An Asymmetric Virtual Reality Game on Water Scarcity

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An Asymmetric Virtual Reality Game on Water Scarcity

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Abstract

Access to water is a necessity for farmers for them to be able to produce food. This poses a problem in Jordan, one of the world's driest countries, but also in Sweden, where after a drought in the summer of 2018 the state of the water levels was more critical than ever. Virtual reality (VR) has shown to be a tool with a good effect on students' learning. In this work VR has been taken advantage of in order to increase the understanding of water scarcity.

The challenge was to present the issue of water scarcity within farming for a group of high school students in a VR game suitable to be used at a science center. An obstacle to introducing VR in such a setting is that the experience should be suitable for a group of people. In this report a user centered design approach has been taken to make a VR game on drought to be used in groups of up to about 10 students. By including 360-degree video footage of farmers and experts in Sweden and Jordan a game has been developed to make students more aware of the issues of water scarcity. The goal was to design a game involving all students regardless of playing in the VR headset or outside and encourage a discussion on water scarcity between the players.

The game was developed in four iterations and concluded with a user verification test where the application was used in a real life setting at a school visit of a science center. The final tests showed that the solution worked well as an asymmetric game and had potential in increased learning but it did not reach the hoped level of discussion and the roles inside and outside VR were not equally engaged.

Keywords: user centered design, virtual reality, educational games, multi-player

Sammanfattning

Tillgång till vatten är en nödvändighet för bönder för att de ska kunna producera mat. Detta utgör ett problem i Jordanen, ett av världens torraste länder, men också i Sverige, där vattennivåerna blev mer kritiska än någonsin efter en torka sommaren 2018. Virtual reality (VR) har visats vara ett verktyg med bra inverkan på elevers lärande. I detta arbete har VR använts för att öka förståelsen för vattenbrist.

Utmaningen var att presentera problemet med vattenbrist inom matproduktion för en grupp högstadie- eller gymnasieelever i ett VR-spel som skulle kunna användas på ett science center. Ett hinder för att använda VR i ett sådant sammanhang är att upplevelsen ska passa en grupp. I denna rapport används användarcentrerad designmetodik för att göra ett VR-spel om torka som kan användas för upp till cirka 10 elever. Genom att använda 360-graders videoklipp med bönder och experter i Sverige och Jordanien så har ett spel utvecklats som ska göra elever mer medvetna om problemen relaterade till vattenbrist. Målet var att designa ett spel som skulle aktivera alla elever, oavsett om de var i VR eller utanför, samt uppmuntra en diskussion om vattenbrist mellan spelarna.

Spelet utvecklades i fyra iterationer och arbetet avslutades med ett verifierande användartest där spelet användes i ett verklighetsnära scenario vid ett skolbesök på ett science center. Sluttesten visade att lösningen fungerade väl som ett assymetrisk spel och hade potential för ökad lärande, men att den inte uppmuntrade önskad nivå av diskussion och att rollerna i och utanför VR inte engagerades likvärdigt.

Nyckelord: användarcentrerad design, virtual reality, lärospel, multiplayer

Acknowledgements

There are many people without whom this project would not have been possible, and many more without whom it would not have been as good nor enjoyable.

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CHAPTER 1

Introduction

This project's focus is to raise awareness on water scarcity both globally and locally through a multiplayer game using virtual reality (VR). It is done with a focus on the farmers' challenges in Sweden and Jordan.

Jordan is today one of the world's driest countries [The Economist, 2017] and the situation there has both differences and similarities to the situation in Sweden, which still has sustainable water levels. The groundwater levels in Sweden are lower than normal [SMHI and SGU, 2018] and after the drought of the summer of 2018 the state of the water levels is more critical than ever [Hovne, 2019].

In order for the groundwater to fill up the rainfall has to be continuous throughout the year. If the rain is too scant the plants will take up all the water, and if the rainfall is too heavy most of it will be washed out into the sea. A steady and not too heavy rainfall is needed for the water to sipper down through the ground and fill up the groundwater. With climate change the weather is getting more extreme [Lubchenco and Karl, 2012]. This means that with the changing climate it could in total rain the same amount, but during a shorter period, which leads to less probability of the groundwater filling up.

With longer periods of time without rainfall the farmers have to irrigate with the water from their own wells that are connected to the groundwater, and this will affect the groundwater levels. If the groundwater runs out, the farmers have to ask for permission to take water from lakes in the area. When in this state it probably has not rained for a while, and the surface water levels in the lakes are low. This means the farmers will not get permission to take water from the lake, and they will end up without the possibility to water their plants. Apart from affecting the farmers this also affects the food market. [Beckman, 2019]

This chain of effects are complex, but is today part of the farmers' reality. So how can this be made easier to understand?

VR has in several studies showed positive effects on understanding and learning. One such study covers a VR experience done by Markowitz et al (2018), which was done as an excursion to learn about acidification. The study contained several investigations with different target groups which all showed that the VR excursions led to an increased knowledge and curiosity about climate change. Some also resulted in giving the user a more positive attitude towards the environment.

1.1 Purpose and Goal

The main purpose of this thesis was to research how to design an asymmetric virtual reality game [1] to be used as an educational tool. From this purpose the following research questions were formulated:

- How can the game be designed in order to facilitate discussions on water scarcity?
- How can a group be engaged in a VR game using only one VR headset?
- How can the game be designed in order to make all participants feel equally engaged in the game?
- How can the game be designed to be suitable as an educational tool?

The thesis was done as part of the science communication project *Save the Basin* where the purpose and goal with the VR experience was summarized as following: "This multiplayer game gives pupils an awareness and an overall picture of what it means to tackle water challenges. This both globally and locally, and how it affects farmers specifically. It also gives them an understanding of how cooperation between all parts of society is necessary. The pupil should leave the game with a feeling of the situation being critical, but that it can be solved through cooperation."

1.2 Limitations and Scope

The VR experience was developed with the goal to fit as an activity at an exhibition at Vattenhallen Science Center at Lund University. Vattenhallen

[1] An asymmetric game is a game for multiple players where the different players have completely different roles in the game.

Science Center is a regional resource for technology and science education were students and the public can go on exhibitions and learn about different science topics. The VR experience designed in this project is meant to fit among other activities in an exhibition about climate change. To fit at Vattenhallen the game should take up to about 10 players at the same time, but still work for fewer players, and have a duration of around 30 minutes.

Additionally, since this thesis was done as part of the project Save the Basin some limitations and scopes were given from the project.

Limitations and scopes determined by Save the Basin:

- The main target group should be 14-18 year olds from Sweden
- The VR experience should be in English
- The standalone Oculus Go headset should be used
- The experience should include 360 videos from Sweden and Jordan

Other than the above given limitations this thesis is time restricted to 20 week of two students working full time, which sets a limit for the size and complexity of the project.

CHAPTER 2

Theory

This chapter the theoretical background of the report. The main themes covered are VR, education, learning and motivation and design methods.

2.1 Virtual Reality

This section begins with introducing a definition of VR. After that the history of VR is presented along with a presentation of Oculus Go in comparision to other VR headsets. The game engine Unity is introduced, and finally VR ergonomics are highlighted.

2.1.1 Definition of VR

Virtual Reality is what the name refers to: reality created virtually. One definition of what VR is, is in The Oxford English Dictionaries: "The computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors" [Oxford Dictionaries, 2019].

2.1.2 Presence

Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another environment

[Witmer and Singer, 1998]. Involvement and immersion are needed in order for a person to experience presence. Involvement is how much the user focuses their attention on the virtual experience. Immersion is in short feeling included and interacting with the environment one experiences. These factors contribute to presence and can exist to different degrees. For example novelty is something that can make people more focused and thus increase their involvement. Immersion in a virtual environment can be heightened by being fully isolated from the physical environment [Witmer and Singer, 1998].

2.1.3 The History of VR

Creating the reality virtually can be done in many ways and it has been done for a long time. Today VR is usually referred to as a simulation in a Head Mounted Display (HMD). An example of a HMD can be seen in figure 2.1.

Figure 2.1: The first modern HMD, the Oculus Rift DK1 - released after a Kickstarter campaign in 2012. Image from Wikimedia.

The oldest known attempt to create the real world in a different format is paintings on the walls of caves. Paintings has then continued to emulate the world as realistically as possible. Recording or creation of videos is another medium for showing a world that does or does not exist.

In 1962 a product came out trying to stimulate several senses at the same time when watching a movie in 3D, to simulated reality. It was made by Morton Heilig and called Sensorama (see figure 2.2). This is considered a milestone in the history of VR [Wallergård et al., 2018].

In the 90's several new VR products were being developed. At this time however, VR got connected with bad UI, dizziness and high costs [Wallergård et al., 2018]. It was in 2012, when a kick starter campaign launched Oculus Rift and after that other companies followed VR was made into what it is today with a lot of companies creating VR products [Wallergård et al., 2018]. The Oculus Rift in question can be seen in figure 2.1.

Today VR experiences are made in two different ways: A 360-degree video can

Figure 2.2: The Sensorama from 1962. Image from Wikimedia.

be shown, or it can be a 3D generated environment. With 360-degree video scenes from the real world are captured with a 360 camera. This is a quick way of making a realistic experience, but it has the constraint of only being viewable from one point (the point of which the video was filmed), and the possibility of adding interactive elements in a natural way is restricted. Building a 3D generated environment in a game engine on the other hand is a lot of work, as each object in the world has to be constructed and placed out specifically. When such an environment has been set up it is however easy to edit, for example to add interaction to the objects, and the objects can be viewed from different angles. The VR experiences may also contain a mix of the two elements to combine the aspects of swift development and interactivity.

2.1.4 The Oculus Go in Comparision to Other Headsets

There are different types of VR headsets such as wired VR headsets with head motion sensors mounted outside the headset where the experiences are run on a separate computer (e.g HTC Vive, Oculus Rift) or standalone headsets e.g Oculus Go, as seen in figure 2.3. The Oculus Go is an accessible device due to its low price, although it lacks in quality compared to the HTC Vive and Oculus Rift.

The performance of the Oculus Go standalone headset is lower than that of

headsets connected to a computer. The greatest difference lays is in the degrees of freedom. The Oculus Go has only three degrees of freedom whereas the other mentioned headsets have six degrees of freedom. What this implies when it comes to VR in the Oculus Go is that the user can rotate in 360 degrees but not move along the x, y nor the z-axis in the space [Snyder, 2016]. This means that when using a headset with three degrees of freedom such as the Oculus Go, if you move your head up, down, forward, back or to any side the whole environment in the experience will move as well. In six degrees of freedom it will appear as you are moving within the VR environment. This has a great impact on the experience of reality. To keep the experience natural when moving the head in the Oculus Go, the head can only rotate around its own axis. The controller of the Oculus Go is also restricted in movement to an area around its starting points which leads to hand movements forward or backward not being recognized.

When a VR headset has only three degrees of freedom it gives some specific design constraints. Since the user can not move around in the environment nothing can be reached by reaching out a hand or walking to the object. Instead a pointer can be used. The game should not trigger the users' natural movement along the axes. For example a user might want to duck if something is coming too close. That would break the feeling of reality using Oculus Go as the world in VR will move with the user.

