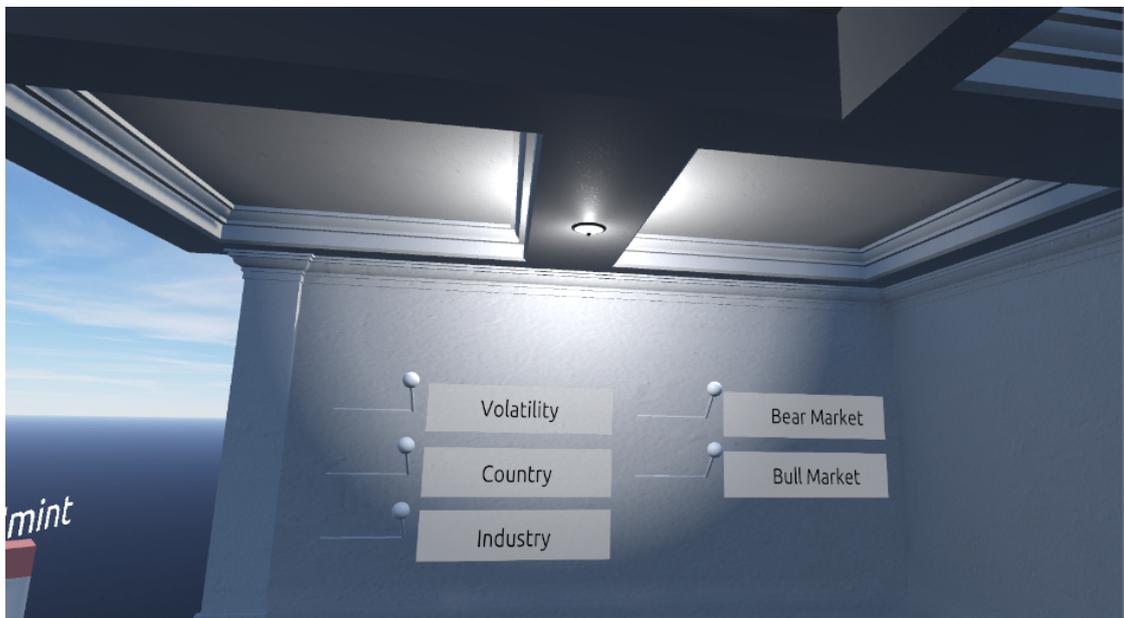


Figure 4.17 "The steering wall"

4.4.3.2 Country

The country diversification was said to be represented with flags from the companies' countries when turned on.

4.4.3.2.1 Improvements after user test

- Scripts to make the flags wave were added due to increase the feedback of the action

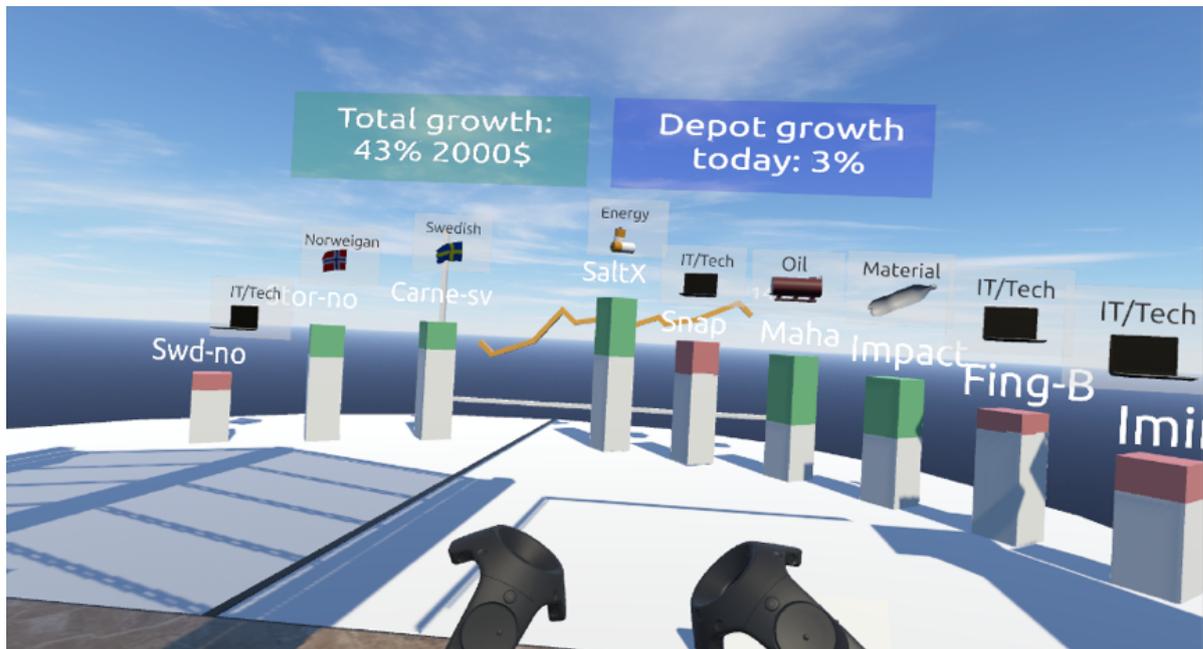


Figure 4.18 The state when country diversification is turned on

4.4.3.3 Industry

To show industry allocation: icons with significant objects from each industry was the chosen solution.

4.4.3.3.1 Improvements after user test

- Industry name had to be added under the icon since it was to hard understand what was conveyed