Figure 2.3: The Oculus Go. Image from Oculus.

2.1.5 Development in Unity for Oculus Go

One game engine for developing VR experiences is Unity. Unity supports game development in both 2D and 3D environments [Unity, 2019]. When building an application to Oculus Go through Unity an Android build is done and then installed to the headset. This can be compared with having an application on an Android phone, and this is what makes it possible for the Oculus Go to be a standalone device [Oculus, nd].

2.1.6 VR Ergonomics

When designing VR experiences layout positioning is important to consider for good ergonomics of the experience [**?**]. In Figure 2.4 different zones are shown based on how comfortable it is to view content in them. There is a "no-no zone" for elements in VR within an area of 0.5 m in radius around the head, and a general comfortable zone up to 77 degrees to either left or right. When it comes to neck movement, the users should maximum move their sight 60 degrees up, 40 degrees down and 55 degrees to each side, as can be seen in figure 2.5. Elements can be comfortably visible up to 77 degrees figure 2.4 to each side, but if the user should look straight at an element it should not be located more than 55 degrees to the side (see figure 2.5).

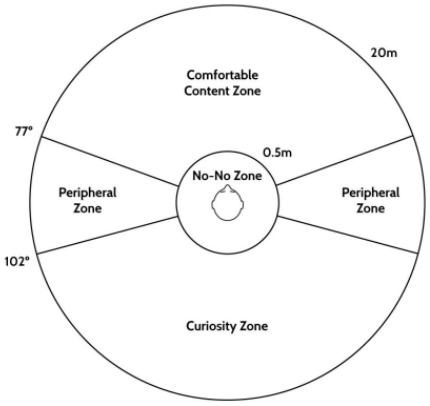


Figure 2.4: Zone diagram for comfortable visuals [Alger, 2015]

2.1.7 User Interfaces in VR

Design of user interfaces in VR differs from interface design of 2D applications. Both because of the difference in interaction, and due to the different type of screen. In VR you have 360 degrees of possible locations for placing user interface elements, whereas in 2D you are usually restricted to a rectangular screen. With touch on a tablet or with a mouse on a computer you have a very high precision in comparison to using a controller or gaze in VR. For instance it can be hard to hit an object in VR and therefore the buttons should be bigger than they can be on a 2D screen to make it convenient for the user to interact with the environment.[Alger, 2015]

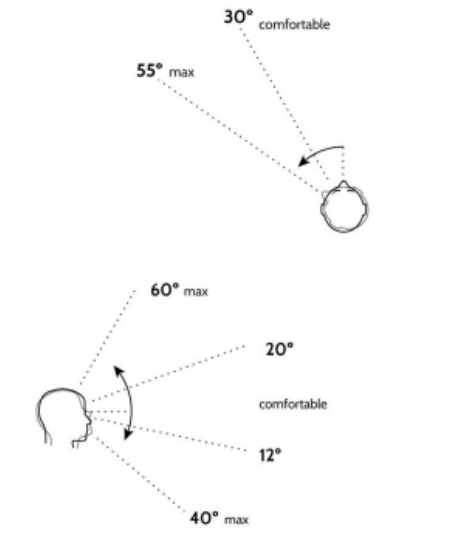


Figure 2.5: Neck movement degrees when using VR headsets [Alger, 2015]

2.2 Education, Learning and Motivation

This section covers how VR has been shown helpful for education and motivation, and how group discussions in education can be good for promoting critical thinking and giving new perspectives.

2.2.1 Virtual Reality as an Educational and Motivational Tool

This section highlights several studies where VR has been investigated as an educational tool. The studies show that students' motivation increases when using VR for education, and in some cases they also show more efficient learning.

A study by Liou and Chang showed that education in VR can increase high school students' motivation and results in a chemistry laboratory and when learning the human anatomy [Liou and Chang, 2018]. Babu et al. showed that education in VR can be made more effective than the same experience in 2D concerning learning different motorbike parts for adult students [Babu et al., 2018]. In a study by Parong and Mayer, Powerpoint slides were compared to a VR experience about how the human body works [Babu et al., 2018]. It was done on a group of university students and the study showed that the students re-

membered the information better from the Powerpoint, especially when it came to learning facts. When adding a summarizing prompt to VR the results were similar to when using a Powerpoint [Parong and Mayer, 2018]. However, the students reported feeling more motivated and interested in learning more when doing the VR lession [Parong and Mayer, 2018].

There are also signs of an experience in VR being able to increase a person's likelihood to act on the given information. Herrera et al showed that people who got to experience homelessness in VR were more willing to sign a petition for price worthy housing than both those who got the information without an experience and those who got the same type of experience but on a 2D screen [Herrera et al., 2018].

2.2.2 Group Discussions as an Educational Tool

Group discussions are an educational tool with both advantages and disadvantages. A group discussion is when individuals verbally communicate either to share knowledge, or to decide on something together [Stenlund et al., 2017]. A study by Stenlund et al showed that test-enhanced learning was more effective than group discussions for retention of facts [Stenlund et al., 2017]. Pollock et al conclude that several studies suggest that discussions are beneficial for learning, for example through that they promote critical thinking and give the students new perspectives [Pollock et al., 2011]. They also mention that discussions do not always lead students to learn what they are supposed to know, as they might not have sufficient knowledge to do so. Students may also develop false memories, thinking that information from the group discussions was learned in the original learning situation [Roediger et al., 2001].

In group discussions, the amount of people in the group influences the nature of the discussion. Larger groups (of 10 people) have been shown to be less interactive than smaller (of 5 people) and when making decisions in a large group the members' decisions were more significantly influenced by the dominant speaker in the group [Fay et al., 2000].

2.3 Design Methods

This section presents the user centered design process and its three phases: the conceptual design phase, the elaboration phase and the detailing phase. It also presents different interview methods and prototyping.

2.3.1 User Centered Design

User centered design is a design process which is iterative, building upon understanding of the situation of the users and other stakeholders in the situation where the product is to be used [Arvola, 2014]. The key principles are that it should focus on users and their tasks early in the design process, that the designs should be measured by the use of prototypes and that the process should be iterative: as problems are uncovered by user testing of the prototypes, the design should be improved and tested again [Gould and Lewis, 1985] [Preece et al., 2015]. User centered design is good for discovering errors in thinking in prototypes before making the actual product. The design process consists of three phases: the conceptual design phase, the elaboration phase and the detailing phase. The conceptual design phase focuses on finding what should be designed by learning about the usage situation and discussing ideas with stakeholders. Once that is done rough prototypes are made and the general ideas of the product developed in the elaboration phase. Lastly in the detailing phase a detailed prototype is made [Arvola, 2014].

2.3.2 Interview Methods

Interviews are a tool that can be used in order to get information from users and other stakeholders when making a design.

There are different types of interviews suitable for different situations. Interviews can be conducted individually or in group. They can also have different levels of formality. The most formal type of interview is the structured interview, where all questions are formulated beforehand and every interviewee get the same set of questions formulated in the same way and the questions have only a few possible answers [Preece et al., 2015]. The formal interviews are well suited for surveys. The most informal type of interviews are the unstructured interviews. Unstructured interviews have open ended questions and areas to explore rather than questions precisely formulated on beforehand. The unstructured interviews are good for exploration as questions may be asked depending on what the interviewer finds interesting to explore during the interview [Preece et al., 2015]. Semi-structured interviews are a mix of formal and informal interviews. These have some questions or topics that are covered with each interviewee, but the interviewer can also freely ask follow up questions [Preece et al., 2015]. These are suitable for getting more information while still making the interview replicable [Preece et al., 2015].

2.3.3 Prototyping

Prototyping is an important activity in the user centered design process. Designers make use of prototypes to get input on the ideas and concepts of a product in order to gradually improve and refine it.

A prototype is a draft of a product idea. The prototype may cover the whole product or only a part of it, the level of detail in the prototype may also differ [Arvola, 2014]. Prototypes of low detail are called low-fidelity (lo-fi) prototypes. The lo-fi prototypes may not look like nor provide the functionality of the final product - for example a prototype of a computer program may be made out of paper [Preece et al., 2015]. The advantages of a paper prototype include its low development costs, which makes them good for exploring design ideas. A detailed high-fidelity (hi-fi) prototype on the other hand should have the complete functionality and look similar to the final product to be produced [Preece et al., 2015].

CHAPTER 3

Design and Development

This chapter presents the activities and results of each design and development phase in chronological order. The phases and the prototypes developed can be seen in figure 3.1. In the conceptual phase a pre-study was made which resulted in a detailed goal and concept for the project. During the elaboration phase the concept was prototyped on paper and then tested and evaluated. In the detailing phase the concept was tested several times through the development and testing of prototypes, finally resulting in the final prototype used in the verification phase (chapter 4).

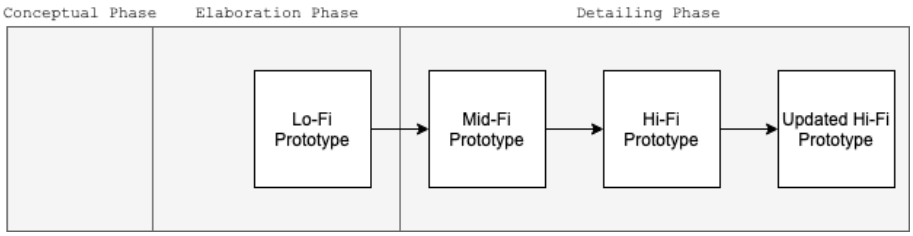


Figure 3.1: The phases of the project and the prototypes made in them.

3.1 Conceptual Phase

In the conceptual phase it was explored what should be developed by discussing with stakeholders and interviewing representatives of the target users. Relevant theoretical background was also gathered through interviews with experts. At the end of the section a summary of the concept decided on in the conceptual phase is presented.

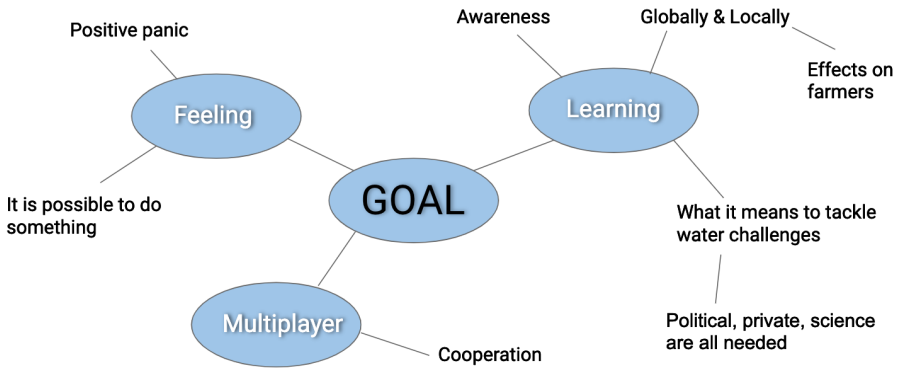


Figure 3.2: Results of brainstorming session

3.1.1 Brainstorming with Stakeholders

A brainstorming session was held with the project manager from Save the Basin and representatives from Vattenhallen Science Center on their goal for the application within the areas learning (what the users should learn when using the application), feeling (what the users should feel when using the application and afterwards), and multiplayer (what the multiplayer element should add to the application). The ideas were summarized in a mind map and later prioritized.

The goals which were deemed to be of high priority are presented in 3.2.

3.1.2 Interviews with Representatives of Target Users

To get an understanding of which knowledge the target users have in the area, which attitudes they have towards saving water and how they view the problem with water scarcity interviews with students in grade eight from two different schools were conducted in connection with a visit to Vattenhallen Science Center.

To aid discussion and reflection the interviews were done in groups of three students. They volunteered themselves in groups. One interviewer conducted each interview, making notes during the interview. Each interview took about 10 minutes and five interviews were conducted in total.

After the interviews the impressions were summarized. The conclusion was that the students know specific facts on the subject, but usually lack a deeper understanding. They think drought is an issue but they generally think it will not grow to be a big issue in Sweden.

3.1.3 Gathering of Information on Water Supply

To get an understanding of the water situation in Sweden and Jordan two interviews with experts were held. The first expert was working with drinking water supply in Scania. She gave an overview of where the water comes from (source water and groundwater) and what the issues and solutions are. The second was with a professor of water resources engineering at Lund University. That interview focused mainly on the situation in Jordan, and the situation in Sweden in relation to that. Also a range of other factors were raised such as: the role of the local climate, relations between neighbouring countries and financial means of farmers.

The interviews were unstructured to get a broad understanding of the expert's knowledge on the situation. Each interview took about an hour and detailed notes were taken during the interviews.

3.1.4 Concept Summary

Here a summary of the concept is presented. Firstly the technical constraints and secondly the design concept.

Technical Constraints

The technical constraints of the game was that the target users should be 14-18 year olds, that the game should be in English and maximum 7 minutes. It should be multiplayer with two players and utilize the Oculus Go VR headset. Regarding content the game should be about water shortage in Sweden and Jordan and contain video footage of interviews with farmers. Lastly, the game should be suitable to use at Vattenhallen Science Center.

Design Concept

From the brainstorming with stakeholders and interviews with students the following design concept was defined:

> *The multiplayer game should give students (age 14-18) an awareness and an overall picture of what it means to tackle water challenges. This both globally and locally, and how it affects farmers specifically. It also gives them an understanding of how cooperation between all parts of society is necessary. The student should leave the game with a feeling of the situation being critical, but that it can be solved through cooperation.*

3.2 Elaboration Phase

In the elaboration phase a number of detailed concepts were explored starting off with brainstorming and ending with user testing of a lo-fi prototype.

3.2.1 Change of Technical Constraints in Concept

When looking closer into how the set-up would work with multiplayer on Oculus Go it was shown very technically difficult. Also, when starting brainstorming the concept for the game to fit a group at Vattenhallen it got very complex with two students in VR at the same time as the ones outside should be involved. Therefore it was decided to make a multiplayer game with only one player wearing the headset and the rest playing from outside VR.

3.2.2 Initial Brainstorming and Concepts

Two brainstorming sessions took place to gather ideas for the game. One with only the thesis workers, and one with also the project manager of the Save the Basin project.

To cover all parts of the project the brainstorming sessions had the following themes:

- VR elements
- Multiplayer
- Satellite imagery
- 360-degree videos
- Water concepts

After the brainstorming sessions elements were put together to four concepts. Those were:

- **Control Room** a control room where one makes adjustments to water usage,
- **Comparison** a comparison of Sweden and Jordan,
- **Virtual World** a generic virtual world focusing on the relationship between groundwater, surface water and water use and,

- **Information Overload** standing beside a watercourse and having a lot of videos to choose from, where you need to choose the most relevant videos to make the water levels rise.

3.2.3 Feedback from Education Technology Expert

After proposing the four concepts Control Room, Comparison, Virtual World and Information Overload a Professor in Cognitive Science and expert on learning technology was consulted to provide feedback. She thought all concepts had potential. The main takeaway from that meeting was that what makes a good learning game is a good balance between fun and learning. She also stressed that youth are a very diverse group, for example their level of general knowledge can differ more than among adults.

3.2.4 A Cohesive Concept

A set-up with three different themes was selected. It was decided that a good way to get all important aspects of the issue of water scarcity and still have it be easy to comprehend was having a series of small tasks. Technology for water saving, selection of which crops to grow and cooperation among the countries along the Jordan river were chosen as these were found to give a good overview of concepts needed to solve water scarcity related issues.

To engage those outside VR the concept of fact sheets was added. The fact sheets can be seen in appendix A. The main idea of the fact sheets was to make the people outside VR and inside VR need to communicate to exchange additional information. Also it is a way to give extra information, which does not suit the format of VR.

The people outside VR should also be able to see what is done in VR on a TV screen so that they can see the videos and understand what is happening in the game to increase the possibility of suitable discussions.

The set-up can be seen in figure 3.3.

To make the game and set-up feel more natural a story was added. It was created to combine that only one of the students is wearing the VR headset, that the students outside the headset had information sheets and the video content in the game. The idea was to make these three element feel naturally connected and used in the game as well as making each player equally included even if not wearing the headset. The story concept that was created was a time traveling story. All players starts in the future and then one person, by putting on the headset, travels back in time. To add to the feeling of severity the idea

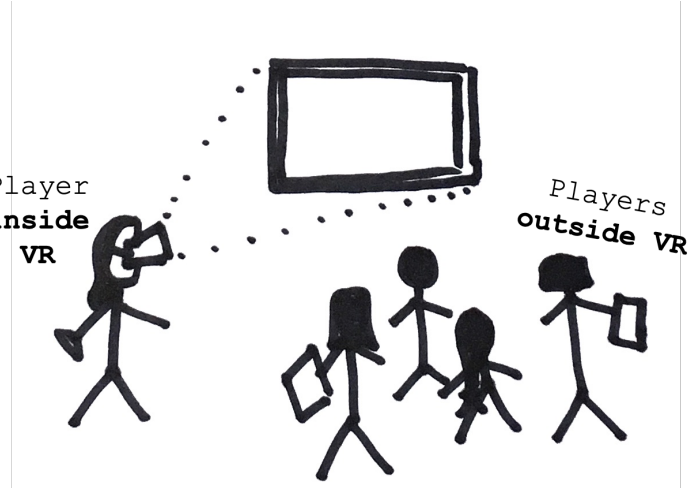


Figure 3.3: The assymetric game set-up with one player in the VR headset and the rest of the players outside, seeing what the person in VR sees on a TV screen. The people outside VR are holding fact sheets.

was that the students were in the future, when the world has collapsed due to a lack of water. To get the feeling that now in 2019, it can still be solved, they travel back in time to the in Sweden particularly dry summer of 2018 and solve issues related to water usage. With this story the hope was that the students would be able to relate to the problem as well as enjoy a science fiction story with time traveling.

3.2.5 Feedback on the Concept

When having the complete concept it was run through with some colleagues for feedback. They brought the ideas that one could see the earth as dried out in the beginning - and then still dried out or green and lush at the end in case the world was saved. Feedback on the concept's viability in VR and tips on how to structure the project in Unity was also received.

Feedback was also collected from the project manager from the Save the Basin project. Following that time keeping through a the use of a timer visible for the players was added to the game concept.

3.2.6 The Lo-Fi Prototype

After having collected feedback on the game idea a paper prototype was built. The prototype consisted of the following parts:

- Introduction script with background to the game
- Menu
- Tasks
  - Picking crops suitable for Sweden and Jordan
  - Picking a technology to be introduced in Sweden and Jordan
  - Allocating water resources between the countries along the Jordan river
- Outro script
- One information sheet for each task

The paper game elements can be seen in figure 3.4-3.6. The set-up for the crops task was similar to the one for technologies in figure 3.5a, but had the crops cards shown in figure 3.5b instead of technology cards.

Five videos were placed in the game to give information from experts and farmers. They were each about 20 seconds long and there were at least one video per task. Both the videos and manuscripts for them were mocked.

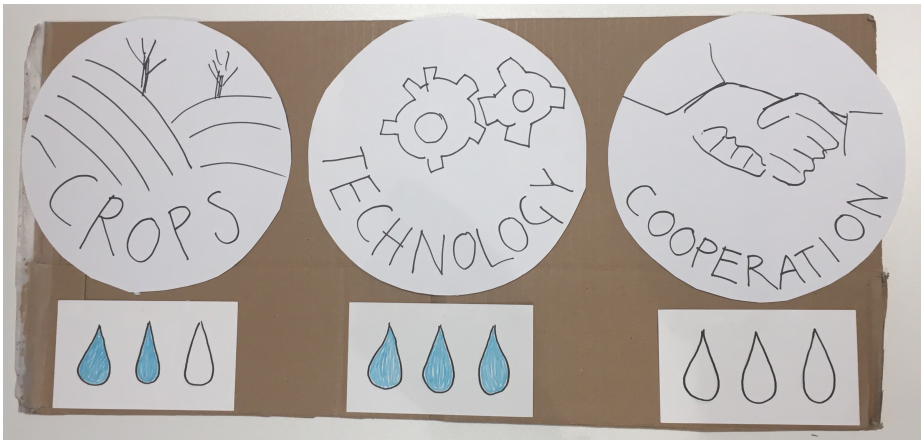


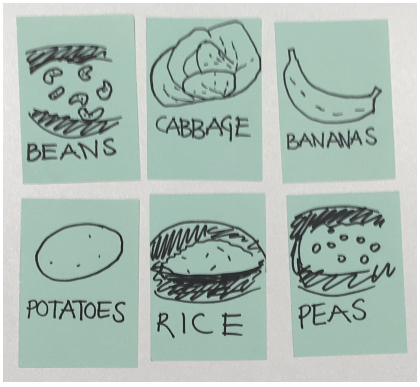
Figure 3.4: The menu for the lo-fi prototype. The circles with icons and text represent the buttons to go to each task and below them points in the form of water drops

Fact sheets were also prepared for each task. The crops task had a table with crops and their water consumption. The technology task had a table with the technologies, a description of them and how much they cost in comparison to each other. The cooperation task included information on the countries population, their water use in different sectors and their GDP among others. Different types of information was added to see which the players would pick up on in their discussions.

The points system was not detailed in the prototype, the same amount of points were always given and the game was impossible to fail.

Additionally, a physical timer was used showing the minutes left of the experience, which rang when the game was to be over.

(a) Sweden and Jordan maps and the technology cards by the side



(b) Crop cards

Figure 3.5: Overview of the game set-up for the technologies and crops task. It shows Sweden and Jordan side by side with a red post-it with a stick figure on representing a video with a Jordan water expert. Cards can be placed on placeholders on the countries. In figure a the cards representing the different technologies can be seen, and figure b shows cards representing crops.