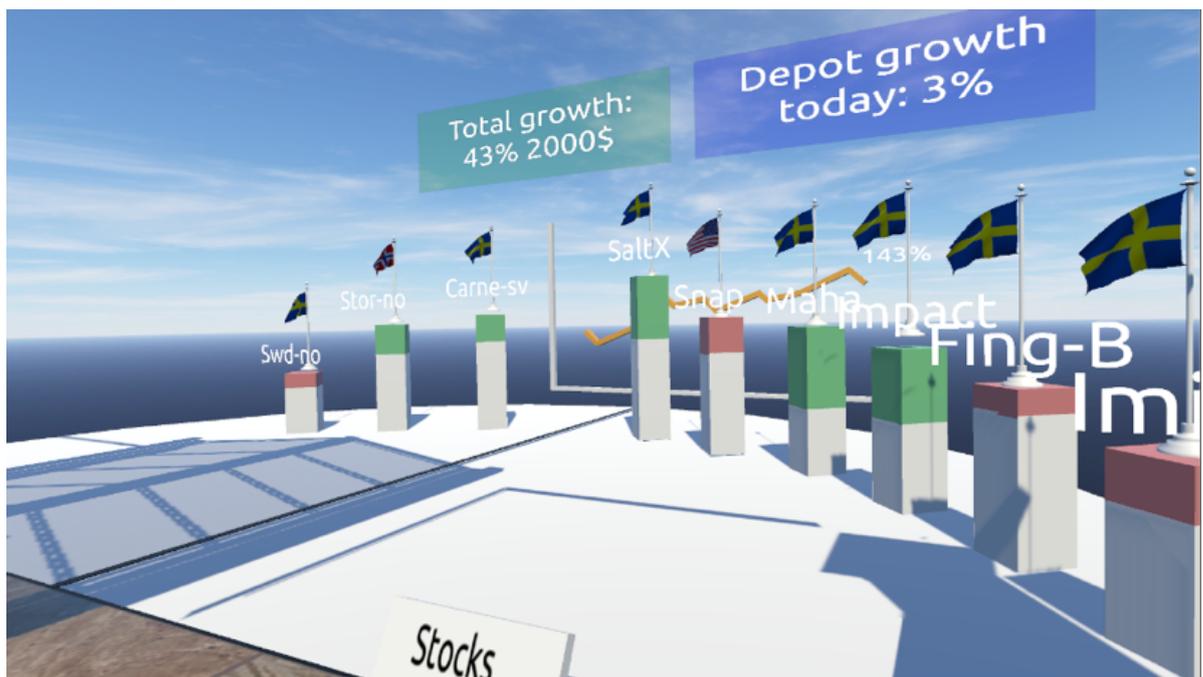


Figure 4.19 The state when industry diversification is turned on

4.4.3.4 Volatility

For the volatility which had no good metaphor, a warning sign with the number was decided to be used.

4.4.3.4.1 Improvements after user test

- Different colors depending on level of volatility (from gray to dark yellow)

- Sparkling smoke was added on the volatility numbers considered as very high risk to the financial advisors participating in this study

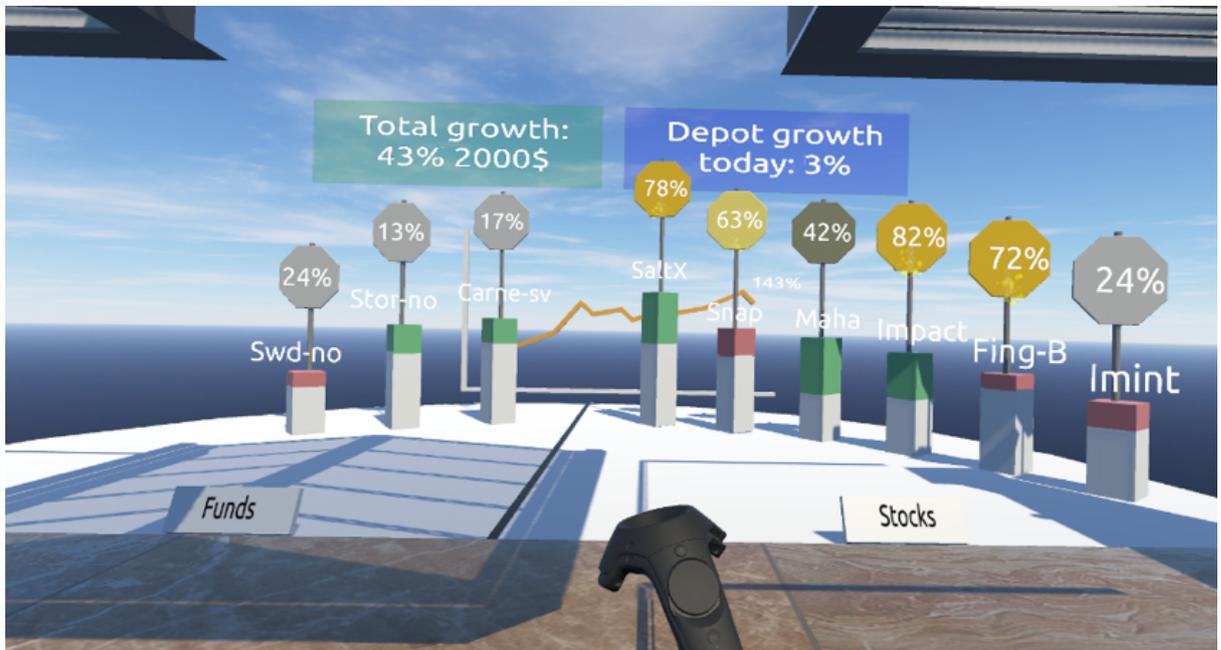


Figure 4.20 The state when volatility diversification is turned on

4.4.3.5 Bull & Bear Market

Bull and bear market expectation will regulate the stocks staple height depending on what could happen with the stocks value.

4.4.3.5.1 Improvements after user test

- A panel showing the chosen market and the expected growth/loss was made



Figure 4.21 Bull market expectation mode

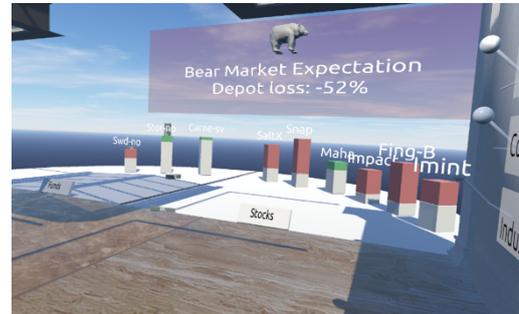


Figure 4.22 Bear market expectation mode

4.4.4 Value

The information about the portfolios market value and the balance is located on the left side of the valve. Interactable money was a requirement to raise the sense of money not just being a number.