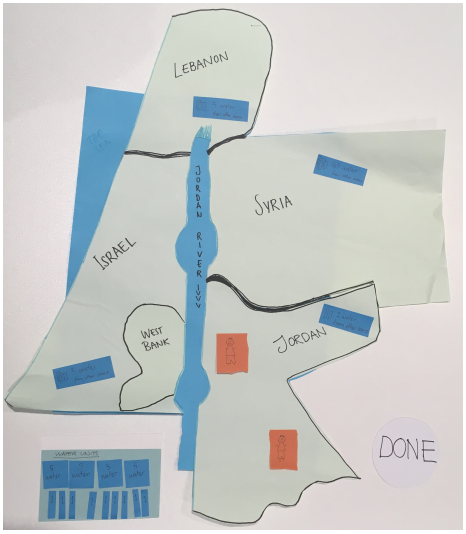


Figure 3.6: Overview of the game set-up for the cooperation task. It shows a map of the Jordan river with surrounding countries, a farmer and an expert placed out represented by stick figures on red papers, water to be placed out and water the country has from other sources.

3.2.7 User Testing of Lo-Fi Prototype

In this section conduct and results of the user testing of the lo-fi prototype is presented.

Description

Before the main user test with students a pre-test was done with two developers and one designer with the same instructions and test script to find the most obvious issues before running the user test with the students, to increase the chance of being able to be consistent in the execution of the user tests. This also gave the possibility to practice working with the lo-fi prototype. The language of the intro and outro was also checked by a native English speaker.

The lo-fi prototype was tested on seven groups of two or three 8th grade students for 15-20 minutes per group. The total time for the game was set to 8 minutes due to the extra time it took to rearrange the paper prototype.

Before testing the game all students got information about the user testing from a manuscript. After the testing they were all asked five general questions, and sometimes an extra one added on spot in case something had happened during

the test that required extra attention. The tasks were given in different order for the different groups to make all tasks equally tested as most groups did not have time for all of them.

To simulate the situation in VR the students who were simulated not to be in the headset had to sit about 1/2 meter diagonally behind the person interacting with the prototype, so they could see what that person was doing but not perfectly.

The videos were shown on a laptop next to the paper prototype.

After the test a short unstructured discussion was held with the science teacher to the students regarding how the test went.

Notes were taken during the user tests and the notes were all summarized later the same day and the morning after to make sure as much as possible was remembered and analyzed.

Summary of Results on the Lo-Fi Prototype

The results differed vastly between different groups. The first group did not have any discussion. After that test a line was added to the introduction manuscript encouraging the students to discuss and after that all groups had some form of discussions or cooperation. Some groups had a lot of discussions raising several different ideas and dimensions. Also it differed how many videos they watched. Some watched all and others none. A common tendency was to watch one of two videos when there were two and then start doing the game and forgetting to watch the other video. It was different how many tasks the groups had time to do, some groups had time for all and others only one. The majority took 3-5 minutes per task, but some spent all 8 minutes on one. How much they used the fact sheets also differed between groups.

The diversity of the students both knowledge and personalities were highlighted as a challenge in teaching in the 8th grade by the students' science teacher. She highlighted that as a challenge when holding discussions in class.

Issues Identified

The following issues were identified during the user testing of the lo-fi prototype:

- Discussion and cooperation
  - Some groups had very little communication.

  - When there were only two students they seemed to struggle with using the fact sheet as they did not have the time to both communicate and read the fact sheet.
  - For cooperation no other information than the number of inhabitants in the countries was ever used, sometimes water was just divided "equally" with the same amount of water to each.
  - It happened that the person in the headset sometimes pressed done when there were still discussions going.
  - It happened that the people outside VR did not answer when the person in VR asked them a question.
  - The groups who did not watch videos generally had less complex discussions bringing up less different dimensions.

- Videos
  - Two out of seven groups watched less than half of the videos they could have.
  - Several groups watched one video on a task and then did not watch the other.

- Interaction
  - There was sometimes confusion about how to interact with the prototype.

- Clarity
  - The instructions were not always clear to everyone leading to a lot of discussions about what the task actually was in some groups.
  - One group played a video by mistake and did not understand what had triggered the video. They did not play any other videos after that.
  - It was unclear in which order the tasks could be picked from the menu.

- Miscellaneous
  - When the fact sheets were handed out made a big difference in how much the students were able to focus on the instructions and the current task.
  - Several groups felt like the game was designed for a younger audience.

3.2.8 Feedback from Project Meeting

After the user testing with students the prototype was tested by the thesis supervisor and the project manager of the Save the Basin project. The main feedback from this was that the cooperation part was too complex to be covered in such a short game, and that cooperation was already incorporated in the concept by aiding cooperation between the students, and it was decided that the cooperation task should be removed. Another idea raised at this meeting was there being an expert or farmer guiding through the game, giving instructions and feedback. Some fact concerns were also raised and also how to get the students to quickly get comfortable with using VR.

3.2.9 Points for Improvement

It was clear from the user testing that the communication could be improved. Perhaps something could be done so that the person in VR would not be able to abruptly shut off discussions by pressing the "done-button" in the task and with that end the task. One idea is that this could be facilitated by a timer in the game, and the group is notified when a certain amount of time is left for them to be able to wrap up the discussion.

The video content must be more prominent as this was something that aided discussion and many students appreciated, but not all took part of. To improve this some information should be added in the introduction to the game. Also, it must be more encouraged to both watch the videos and watch more than the first when there are more than one.

The clarity of instructions should be improved. What one should do in each task should be made clearer, especially concerning the technology task. More introduction is needed for the different technologies in the game, as they are usually new to the students they need more of an introduction than the crops which are easier to relate to.

Based on the user testing and feedback during the elaboration phase the cooperation task was removed to be able to focus more on the other tasks, both development wise and in terms of the limited time the players have for playing the game.

Some other details could be noted in the user testing. Firstly, there is a lack of feedback related to what the group did. Secondly, the fact sheets should ideally be handed out shortly before for the specific task in which they are needed. Lastly, the menu items that cannot be picked should be clearly signified as inactive, or the tasks should be possible to solve in any order.

Due to the differences between VR and a paper prototype, a mid-fi prototype should be developed in VR containing at least part of the game to try out the interaction and cooperation elements in the VR environment, and ideally also one or more genuine interviews with farmers and experts. This test should also be used to assess if additional elements are needed to get to know how to use VR for the person in VR and to aid communication between the person in VR and those outside of it. People outside VR not answering the person in VR might also lead to a bad experience when one cannot see one's peers. Lastly it can be assessed if the game is still found to be targeted for younger children when it is in VR with some genuine videos.

3.3 Detailing Phase

In the detailing phase the full concept and experience from the elaboration phase was implemented. First a mid-fi prototype was created and tested. With the feedback from the mid-fi testing a hi-fi prototype with full functionality was implemented.

3.3.1 Project Meeting

At the very start of the detailing phase a project meeting was held. Participating on the meeting was the project manager, two representatives from Vattenhallen, a spatial sound expert and via video link the thesis supervisor. The experience was talked through and it was concluded that the focus from now on should only lay on the crops part of the game. This to make that one experience as good as possible with the time left.

3.3.2 Feedback from Spatial Sound Expert

The game concept was run though with a spatial sound expert, who raised the problem of the spatial sound. Since the players are both inside and outside VR it is hard to make the spatial mapping work for all players.

Another suggestion from the spatial sound expert was to have some background sounds between the video clips shown (for example birds chirping) and also add sounds for example when items collide to enhance the experience.

3.3.3 The Mid-Fi Prototype

To try out the lo-fi prototype with a set-up closer to the final product a mid-fi prototype was made in VR. A screen cap from the prototype can be seen in figure 3.7. The mid-fi prototype was created to see if the collaboration between the participants worked in the same way even if the player where wearing a headset, and from that not being able to see the other participants when communicating. Here, as decided earlier, only the game on choosing crops was implemented. Beef, eggs and cheese were added to show the water consumption of these in comparison with plant foods. In the fact sheets also amount of water per calorie was added as animal foods often have an a lot higher calorie density as compared to plants.

Another difference between the lo-fi and the mid-fi prototype was that the mid-fi contained real 360-footage of an expert and a farmer in Sweden. No footage from Jordan was included and the material from Sweden did not have content suiting the game that well this due to that the footage meant to be included was not yet recorded. The strict time limit was not included in the mid-fi prototype finding that the time limit did not having to be as strict as first thought, to instead give time for discussions. Basic situational feedback was given through text in the mid-fi prototype, the feedback and points system was however not yet very refined.

Yet, the intro and outro to the game was read manually still in the mid-fi prototype and there were no videos from Jordan (due to them not being produced yet).

The interaction in the mid-fi prototype was through a basic pointer from the controller where things could be attached to the point of the pointer by pushing the trigger button on the controller down and released by releasing the trigger. The controller is seen in figure 3.8.

3.3.4 Feedback from Supervisor

Our tutor from the university was the first to give feedback on the mid-fi prototype. He did for example, as the spatial sound expert, point out that it would be nice with a sound as feedback when having placed something and when switching videos. He found it hard to see what the rice was, and also found it hard to put the rice on the plane. He though it should be easier to see what the expert and farmer represented. He also found the angle one had to look down to see the crops too sharp. In general he though it should be made easier to interact in the prototype. Lastly he suggested that it could be made impossible to place crops or foods before having listened to all information videos.

Figure 3.7: The countries to place the foods on and figures to press to watch videos.

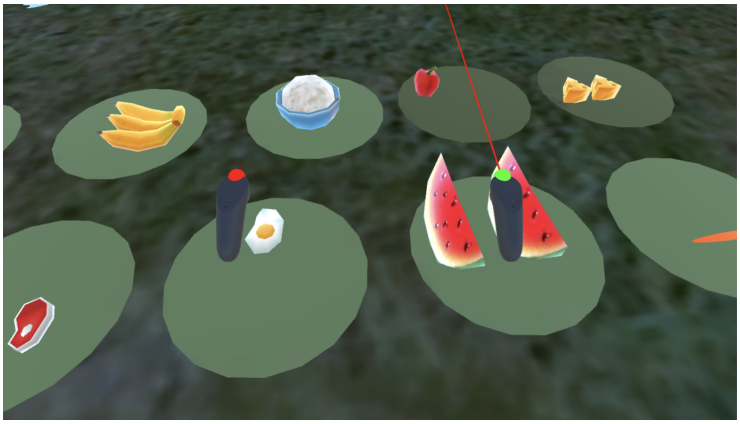


Figure 3.8: The controllers and some different foods.

3.3.5 Feedback from Vattenhallen

A meeting with two representatives from Vattenhallen was arranged where they got to try the prototype and the incorporation of the game at Vattenhallen was discussed.

Their main suggestions for improvement was that it was hard to move things, that there was not much of a wow effect from being in VR. For example they would like more interesting scenes in the videos. That it was hard to place foods was not found to be all bad, but also found to be a fun element in the game.

They liked that the persons outside the headset had a task. But as 8-12 students should play at the same time more should be done to engage those outside of the headset. For example it was suggested that the fact sheet was divided into parts handed out to different people, or that more perspectives would be added in the fact sheets. Also some questions to discussed could be prepared for the instructor to ask and lead a discussion on. They would also like there to be a landscape video prepared so that everyone can try looking around in VR before or after the game. This so that all students would be able to try VR easily if more than one wanted to try.

They thought the consequences of one's actions should be made more clear. For example, if one chooses the beef it should be visualized if one can compensate for that by the other choices.

Since an instructor would be present whenever the game is played a time limit was found to be better added in the real world when needed (under the influence of the instructor) than within the game. They fear a static time limit could inhibit discussions. The experience including instructions and summarizing discussion will be 20 to 30 minutes. With this set-up the 7 minute limit was not considered suitable any more. Instead the instructor will get the flexibility to end the game or speed up the students when needed. For instance if the students are having a good discussions they could keep on playing longer but if it starts to get unfocused the instructor could ask them to round up and then have a more structured discussion keeping them on the subject.

3.3.6 User Testing of Mid-Fi Prototype

In this section the conduct and results of the user testing of the mid-fi prototype is presented.

Description

Three user tests of the mid-fi prototype was conducted with developers and designers at Jayway with four or five people in each test round. Each test took 30 minutes including an introduction and answering questions afterwards. The VR headset was connected with a cable to allow casting to a TV screen what the person in VR saw. A small loudspeaker was also connected to the headset.

Summary of Results on the Mid-Fi Prototype

The game took about 10 minutes for the test groups to complete. All groups were highly active and communicating with each other. It did not appear to be a problem that the person wearing the headset could not see the other participants when communicating. All groups watched both videos, sometimes twice due to not hearing what was said properly.

All groups struggled some with recognising what some foods were, and struggled a bit with placing the foods and one group lost one of their foods. They found it hard to place the foods correctly. Placing foods incorrectly or loosing them was however also found fun and unexpected.

All groups were highly cooperative and had a lot of discussions. They all discussed the water consumption and calorie density, and two of the three groups also discussed if they should try to include other nutrients, mainly focusing on also incorporating proteins in their choices. They also spent a lot of time discussing things related to the game, for example which of the crops on the fact sheet that were also in the game.

They did not think the videos gave much relevant information. They suggested using more fact sheets so that not everyone had the same one, for example on which crops could be grown where. Afterwards two of the groups also mentioned that they were a bit puzzled with which information that was relevant and how they should reason.

Issues Identified

The following issues were identified during the user testing of the mid-fi prototype:

- Discussion and cooperation
  - A lot of time was spent discussing what was to be done and which crops that were in the game.

- Videos
  - The videos did not give much relevant information.
  - It was found to be hard to hear what was said.
- Interaction
  - Sometimes food objects were lost in the game.
  - It was found hard to place the foods on the countries correctly.
  - There were some confusion about the controller buttons. One test person was confused about which buttons to use on the controller, and if both grabbing and clicking should use the same button. Another had a hard time finding the done button.
- Clarity
  - It was found that there should be more information.
  - Two groups mentioned being unsure of which information that was relevant and how one was supposed to reason.
  - Most found it hard to read what the food objects represented, mainly identifying rice and potato and differentiating between tomato and red pepper.
- Miscellaneous
  - It was found strange that no soybeans were in the game.

3.3.7 Points for Improvement

From the results of the mid-fi testing the discussion and cooperation elements were deemed to be successful. However, several points for improvements were also found.

From both discussions with Vattenhallen and the user testing it was found that different fact sheets should be made and handed out to different people in the group to better activate a larger group.

Regarding the videos, videos with more information that feel more like a personal visit and shows landscape should be added. Also the videos should give a hint on how to reason when solving the task. To make it easier to take in the content of the videos the subtitles should be added and the sound should be improved. A back button should also be added in the videos as the videos were sometimes clicked by mistake.

Sounds should be added for the interaction. This has been suggested by several stakeholders and might also make the interaction feel easier, which was an issue

in the user testing. Also immediate feedback should be shown when placing foods.

Furthermore, to make the interaction easier by making the placing of foods on the countries easier. However it should still use physics as that was found a fun element. It should also be made so that one cannot loose foods, or so that one gets an infinite amount of them.

It should be made more clear what the objects in the game represent and how you can interact with them. For instance that the foods and humans are triggers that are either clickable or grabbable. The results of one's actions (which foods that are chosen) should be also be better visualized as suggested by Vattenhallen.

Plant based protein sources should be added in the game, those were found to be missing from the game by test persons who wanted to add soybeans to get a water efficient protein source (soybeans was on the fact sheet but not in the VR game). It should also be clearly marked what foods that are in the game on the fact sheets to make it quicker to identify.

Lastly, there should be a summary at the end of the game to connect to the plot given in the beginning of the game.

3.3.8 The Hi-Fi Prototype

After the Mid-Fi prototype was tested it was updated to include full functionality. It was made into a hi-fi prototype. The changes made were:

- Discussion and cooperation
  - The fact sheet was updated - the foods were ordered and it was marked which foods where in the game to decrease the need of discussing this.
- Videos
  - Intro was recorded into a video to be played on a screen.
  - Intro and outro 360-degree videos recorded in Jordan were added.
  - Videos with farmer in Sweden and expert in Jordan were added.
- Interaction
  - Objects in the game were moved further away from the user to give a more ergonomic viewing angle.
  - It was made easier to put things on a country by making foods fall snap onto the country when the pointer was directed towards it.

  - An infinite amount of crops was added, so the user could pick more than one of each. With this the placeholder for fetching new ones floats in the air to distinguish it from the copies.

- Clarity
  - Sounds were added for when a food is placed on a country, when a video is started and when the game is solved.
  - The pointer was made to change color when something could be interacted with.
  - Subtitles were added for all videos.
  - The videos added had better sound than the previous ones.

- Miscellaneous
  - A soybean object was added and the potato was updated.
  - Instant feedback was added in the form of two columns showing the amount of water used and amount of population fed. The game can now not be finished unless enough food has been placed out without running out of water. Screenshot of the game showing the columns can be seen in figure 3.9.
  - Back button in videos was added.
  - An additional fact sheet was added with country info: amount of rain, temperature, national dish.

Figure 3.9: The hi-fi prototype.

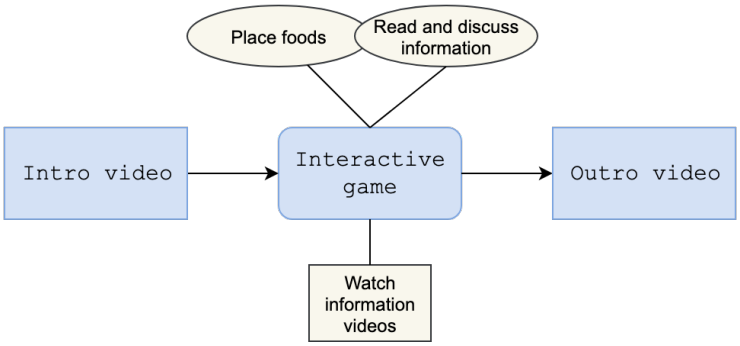


Figure 3.10: The game flow and what is done in the different phases of the game.

With the intro and outro videos added, the steps of the game from start to finish in the hi-fi prototype are presented in figure 3.10. Starting with an intro video, leading to the interactive part of the game and then ending with the outro video. In the interactive part of the game videos can be watched, the person in VR can place foods and those outside can read information on the fact sheet which then all players can discuss.

3.3.9 User Testing of Hi-Fi Prototype

In this section conduct and results of the user testing of the hi-fi prototype is presented.

Description

The hi-fi prototype was tested on adults with various backgrounds at an event at LTH with a sustainability theme. The tests were made in groups of three to six people. In total there were five groups. The game was casted from the Oculus Go to a TV over wifi. Sound from the Oculus Go was broadcasted on a small cord connected loudspeaker that the player in VR kept in their lap. The test started with a short background of the project. After that the intro video was shown on the TV before the game started (see it's manuscript in appendix C) and fact sheets were handed out. In some cases hints were given in the game, for examples what the rules were. This is realistic to the usage situation as when at use in Vattenhallen an instructor will be present to answer questions. After the game three questions were asked: "How did it feel?", "Did you feel equally included in the game?" and "Did you learn something?".

Summary of Results on the Hi-Fi Prototype

Each game took about 10 minutes to play. All groups were highly cooperative. They did for example discuss which nutrients they should consider, farming conditions in Sweden and Jordan, water consumption per calories vs kilo and the national dish. Many groups however spent time discussing the rules. The test persons said that they thought the game was very collaborative. Several people in VR did however point out that they mostly did what they were told to do from those outside.

Regarding the interaction in the game the players in VR struggled with fetching small crops as soybeans and carrots.

Not everything in the game was very clear. Firstly, the players had some issues with identifying what the columns represented. All groups understood it eventually, but none immediately. Secondly, groups did not click to watch videos if not reminded of it.

Lastly there were some issues with the technology. Firstly, the game crashed before showing the outro video. There was also lag on the casting from Oculus Go to the TV - in the beginning very little, but in the last round it was unbearable - over 30 seconds. In that round there was almost no cooperation.

Issues Identified

The following issues were identified during the user testing of the hi-fi prototype:

- Discussions and cooperation
  - Groups spending a lot of time discussing rules.
- Interaction
  - Players not being able to fetch small crops.
- Clarity
  - Players not clicking on farmer/expert avatars to watch videos.
  - Some groups did not press the done button at the end. They thought the button popping up meant that they were done.
  - Groups found it confusing whether it mattered what could be grown where - and if nutrients should be taken into account.
  - Players found it confusing whether it mattered what could be grown where - and if nutrients should be taken into account.
  - It was not immediately clear what the columns represented.

- Technical
  - There was increasingly more lag for each test.
  - Sound starts before video when loading.
  - Game crashed at the last video.
  - Battery running low on the Oculus Go at the end.

3.3.10 Points for Improvement

After the user testing of the hi-fi prototype it was clear that recognising the potato was still an issue. People with knowledge of farming were puzzled by rice being an option as that cannot be grown in either of the countries. Crops should be switched out to better represent what is grown in Sweden and Jordan. It should also be clarified what can be grown where to decrease the need of discussing that.

Though the user testing it was also clear that the rules have to be clarified more and that it must be clarified that the avatars can be clicked to watch videos.

Some improvements for technical stability would need to be made. Two headsets should be available to be able to switch between groups if used for a longer time and perhaps a cable to plug in the Oculus Go should also be available in case the lag over the wifi is currently too high.

3.3.11 The Updated Hi-Fi Prototype

After the testing of the hi-fi prototype the following updated were made to the hi-fi prototype:

- Discussions and cooperation
  - Instruction sheet with rules of the game and mapping between crop names and picture was added to decrease the need for discussing this (see final fact sheets in appendix B).
- Interaction
  - Small crops were made larger, for example the carrot in figure 3.12.
- Clarity
  - Buttons were updated to make it more clear that they can be interacted with by adding a halo signifying this, see figure 3.11.

  - Highlighting of farmers was added before videos are watched, see figure 3.12.
  - Text was added to the columns to explain what they represent. A transparent column was added to the columns representing the amount of food produced to show how much food the population needs. These changes can be seen in figure 3.12.
  - The potato was made look lighter and less realistic to better resemble a potato and also fit the look of the other crops better.

- Technical
  - Video playing was made more efficient to prevent crashes.

- Miscellaneous
  - Foods were changed to better represent what is grown in the countries: rice and soy was removed and beans (generic), bread representing wheat and apples were added.
  - Fact sheet on main cultivated crops in Jordan was included (see final fact sheets in appendix B).