4.4.4.1 Improvements after the user test

- A “bankers lamp” was added in order to increase the conceptual model
- Total growth label was moved to the start screen

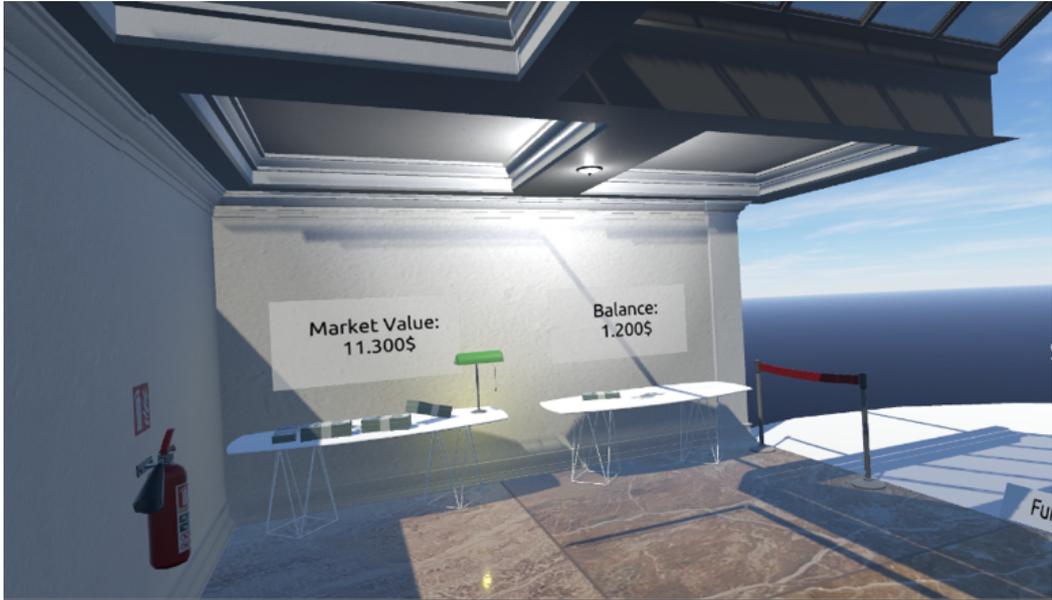


Figure 4.23 The value corner



Figure 4.24 Interactable money

4.4.5 Evaluation of requirements

After the final Hi-fi prototype was finished, the environment was tested on two persons, new to the environment, to evaluate if the functional requirements were fulfilled or not. The functional requirements can be found in the section 4.3.1.1.

<i>Requirement Id</i>	<i>Evaluation</i>
1	Fulfilled
2	Fulfilled
3	Fulfilled
4	Fulfilled
5	Fulfilled
6	Fulfilled
7	Unfulfilled
8	Fulfilled
9	Fulfilled

Table 4.1 Non-Functional requirement evaluation

As a result of the evaluation every requirement succeeded but the number 7:” All interaction features will clearly show its interactable”. It turns out it was harder than expected to understand that the securities were interactable for further reading. Every other interaction moments were, according to the final testers, clear.

5 Result

This chapter will present the result from the experiment explained in Chapter 3.

5.1 Test persons

The user study was conducted in 16 test persons - 3 women and 13 men in the age group 20-27 years. All participants are or have been students at Lund University/Lund Faculty of Engineering. The goal was that half of the test persons had general knowledge in economics and the other half with no experience but interaction with saving accounts. General knowledge in economics refers to experience with studies in economics, trading on a weekly basis or jobs in the economic area. Unfortunately, the distribution between the groups was uneven with 6 in the “economics group” and 10 in the second group.

5.2 Today’s system

The test began to investigate the current perception on today’s data visualization with Nordnet bank’s current portfolio visualization, which can be seen in chapter 2 under 1.6.2. It was shown with a made up portfolio with stocks and funds just to see how the savings are visualized today not to analyze anything about the risks and opportunities.

5.3 Simulation

5.3.1 Pre-knowledge

<i>VR-Experience</i>	<i>No VR-Experience</i>	<i>Familiar With Economics</i>	<i>Non-familiar With Economics</i>
9 (56,25%)	7(43.75%)	6(40%)	10(60%)

Table 5.1 Pre-knowledge statistics

5.3.2 The Tasks

The scenario-based testing was performed with the 7 different task from Appendix B. If a test person didn't understand how to finish the steps –guidance was provided. Below a table of the amount of users who did finish the steps without guidance.

<i>Tasks</i>	<i>Econ. Exp.</i>	<i>Non-econ Exp.</i>	<i>Total</i>
1	5(83.3%)	8(80%)	13(81.25%)
2	6(100%)	10(100%)	16(100%)
3	5(83.3%)	9(90%)	14(87.5%)
4	6(100%)	10(100%)	16(100%)
5	6(100%)	9(90%)	15(93.75%)
6	5(83.3%)	9(90%)	14(87.5%)
7	5(83.3%)	9(90%)	14(87.5%)

Table 5.2 The scenario-based testing, complete percentage

- Task 1

The task urged one to teleport into the environment and find some particular stocks values. The 81.25% of both groups who found out how to interact with the holding also found the right values.

- Task 2

Similar to task 1, this task evolves around finding information about one of the portfolios holding, this time a fund. Every participant who finished the steps found the right value.

- Task 3

The economic experienced group, 5 out of 6 managed to finish the steps without guidance. When asked to analyze what they saw when turning on country diversification, 4 out of 6 saw a risk with almost exclusively investing in Swedish stocks. The other 2 notified the Nordic tone on the portfolio but came to the conclusion that is reassuring.

The non economical experienced group, had 90% of the steps completed. In the analyzing part 3 out of 10 just said what they saw which meant Swedish, American and Norwegian holdings. 3 other thought it was a bad idea to invest so much in Sweden. The rest were satisfied with the country allocation since they believed in Swedish companies.

- Task 4

The economic experienced group needed no guidance for this step which was about turning on industry allocation. Two persons thought it was a doubtful allocation with industries known to be risky. Two testers were pleased with the current distribution and the other two thought it was too much IT/Tech companies involved.

The non economical experienced group, also didn't need no guidance for this particular task. 6 out of 10 thought it was a good industry allocation. Two persons thought it was to much IT/tech and one person believed it was risky industries all of them. The last one didn't think anything at all about the chosen industries.

- Task 5

The economic experienced group, without guidance through the steps 6 out 6 thought the volatility in general was too high.

The non economical experienced group, only 1 out of 10 didn't find the handle for volatility and was required guidance. When analyzing the distribution 5 persons thought the volatility for the stocks and the portfolio in general was high and risky. 3 people didn't think anything about it at all and the last two participants thought it was good.

- Task 6

The economic experienced group, 5 of 6 managed to find the market value and balance. When in front of the money visualization, 2 people thought it was too much of the whole bank roll invested. When interacting 4 out of 6 started to throw and play with the money which in two cases led to throws with other interactable furnishing.

The non economical experienced group, 90% found the wall with the bank roll information. One single person thought it was dumb not to invest every penny. The rest of the bunch didn't say anything about the numbers. 8 out of 10 started to throw the money towards the horizon and 6 out of these 8 participants brought the madness to other objects.

- Task 7

The economic experienced group, 5 persons accomplished the steps of this task which meant turning on bull and bear market speculation. What could be said out of everyone was that the potential winnings were good and the potential losses were big. 4 persons hinted that the portfolio was far to risky when seeing the bear case.

The non economical experienced group, 9 out of 10 successfully turned on bull and bear market without guidance. 5 applicants made thought the portfolio could generate high reward and was therefore good. 4 testers believed the risk was to high for the whole portfolio when seeing the bear market calculations. The last person didn't have any thoughts at all about the market speculation.

5.4 Feedback

The feedback, was as mentioned, collected with the survey attached in Appendix B. The statements were answered with a Likert scale from 1 to 5 with 1 representing “not agree” and 5 being “totally agree”.

In the staples the group with economic experience is visualized with blue and the other group without knowledge in the area is pictured with orange.

- S1: I found the tool unnecessarily complex

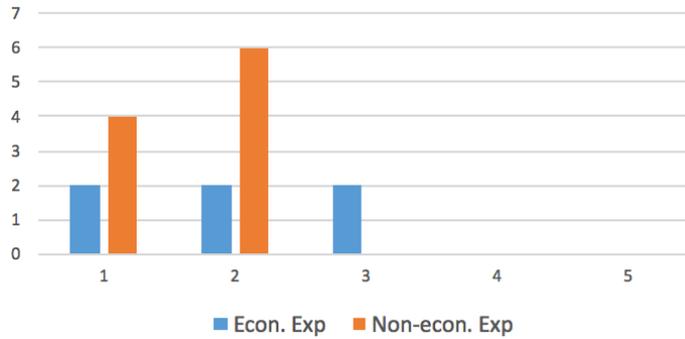


Figure 5.1 Feedback on S1

Economic Experienced Average: 2

Non-economic Experienced Average: 1.6

Total Average: 1.75

- S2: I think that I would like to use this tool on my investment portfolio

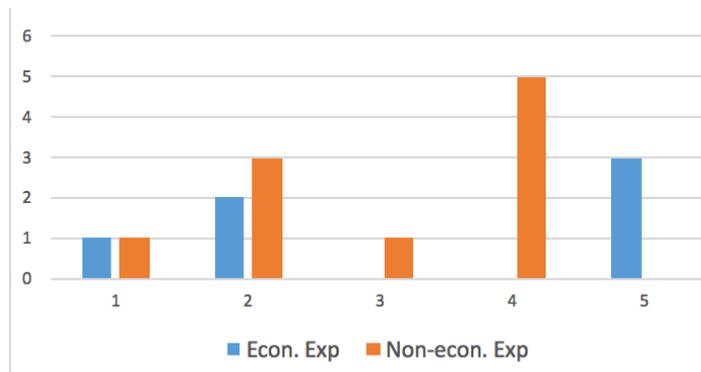


Figure 5.2 Feedback on S2

Econ. Exp. Average: 3.333

Non-econ. Exp Average: 2

Total Average: 3.125

- S3: I thought the tool was easy to use

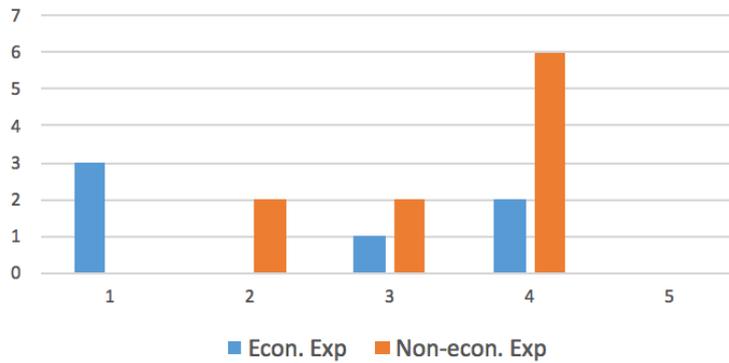


Figure 5.3 Feedback on S3

Econ. Exp. Average: 2.333
 Non-econ. Exp Average: 3.4

Total Average: 3

- S4: I think that I would need the support of a person with economic background to be able to use this tool