Figure 3.11: Updated button with a glowing halo

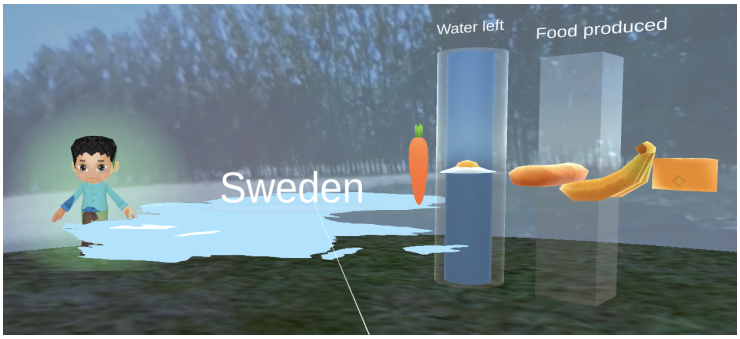


Figure 3.12: Clarification in hi-fi prototype using text descriptions.

CHAPTER 4

Verification

This chapter presents the verification of the final prototype. It includes a presentation of the method of the user tests as well as the results of the three test groups. After that comments from employees at the science center Vattenhallen who attended the testing of the prototype are summarized. At the end of the chapter feedback from when the prototype was shown for a education technology expert is presented.

4.1 Method

In this section the method of the user evaluations and feedback from Vattenhallen employees and the education technology expert are presented.

4.1.1 User Evaluation

User evaluations took place at the science center Vattenhallen. Three groups of high school students from the same school did the evaluation. There were two groups of 10 students and one of 9. There were maximum 30 minutes available per group. An instructor at Vattenhallen managed the game.

Before the user verification some minor updates were done, for example improving the clarity of the videos and making some additions in the interface for clarity. Images of the prototype used in the verification test can be seen in appendix F.

The day before the test a pre-test was made with four high school students

(others than the ones doing the actual tests) led by the instructor leading the game at the user evaluation as practice for the instructor. It was discussed with the instructor which instructions she could give during the game and not. For example she was asked to explain if they had misunderstood instructions and to tell them to wrap up if there was less than 10 minutes left of their session. She was asked not to lead the discussion, for example not try to engage disengaged students, to be able to see how well the game could do that on its own.

The set-up of the test was that the instructor first welcomed the group and they all got to sit down on a stool, see figure 4.1. After that the introduction video was played. A volunteering student was then picked to wear the VR headset. That person got an introduction to using the controllers, was seated in a chair in the middle and started the intro video in VR. After the introduction videos in VR fact sheets were handed out to the students outside VR. As the groups were large most fact sheets were shared.

Figure 4.1: The set-up of the game with the person in VR sitting in the chair and the rest on stools.

During the game it was observed and made notes of how much each person spoke and with whom, what the instructor said, what the group discussed and how many videos the group watched. To document the discussions a map of the positions of the participants with color coded dots depending on what fact sheet they had was used. On this map a line was drawn by the dots each time they said something and as well lines were drawn between dots to demonstrated if they were talking directly towards someone or just in general to everyone. Comments and quotes where noted as well.

When 10 minutes was left and the students were not finished with the game they were encouraged to wrap up by the instructor.

After the game a questionnaire was handed out on what the students thought of the game. In this they marked their role in the game, in or outside VR and which fact sheet they had, and answers to questions such as how included they felt in the game, what they thought of the discussion and if they felt like their peers listened to them during the game. The entire questionnaire can be seen in Appendix D (both Swedish original and English translation).

The questions from the questionnaire were the following, and they are numbered according to this list:

1. I felt that I understood what the goal of the game was
2. I felt that the others in the group listened to me
3. I felt involved in the game
4. I experienced that we had a good discussion related to water scarcity
5. I thought the game was fun to play
6. I thought all were equally involved when we played
7. I feel like I have gotten a deeper understanding for water scarcity
8. I feel like I have gotten an increased awareness about water scarcity
9. I have felt anxious about water scarcity before
10. I feel more anxious about the climate and water scarcity after having played the game
11. I would recommend the game to my friends

12. The length of the game was .. (Too short / Good / Too long)
13. The most important thing I learned from the game was .. (*free text*)
14. What I found most interesting from the game was .. (Listening to farmers and experts / Seeing how much water different crops need / Playing a VR game / Discussing / Other)
15. My role in the game felt .. (More important than the others'/As important as the others'/Less important than the others')

4.1.2 Feedback from Vattenhallen Employees

After the tests were completed a shorter discussion regarding the game was held with the employees at Vattenhallen. Questions like "What do you think overall", "How is this game in comparison to other activities here" and "Could this solution be used as it is today or what would need improvement" were asked.

4.1.3 Feedback from Education Technology Expert

The prototype was shown and discussed with a education technology expert. First the solution was shown and explained and general feedback was received. Then the result from the user testing at Vattenhallen was presented and discussed.

4.2 Results

In this section the result from the test at Vattenhallen will be presented. That includes the differences between and discussions in the three test groups, the result from the questionnaires and feedback from the employees will be described and shown.

4.2.1 The Test Groups

First quantitative results from all three groups will be presented followed by a presentation of the result from the three different groups from general observations.

The first and third group was more active than the second group. The second group needed several comments and motivation from the leader. The first and third group was in total talking more than the second group. In table 4.1 you can see the number of times each participant talked. This only shows the number of times, and not for how long or how relevant information they contributed with. In all groups students referred to the information given in their fact sheets when discussing. All groups reached maximum time where the instructor had to tell the group to start finishing up because it was soon time for the next group to come. Depending on how quick they were at getting started they played between 10-15 minutes. The first and last group had 10 participants and the second group had 9 participants in the test. Both the first and the second group

watched all videos in the experience, while the third group only watched the intro videos and the outro video, not the four videos in the game.

Table 4.1: The noted number of times each participant in the three groups talked. The participants are noted as A-J in line with how they were seated. Group 2 had one participant less than the others.

	A (VR)	B	C	D	E	F	G	H	I	J
Group 1	8	15	5	17	5	5	10	9	7	2
Group 2	16	12	6	4	8	1	1	5	16	N/A
Group 3	5	2	2	12	5	7	5	5	15	6

In the first group the students talked fairly evenly. Two students talked considerably more and one student only talked twice. In general in the group they discussed quite a lot with their closest neighbour. Participant D and G communicate a lot as well. From the group outside, participant B communicated most with A that was in VR. The test started of with a technical problem that demanded a restart of the Oculus Go. For instance the students commented what crops could be place in Sweden and Jordan, they talked about the difference in amount of water in the countries and whether or not to adjust the placement of crops related to the national dishes.

In the second and least active group participant B and I talked most in general, and a lot with each other. At one point B walked over to I and they compared their fact sheets. Participant F was totally passive during the whole experience not share the information given on the fact sheet. The whole group giggled several times, especially because of comments or things participant A (with the VR headset) said or did. The neighbours B and C as well as D and E had smaller discussion on their own. Things being said was for instance that Jordan is dry and therefore should have water efficient crops and whether or not they should think about nutrients or if they could place only carrots.

The third group seemed to have the the highest participation from the general observation. Participant D was very active - talking a lot with everyone and taking or trying to take lead a lot. Twice during the test participant D told their neighbour to shut up. At the end participant D held on to three fact sheets. These were then shown to discussed with participants C-F. Participants H-J shared fact sheets and seemed to analyze these together and then participant I (in the middle) communicated this to the rest. During the test the group mentioned for instance differences in water amount in the countries and if a country could eat only one type of crop.

4.2.2 Questionnaire Results

After the game a questionnaire was filled out. The results are presented below.

Questions 1-11

On the first eleven questions the students got to answer how much they agreed with each statement on a seven point scale ranging from “Completely” and “Not at all”. These answers were then translated into a score between 6 and 0 where 6 was “Completely” and 0 “Not at all”, making score 3 a neutral response. All statements were formulated so that scoring 6 was the most positive response, except two questions regarding anxiousness about water scarcity, which were neutral statements.

In figure 4.2 and 4.3 histograms of all the responses to question 1-11 are presented showing the diversity in the responses. In figure 4.4 the average score from each group for each question is presented. This shows some variation within the groups where group one was in general more positive.

The result from the questionnaires varied between respondants in and outside VR. This can be seen in figure 4.5, where each question average is presented for the students in VR beside those outside. The difference between the roles was most notable on question 11, ”I would you recommend this game to a friend” where all students in VR answered completely agreed to the statement while the average answer of the students outside VR was slightly below neutral.

Questions 12-15

In figure 4.6 the result of what the students thought about the game length is presented and in figure 4.7 how important the students felt in comparison to the other players is shown. More than 70 % thought it was a good length on the game and 25 % thought it was to short. 66 % felt as important as the other players but 24 % felt less important then the other players in the group. In figure 4.8 the result of the multi-choice question of what they found most interesting is shown. About 70 % (20 out of 29) answered that they thought ”Seeing how much water different crops need” was most interesting. The answers with free text from question 13 on what was thew most important thing they learned from the game can be seen in Swedish in Appendix E. In group 1 they they mentioned saving water, the the severity of water scarcity and how much water different crops needs to be produced. In group 2 they talked about differences in the world, about saving water, about climate changes, about water scarcity and drought. And in group 3 they mentioned differences in the world, compromising in the world, the severity of the situation and relations between crops water consumption and food produced.

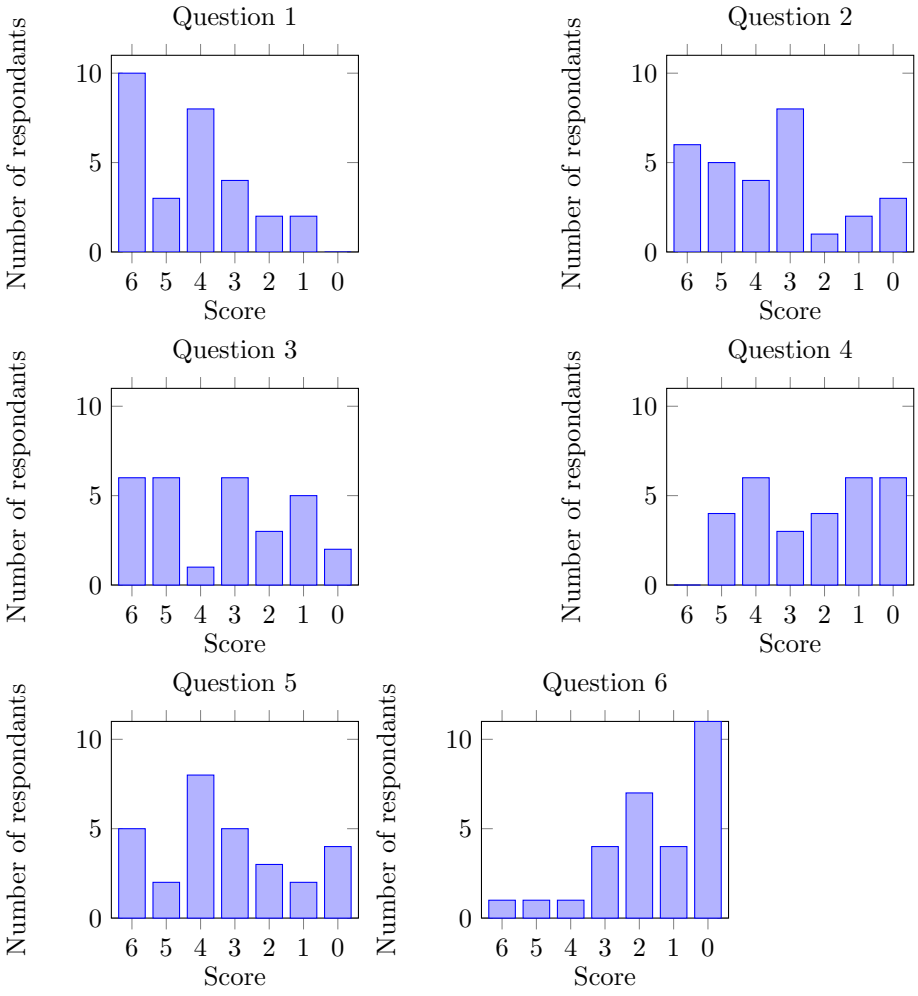


Figure 4.2: Number of respondants giving each score for question 1-6.