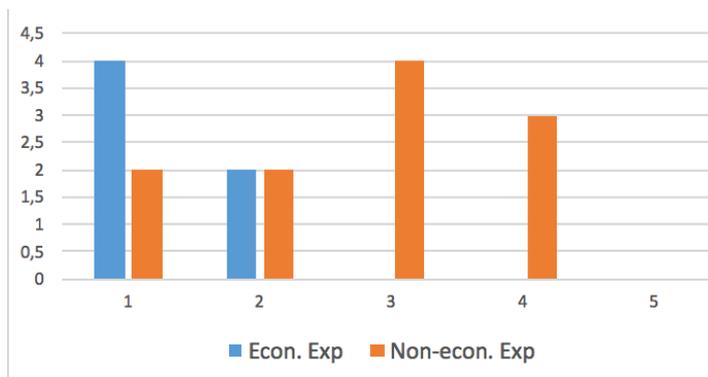


Figure 5.4 Feedback on S4

Econ. Exp. Average: 1.333
 Non-econ. Exp Average: 2.727

Total Average: 2.375

- S5: I think that banking and economics have an area of use for virtual reality

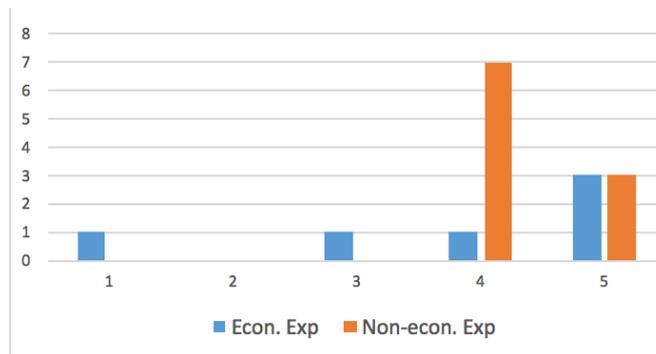


Figure 5.5 Feedback on S5

Econ. Exp. Average: 3.833
 Non-econ. Exp Average: 4.3

Total Average: 4.125

- S6: I thought there was too much inconsistency in this system

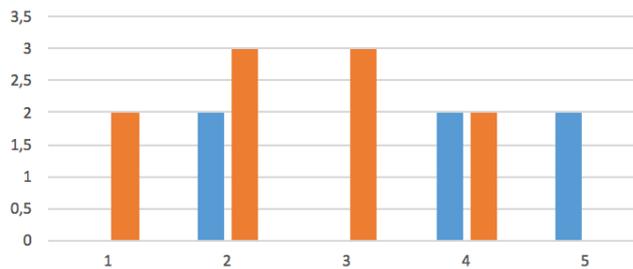


Figure 5.6 Feedback on S6

Econ. Exp. Average: 3.667
 Non-econ. Exp Average: 2.5

Total Average: 2.9375

- S7: I would imagine that most people would learn to use this system very quickly

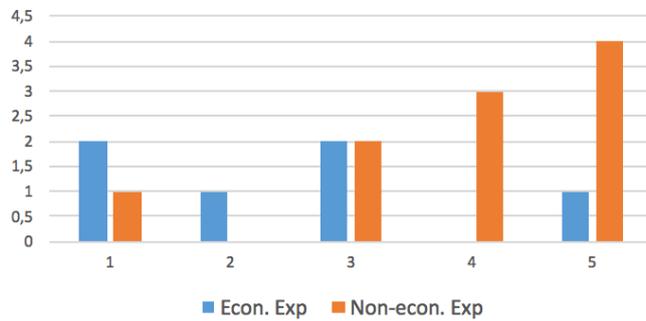


Figure 5.7 Feedback on S7

Econ. Exp. Average: 1.5
 Non-econ. Exp Average: 3.9

Total Average: 3.375

- S8: I found the system good in showing risks with investments

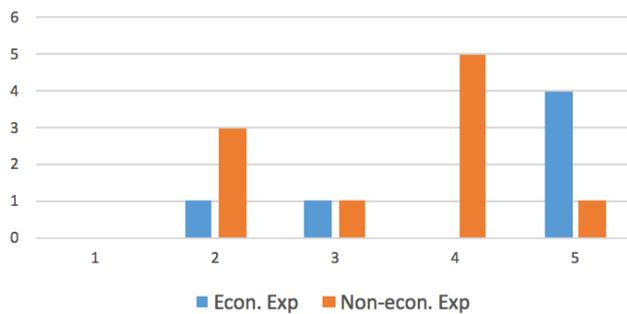


Figure 5.8 Feedback on S8

Econ. Exp. Average: 4.167
 Non-econ. Exp Average: 3.4

Total Average: 3.6875

- S9: I felt very confident using the system

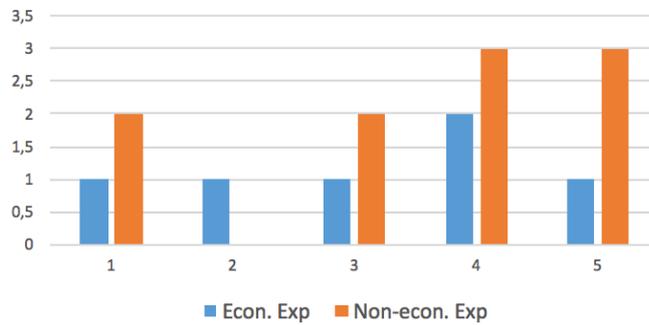


Figure 5.9 Feedback on S9

Econ. Exp. Average: 3.167
 Non-econ. Exp Average: 3.5

Total Average: 3.375

- S10: I needed to learn a lot of things before I could get going with this system

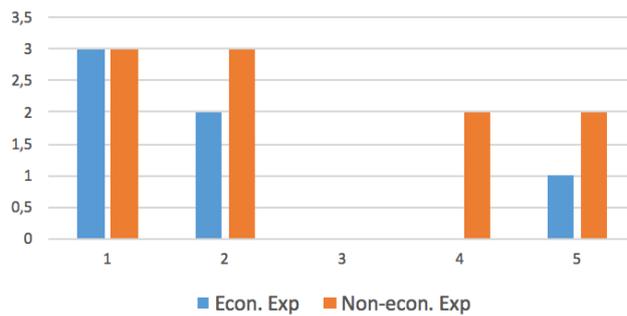


Figure 5.10 Feedback on S10

Econ. Exp. Average: 2
 Non-econ. Exp Average: 2.7

Total Average: 2.5625

- S11: I think virtual reality made portfolio management more entertaining and fun than normal

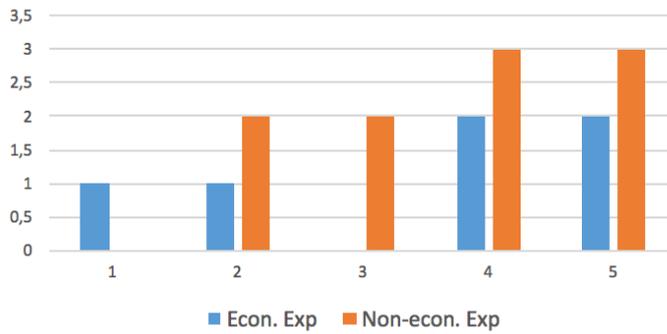


Figure 5.11 Feedback on S11

Econ. Exp. Average: 3.5

Non-econ. Exp Average: 3.7

Total Average: 3.625

- S12: The environment tricked me into thinking I was really there

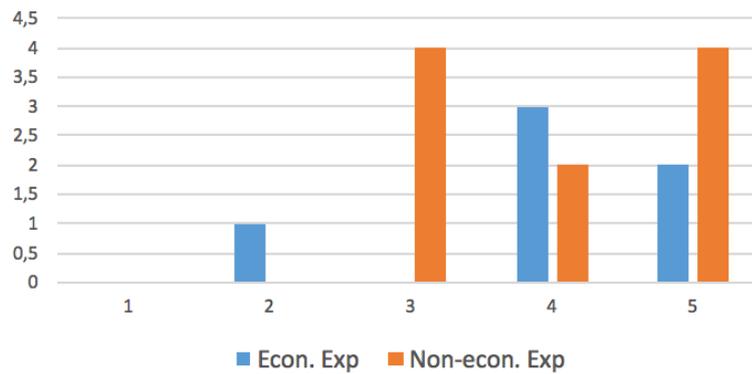


Figure 5.12 Feedback on S12

Econ. Exp. Average: 4

Non-econ. Exp Average: 4

Total Average: 4

- S13: I could appreciate the value of money

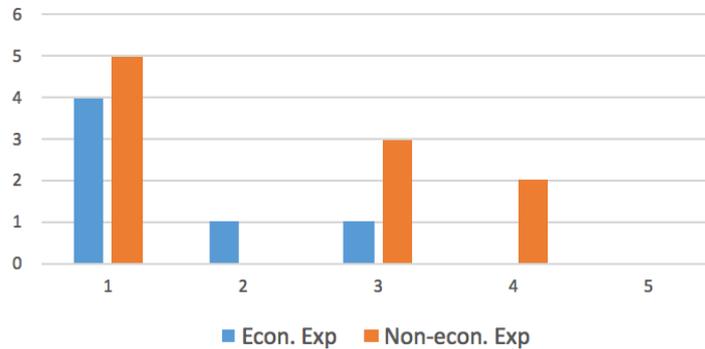


Figure 5.13 Feedback on S13

Econ. Exp. Average: 1.5

Non-econ. Exp Average: 2.8

Total Average: 2.125

- Comments

Econ. Exp. Group:

”Nice environment with good visual effects and sound effects”

”I can clearly see improvements on the system but it made me realize the technique have a future in banking”

”First time I tried VR and I really can say I want to use it in future banking”

”Every amateur should use a tool like this on their portfolio”

Non-econ. Exp. Group:

”Well made environment, easy to handle. Good use of colors. Good structure, nice model of a bank.”

"All in all, a nice environment with nice effects"

"Made me realize how risky it could be to invest"

"It would be nice with some highlighting to show that you can interact with it. Maybe you could hide the other staples too."

6 Discussion

This chapter will interpret and discuss the results from the test execution and present conclusions that can be drawn from the course of the study

6.1 Results

The result shows a number of interesting things that should be discussed further. Firstly, the average values on the feedback differ between the groups' results on the questionnaire. The economic experienced group had a lower average than the group with no economical background. A higher average indicates a more optimistic view on the system and on VR as a financial instrument.

Also worth mentioning is that the economic group had a slightly lower average on finishing tasks than the other group, which may affect the concentration negatively and make it more difficult to focus on the information presented in the system. This may have led to the poorer answers on the questions regarding user experience (S1, S3, S6 & S9) which the group accounted for.

The numbers and answers gained can be interpreted in many ways. In order to get credible figures -more test results are required to make calculations. Although the amount of data was small, I discovered some interesting indications to analyse and discuss further.

In the visualizing risk department, it is important to remember that it's hard to show dangers and opportunities if the audience is not aware of what can actually be risky. The non-economic group did agree more than the economic group in the question if that the user needs support of an economic experienced person when using the system, probably aiming on economic terms and mindset. There were no right and wrong with

the imaginary portfolio composed by the financial advisors, but they considered it to be very risky in 5 different ways (see 1.5.2.1). Some tasks involved analysing the information in front of the user which in several cases required a little economic knowledge to think like the financial advisors thought. Most of the people in the economic groups spotted the majority of the risks pinpointed by the advisors. Fewer risks were notified by the other group, even though the message succeeded, persons didn't really associate it with a risk. For example, many people were satisfied in just investing in Nordic companies since the countries considered stable others interpreted this as a bad country allocation. According to the feedback survey question "S8: I found the system good in showing risks with investments" the economic experienced group summed and average of 4.167 out of 5 and 3.4 by the non economic-experienced group which must be considered as success. This can be compared to the initial survey questions where only 23% thought the banks succeed in showing an image of risk and opportunity.

When the test where conducted laughs was heard from the green room. People new with the technique didn't believe their eyes and wanted to stay in the environment. Many of the attendants had VR-experience but most of these folks had just tried the technique when playing games. It is very rare today to combine the technique with something so precious as your savings giving the room a sense of paradoxical mood. When answering; "S11: I think virtual reality made portfolio management more entertaining and fun than normal", with no bigger difference between the groups a 3.625 from 1 to 5 could be collected. This is clearly better figures than from the survey when 28.8% described the data as boring.

I really strived for high immersion in the virtual world which seemed to succeed since the score on the question if the test persons were tricked in to really feeling present in the environment, resulted in a 4 out 5. The survey rattled about some people not feeling that money visualized in todays system was real. In order to increase the link to real value, the money invested in the portfolio was interactable and visualized as normal money. This was probably the biggest defeat of the environment since "S13: I could appreciate the value of money" only generated an agreement level of 2.125 in average. However, regardless of the quality of the VR environment, how it is designed and whether or not using platforms that use active or passive VR -results can be obtained.

What can we say about VRs future in banking? Generally, the economic experience was more critical according to the feedback and the interview with the financial advisers. This may be due to habit with the existing financial systems that work well if you get used to them. But this group still summed up a high 3.8 average on the question if VR have a future in banking, the more unexperienced economists ended up with 4.3. Scattered sheds in the feedback and may prove that current systems may not be superseded but accompanied. The conclusions about how VR made the information more fun to interpret will probably increase the understanding and learning of the private investors. Much of the feedback circuits around how VR may be a better way of visualizing data than normal 2D representation but leaving the money handling/transaction parts to the physical or normal ways. The lack of VR in finance and the fact that no actor offers portfolio management today may lead space for the hungry banks to achieve technical attention which according to the interview with the financial advisers were very important for the trustworthy banks.

Since so few participants attended in the study, we I can not really for 100% express whether the outcome depends on the random or actually demonstrates that VR have a guaranteed future in finance and portfolio management.

6.2 Pre-knowledge

The experiment was carried out at Lunds Faculty of Engineering which led to an overrepresentation of engineers in the study. Engineers may be more open minded for technical evolution; this may have affected the optimism of the study in general. As presented earlier, 56% of the attended had VR-experience –which must be considered as very high. Persons with this knowledge is more comfortable with the virtual environment and could therefore more easily concentrate and thus more easily capture the information that was relevant to the tasks and answering questionnaires.