4.2.3 Discussion with Vattenhallen

The employees at Vattenhallen liked the concept of the game over all. They said that this solution with VR was working with a group with around 10 people in a way they had not seen before. They have tried to include VR at the exhibition earlier but have had a hard time finding something suitable since it usually is only for one person. The reason for the second group being so quiet and how the instructor possibly could effect that was discussed. One suggestion was raised where the students could get some help in how to work together in a better way. For instance they could have started off with explaining their fact sheet

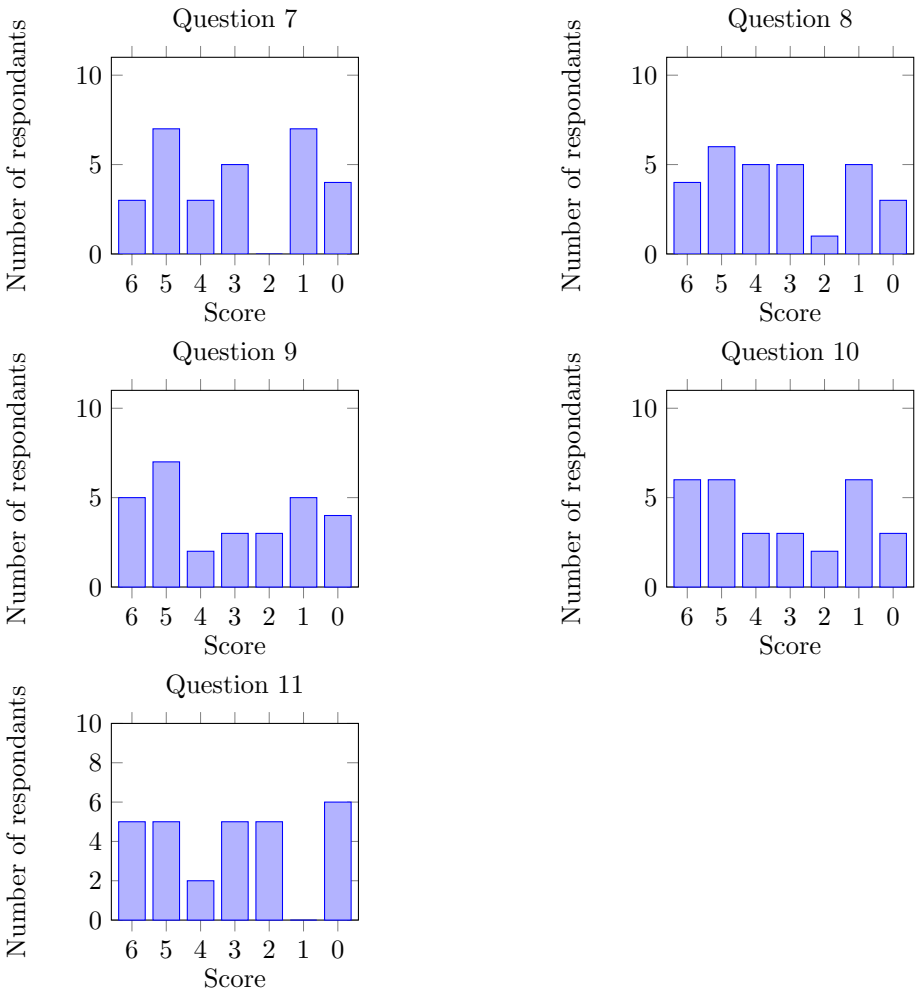


Figure 4.3: Number of respondants giving each score for question 7-11.

for the other students. With this the general importance of the instructors role at an activity on the exhibition was raised as well. How instructors change how the group act and how much or how little the instructor helps the students depending on the group. This was a big difference in this test set-up, where the instructor was instructed to help out very restrictively in all cases. One employee observing the last group said that he thought the students discussed quite a lot in the game and would have liked to take the discussion to the next level taking about how this effects the world in a broader spectrum afterwards. During the discussion the employees agreed that the game would work as a base for a discussion with the students after the game. It would work well to refer to and ask the students what they thought this meant in a bigger picture and

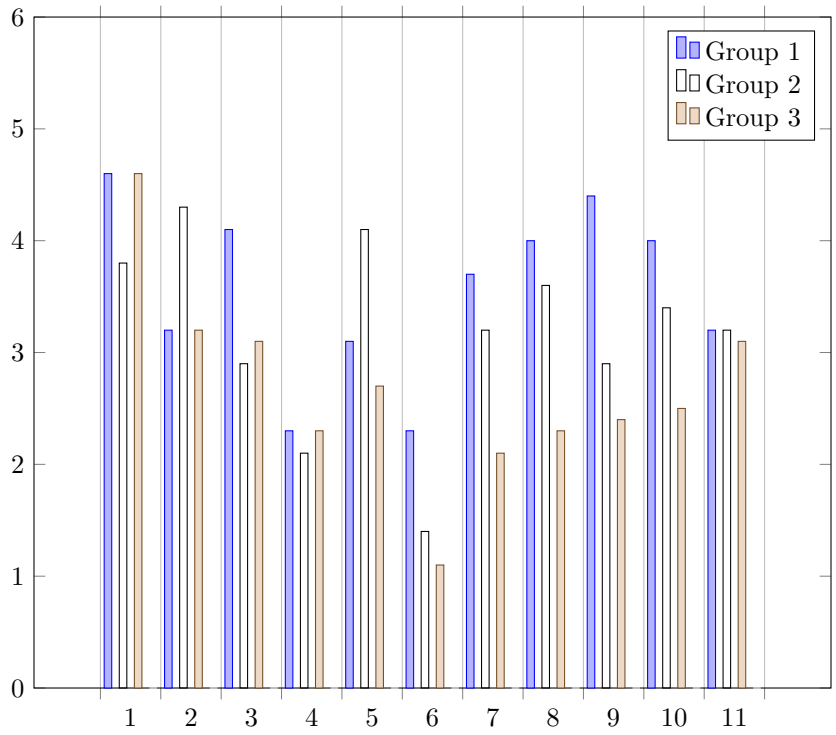


Figure 4.4: Average results of Question 1-11 from groups 1-3

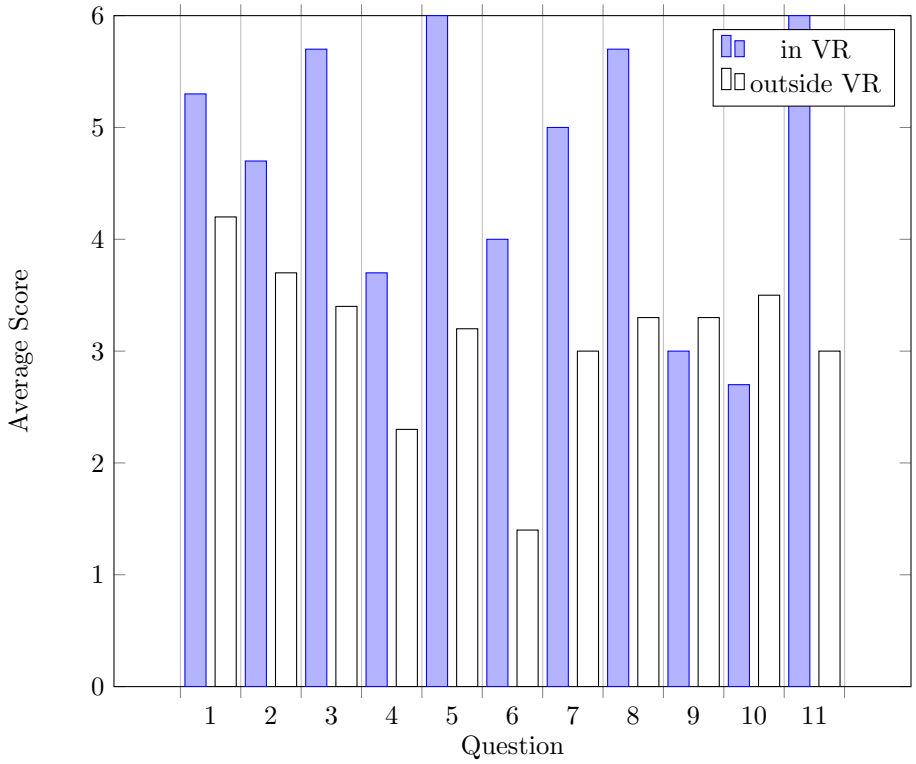


Figure 4.5: Average results of Question 1-11 from participants in and outside of VR

Figure 4.6: Result of question 12: "The length of the game was.."

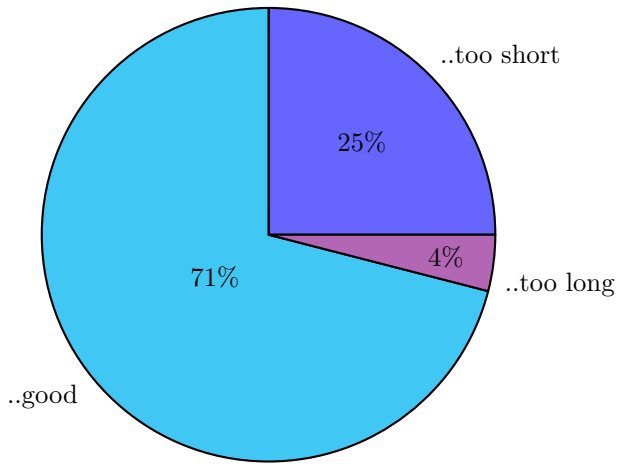


Figure 4.7: Result of question 15: "My role in the game felt .."