6.3 Choice of method

Many different designs of the environments could be developed when examine the use of VR in finance. It can not be sure if the present design was the right way to go since there are very many different ways of visualizing data. What can be said about the environment is that the results suggest that the same investments became more interesting in VR for the majority of the users unlike the regular visualization.

6.4 Problems in the process

Even though minor design decision could be discussed with other engineers and the fact that outsiders attended to the brainstorming and different design iterations, the eager to discuss the the continuation of the process with someone who feels involved was big. This fact affected the biggest potential problem: I could not be sure about the experimental design and thus affect the validity of my experiment. Since I have very little experience in conducting studies on test persons I felt unsecured about the testing process with how the task-based scenarios and the questionnaire was designed. In addition, the experiments were performed in the same way for all test persons, but there is still a certain difference between different participants that should be addressed. The time when the experiment took place varies from 08.00 to about 17.00 which may have affected the cognitive senses and the information interpretation.



Figure 6.1 Interactble bankers lamp

Making objects throwable and interactble first sounded as a good idea when working towards high immersion in the system. This physical freedom later became a disturbance torque instead. Some test persons started to throw stuff and a few when berserk and which made them focus less on the next task.

Did people act realistic in the user tests? Its hard to know if testing on VR can be accurate when VR still is so hot as a technique when people are just excited to see the googles in offline mode. The major downside is that VR shields from reality, and therefore the result can not be said to be consistent with how the research results are reflected in practice.

6.5 Proposals for improvement work

Due to time constraints and the lack of interest by other students to collaborate in this study on how VR can be used in finance, limitations was set for the project. There is much space for additional features and bug fixes in the environment.

6.6 Conclusion

Virtual reality can make today's banking and investing easier and more entertaining, it's very clear according to the feedback survey. This may be at the expense of the handling of money and transactions which is clearly not taken seriously.

So how can financial actors apply the technique to show their data? Just releasing a product with the VR-technique has a great news value, both for economical experience how are more than happy with the existing systems and the ones without experience in the area. The study shows that current systems may not be superseded but accompanied. If the environment should use tables or circles diagrams on data visualization cannot be sure but the conclusions about how VR made the information more fun to interpret will increase the understanding and learning of the private investors. If this is done correctly VR will attract newcomers in investing.

People will be able to see risks in their investments and portfolios if fundamental knowledge is presented to those who are completely unaware of the basics of finance. Most of the evidence suggests that VR has an absorbing effect which makes the user more interested compared to interaction with 2D-data. This, provided that the right data is visualized and that the phenomenon immersion and cyber sickness is taken into account when designing the VR-environment.

7 Reference List

Lulu Chang (2016, October 9th). *Virtual reality is helping to bring the last of Auschwitz's war criminals to justice*. Retrieved October 2th. <https://www.digitaltrends.com/virtual-reality/auschwitz-virtual-reality/>

Ben Chapman (2017, June 15th). *7 best VR-headsets*. Retrieved October 1th. <http://www.independent.co.uk/extras/indybest/gadgets-tech/video-games-consoles/best-vr-headsets-for-iphone-7-phone-note-4-s7-edge-apps-ps4-uk-reviews-a7791841.html>

Chun-houh Chen, Wolfgang Härdle & Antony Unwin (2008). *Handbook of Data Visualization*
Berlin, Germany: Springer

Digi Capital (2017, January). *After mixed year, mobile AR to drive \$108 billion VR/AR market by 2021*. Retrieved October 7th. <https://www.digi-capital.com/news/2017/02/record-2-3-billion-vrar-investment-in-2016/#.Wifu7BP9SjR>

Digi Capital (2017, February). *Record \$2.3 billion VR/AR investment in 2016*. Retrieved October 4th. <https://www.digi-capital.com/news/2017/02/record-2-3-billion-vrar-investment-in-2016/#.Wifu7BP9SjR>

James J. Cummings & Jeremy Bailenson (2015). *How Immersive Is Enough? A Meta-Analysis of the Effect of Immersive Technology on User Presence?*. Stanford, California, USA: Stanford University

Michael Filimowicz & Veronika Tzankova (2017): *Teaching Computational Creativity*, (2nd ed.)
Cambridge, United Kingdom: Cambridge University Press

FXVRTtrade (2016). Retrieved October 5th. <https://www.click-sec.com/corp/tool/fxvrtrade/>

HUI Research (2016). *Årets Julklapp*. Retrieved October 5th. <http://www.hui.se/arets-julklapp>

Handelsbanken (2017). *Om Banken*. Retrieved November 23rd. https://www.handelsbanken.se/shb/INeT/IStartSv.nsf/FrameSet?OpenView&iddef=ombanken&navid=Investor_Relations&navob=54&base=/shb/INeT/ICentSv.nsf&sa=/shb/INeT/ICentSv.nsf/default/q700BBE2F5D0AE8B2C12571F10024A224

Nancy L.Jacob (1974). *A Limited-diversification Portfolio Selection Model for the Small Investor*

USA: The American Finance Association

Jennifer Jolly (2017, July 28th). *Doctors are saving life's with VR*. Retrieved October 1st.

<https://www.usatoday.com/story/tech/columnist/2017/07/28/doctors-using-virtual-reality-breathe-new-life-into-technology/506437001/>

International Organization for Standardization (2010, March). *ISO 9241-210:2010*. Retrieved October 20th. <https://www.iso.org/standard/52075.html>

Investopedia (2017). *Risk*. Retrieved October 29th. <https://www.investopedia.com/terms/r/risk.asp>

Investopedia (2017). *Volatility*. Retrieved October 30th. <https://www.investopedia.com/terms/v/volatility.asp>

Investopedia (2017). *Diversification*. Retrieved October 31th. <https://www.investopedia.com/terms/d/diversification.asp>

iZave (2017). *Om Oss*. Retrieved November 23rd. <https://izave.se/om-izave/>

Patrick W. Jordan, Bruce Thomas, Bernard A. Weerdmeester & Ian L. McClelland (1997): *Usability Evaluation in Industry*
London, United Kingdom: Taylor & Francis

William R. Johnson & Kelly Market (2017). *The American Economic Review* USA: The American Economic Association

Soha Maad, Samir Garbaya, James B. Mccarthy, Meurig Beynon, Saida Bouakaz & Rajagopal Nagarajan (2010). *Virtual and augmented reality in finance: State visibility of events and risk*. Paris, France: Science Arts & Métiers

Soha Maad, Meurig Beynon, & Samir Garbaya (2010). *Realizing virtual trading: What price virtual reality?*. Warwick, England: University of Warwick

Tanaya Macheel (2017, June 1st). *How banks are using virtual reality*..Retrieved October 9h.
<http://www.tearsheet.co/modern-banking-experience/how-banks-are-using-virtual-reality>

Daniel R Mestre (2005). *Immersion and Presence* Marseille, France

Michael Michalko (2006): *Thinkertoys: A Handbook of Creative-Thinking Techniques*, (2nd ed.) Frankfurt, Germany: Ten Speed Press

Mindtools (2017). *Detta är Nordnet*. Retrieved November 3rd.
<https://www.mindtools.com/brainstm.html>

Scott Murray (2017). *Interactive Data Visualization for the Web*(2nd ed.) California, USA: O'Reilly Media

Mimmi Nilsson, Johan Ronge & Leif Brännström (2017, Sep 29th). *Före detta chef på Allra häktades – 140 miljoner beslagtogs*..Retrieved November 29h.
<https://www.expressen.se/dinapengar/140-miljoner-kronor-beslagtagna-i-allra-harvan/>

Nordnet (2017). *Detta är Nordnet*. Retrieved November 3rd.
<http://nordnetab.com/sv/om/oversikt-nordnet/>

Jenny Preece, Helen Sharp & Yvonne Rogers (2015): *Interaction Design: Beyond Human-Computer Interaction* (4th ed.)
Chichester, United Kingdom: Wiley

Lisa Rebenitsch (2015). *Managing Cybersickness in Virtual Reality*.
Michigan, USA: Michigan State University

Christopher Scaffidi, Andrew Ko, Brad Myers & Mary Shaw (2005).
Identifying Categories of End Users Based on the Abstractions That They Create
Pittsburgh, USA: Carnegie Mellon University

Tulio de Souza Alcantra, Jörg Denzinger, Jennifer Ferreira & Frank Maurer
(2012). *Learning Gestures for Interacting with Low-fidelity Prototypes*
Calgary, Canada: University of Calgary

Edward R Tufte (2001). *The Visual Display of Quantitative Information* (2nd
ed.)
Berlin, Germany: Springer

Appendix A

This appendix contains the original survey in Swedish

Finansteknologi

Examensarbete LTH (Information- och kommunikationsteknik)

1. Vilken ålder är du i?

- 0-20
- 20-30
- 30-40
- 40-50
- 50+

2. Har du erfarenhet av ekonomi? (Studier, arbete eller investeringar)

- Ja
- Nej

3. Vilka/vilket ord beskriver bäst hur aktie- och fonddatan redovisas på din bank?

- Krångligt
- Tråkigt
- Tydligt
- Simpelt
- Oförståeligt
- Intressant
- Avskalat
- Roligt
- Aldrig kollat på den

4. Skulle du vilja förstå mer av investeringsdata? (nyckeltal, balansräkning eller resultaträkningar)

- Ja
- Nej, Förstår redan det mesta
- Nej, Inte Intresserad

5. Analyserar du ofta din aktie- och fond-portfölj?

- Ja
- Nej

6. Tycker du att visualiseringen av dina innehav i din aktie- eller fondportfölj ger en bra bild vad gäller risk/möjligheter?

- Ja
- Nej
- Vet ej
- Kollar ej på den

7. I vilken utsträckning känner du att visualiseringen av dina innehav ger dig en känsla av verklighet snarare än bara nummer?

	1	2	3	4	5	6	7	8	9	10	
Bara nummer	<input type="radio"/>	Verklighet									

Appendix B

Scenario-based Testing

1. - Teleport in to the portfolio
- Find the SaltX-holding
- Discover the amount of the stock
- Discover the returns

3. - Find the Carnegie Sweden-holding
- Discover the Morningstar rating
- Discover the actual price

2. - Turn on country diversification
- Analyze the country diversification

3. - Turn on industry diversification
- What can be said about the distribution

4. - Turn on volatility diversification
- What can be said about the distribution

5. - Find the market value and balance
- Interact with the money

6. - Find the bull and bear market handles
- How can the market affect the portfolio?

<i>Test</i>	<i>Result</i>	<i>Time</i>	<i>Comments</i>	<i>Grade (1-10)</i>
1				
2				
3				
4				
5				
6				
7				

Table B.1 The notification protocol for the scenarios

Feedback survey

	1	2	3	4	5
1. I found the tool unnecessarily complex	<input type="checkbox"/>				
2. I think that I would like to use this tool on my investment portfolio	<input type="checkbox"/>				
3. I thought the tool was easy to use	<input type="checkbox"/>				
4. I think that I would need the support of a person with economic background to be able to use this tool	<input type="checkbox"/>				
5. I think that banking and economics have an area of use for virtual reality	<input type="checkbox"/>				
6. I thought there was too much inconsistency in this system	<input type="checkbox"/>				
7. I would imagine that most people would learn to use this system very quickly	<input type="checkbox"/>				
8. I found the system good in showing risks with investments	<input type="checkbox"/>				
9. I felt very confident using the system	<input type="checkbox"/>				
10. I needed to learn a lot of things before I could get going with this system	<input type="checkbox"/>				
11. I think virtual reality made portfolio management more entertaining and fun than normal	<input type="checkbox"/>				
12. The environment tricked me into thinking I was really there	<input type="checkbox"/>				
13. I could appreciate the value of money	<input type="checkbox"/>				

Other thoughts:

Appendix C

<i>Stock</i>	<i>Type</i>	<i>Country</i>	<i>Volatility</i>	<i>Industry</i>
Saltx	Stock	Sweden	78%	Energy
Snap Inc	Stock	USA	63%	IT/Tech
Maha Energy	Stock	Sweden	42%	Oil
Impact Coating	Stock	Sweden	82%	Material
Fingerprint Cards	Stock	Sweden	72%	IT/Tech
Imint	Stock	Sweden	24%	IT/Tech
Swedbank Ny Teknik	Fund	Sweden	24%	IT/Tech
Carnegie Sverige	Fund	Sweden	17%	Swedish Companies
Storebrand Norge	Fund	Norway	13%	Norwegian Companies

Table C.1 The financial assets used in the environments portfolio