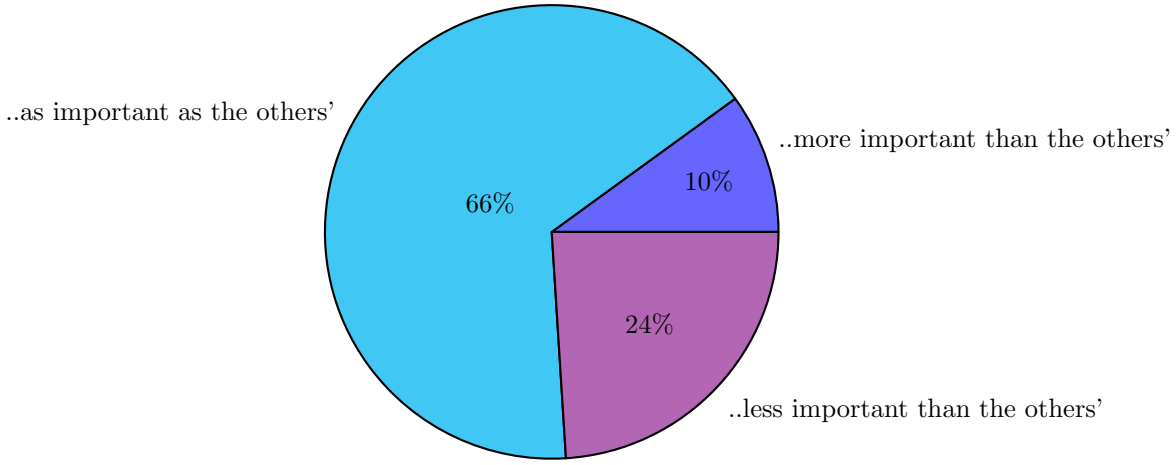
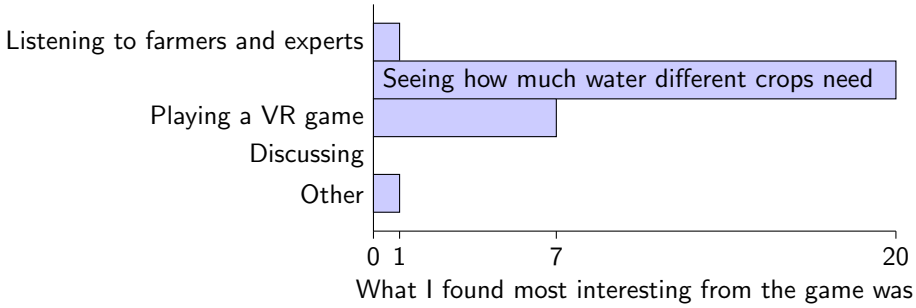


Figure 4.8: Result of question 14: "What I found most interesting from the game was: "



how it affects us today.

4.2.4 Feedback from Education Technology Expert

The education technology expert though that the solution was a step on the way of making a VR education tool. She thought that the game could work as an educational game given that the students were given more "triggers" for discussion, either from the game or an instructor, and also given that it is discussed afterwards. Perhaps the group would however have to be smaller to reach the desired outcomes. She suggested a group size of maximum six participants.

To make all players feel part of the game they should all have roles necessary for succeeding in the game. In this game not all players had necessary roles. While the knowledge of the people outside VR was important for succeeding in the game, not every person outside VR had important information. One suggestion was to try out making it a role play for those outside VR where they would each get an expert to represent. They could also be more engaged by adding places in the game where they could not move forward without all of them cooperating.

To make the discussion better the students would need to be asked or provoked to discuss more specifically. For example the videos could provide situational advice or points of discussion which she pointed out they were now lacking.

The set-up with discussions before and/or after a VR game together with reflection and discussion during the game can be a good set-up for a VR game. She pointed out that an advantage with using VR for a discussion is that the players have all seen the same thing and will with that get some common ground.

CHAPTER 5

Discussion and Conclusion

This chapter presents a discussion: on the research questions, the design process, future work, the usage of VR and the credibility of results. At the end of the chapter it is summed up in a conclusion related to the main goal of the work: How to design an asymmetric virtual reality game to be used as an educational tool.

5.1 Discussion of Result in Relation to Research Questions

In the following section each research questions is discussed.

RQ1: How can the game be designed in order to facilitate discussions on water scarcity?

Three things were mainly done to encourage discussion on water scarcity: Firstly videos were added, secondly fact sheets were developed and thirdly it was through each iteration of the development made more clear what should be done to reduce the need of discussing that.

Another thing learned along the way was that the people outside VR must see what is done in VR, in the hi-fi testing with some lag, the communication was immediately hindered. Making the game only include one area, as decided after testing the lo-fi prototype was proven to be good as it still took a lot of time.

From the final user validation it became clear that it was still not clear enough how to play the game. The students were still discussing what to do and the

discussion on water scarcity was shallow.

To improve this further tests should have been run with the target group of high school students and in bigger groups. In the intermittent test with smaller groups and adults the discussions were better.

The result from the students experience of the discussion and the observed discussion did not fully agree. The students were not as satisfied with the discussion as the employees at Vattenhallen were. By giving the students better tools on how to discuss during the game they could have felt more in control. What a good discussion means probably means different things for the students in 8th grade and the employees at Vattenhallen as well as the observers. According to the employees the solutions could on another hand work as a good base for a more structured discussion on the complex problem afterwards.

What defines a good discussion on 8th graders was not properly investigated before the test which led to different experiences of how good the discussions were and as well affecting the possibility to answer RQ1. This should have been looked in to closer before or maybe observed in another activities at Vattenhallen with considered good set-up for discussions. For instance levels on discussing could have been predefined making it possible to give the test groups bad, okay or good grading.

RQ2: How can a group be engaged in a VR game using only one VR headset?

The main tool used to engage the whole group in the experience was through using the fact sheets. The idea of those is that everyone in the group was given a role in the game, where the people outside VR can contribute with facts and the person in VR has the power of the game.

The fact sheets were developed and refined in several iterations. In the first lo-fi test there was only one fact sheet with crops and their water need. Then, as the game should be usable for groups of up to around 10 players and for the players outside VR to play different roles, more fact sheets were added. During the verification it became clear that the fact sheets played an important role in the game since the students referred several time to the info given on them.

The user evaluations showed that almost every person in the group was engaged in the game to some extent. However, the students outside VR felt considerably less as taking part in the game than the people in VR according to the survey (with a score on that question of 3.4/6 as compared to 5.7/6).

After the tests with the lo-fi prototype one concern that was raised was that maybe the player with the VR headset would experience the communication with the other players differently when wearing the headset compared to when being able to look at the others while playing. From the final result the student in the VR headset responded that they felt listened to, even to a larger extent

than those outside VR (score average 4.7/6 as compared to 3.7/6).

RQ3: How can the game be designed in order to make all participants feel equally engaged in the game?

Two thirds of the students in the user evaluation felt that their role in the game was equally important to the others. However, the players in VR felt involved in the game to a much higher extent than those outside VR. The players in VR were also reporting to very much enjoy the experience, agreeing almost 100% to the statements of finding the game fun and wanting to recommend it to friends, whereas the players outside of VR were only half as positive to this. The players in VR also reported understanding the game and feeling they understand water shortage to a much higher extent than those outside of VR.

Something that is inherently different between the game for the player in VR and those outside is the level of presence they experience. The player in VR is fully encapsulated in the virtual experience and is interacting with it. Also using VR is a much more novel experience than the one of those outside VR simply viewing what is done on a screen. This should lead to the person in VR experiencing a higher level of presence in the 360-video content than those outside. This could contribute to the players in VR being more positive towards the game in a way which could be hard to make up for.

The differences of the experience was discussed with the education technology expert. It was suggested that the students outside VR would need a more unique role, just as the one in VR had a unique and important role, to feel equally engaged in the game.

All in all, the results suggest that more would have to be done to make the participants outside VR get as much out of the experience as those in VR. Simply adding the fact sheets in their current state was not enough to make all the players in the group feel fully involved in the game. However, previous research suggest that interactivity is an issue in groups of 10 students, where the group is more influenced by dominant speakers than in smaller groups [Fay et al., 2000]. The influence of the size of the group was also discussed with the education technology expert who stated that a group of up to six participants would be more suitable for this game.

RQ4: How can the game be designed to be suitable as an educational tool?

Earlier research has shown VR increasing the students' motivation to learning as covered earlier in this report. From the verification test it could be seen that being in VR greatly enhanced the student's motivation for the game. For example the students in VR reported finding the game fun to play, and would also recommend it to their friends. In contrast, those outside VR were much less inclined to agree to these statements. This result indicate that being in VR increases motivation.

Furthermore, discussions can be used as a learning tool to improve critical thinking and giving the students new perspectives. It may however not lead the students to learn what they are supposed to know. From the observations of the user tests the students did not have very deep discussions on water scarcity. Especially when comparing the discussion levels during the tests with students to adult participants in earlier tests. However, most of them reported having learned something in the survey afterwards. What they mostly reported learning was that water scarcity is a serious issue and how much water is needed to produce different types of foods. As their knowledge was not assessed before and after the game it cannot be known for sure if this is actually something they knew on beforehand or not.

When using a VR game like such as this as an educational tool it would according to the education technology expert be suitable to get the discussion going during the game by helping the students to focus on the right thing, for example by asking them questions. Afterwards a broader discussion would be suitable. The game could be used for this but would need further improvements and testing.

One interesting thing noticed during the validation tests were the differences in the engagement between the groups. Group one and three talked quite a lot all the time, and sometimes at the same time as each other. They in general felt more engaged than the second group. The second group where not talking as much and mostly only one person talked at a time. Group two were not as active as the other two groups and they had a significant higher average on question 2 and 5 in the survey: "I felt that the others in the group listened to me" and "I thought the game was fun to play". In group two the free text answers regarding learning were more advanced and provided a broader picture than the groups one and three.

5.2 Evaluation of the Design Process

This section will discuss the design process of this project. It will highlight the benefits of having several prototypes and good communication with stakeholders. It will also raise the importance of testing prototypes on the right target group during the whole design process.

The game was made in four iterations: From a simple paper prototype to a fully functional prototype with video material from both Sweden and Jordan. One important lesson from these was that it was only reasonable to cover one theme within the time frame of about 10-15 minutes. Making a quick first prototype on paper was proven to be a good idea as much of that content was scrapped for the next iteration. The need of direct feedback, which led to the addition of pillars showing food produced and water consumed was also uncovered in feedback on a prototype. Things that needed to be made more clear and improved upon was

also found in each iteration, suggesting that the game could still be improved.

The game in VR was also tested early (the mid-fi prototype). The game in VR differed from the game on paper in several ways: for example when in VR, the person in VR and those outside could not see each other's faces. That could have been an issue for communication but proved fine in the mid-fi testing. After the mid-fi testing interaction in the game was improved as that was an issue in the mid-fi prototype, which could not have been uncovered in the paper prototype.

During the project continuous communication was held with the stakeholders. This was very helpful in the iterative design process and gave several important insights along the way. For instance some misunderstanding of the goal of the experience was cleared up, giving some changes to the limitation during the project. The time was changed from 7 minutes to around 20 minutes and the group size from 2 students to around 10 students. With this only one person was wearing the VR headset to make the set-up less complex compared with if two students would have played and other players would help out from outside as well.

From the user testing it was found that two of the goals with the application were not ideal - discussion on drought and the players outside of VR's feeling of being a part of the game. To have been able to improve on this, at least one of the intermediate user tests should ideally have been conducted on the age group of the end users and also with the size group of around 10 people. All user verification tests were conducted with the maximum or close to maximum group size, whereas the user testing was conducted with groups of at the most six people. A larger group size decrease the chance of all group members being able to contribute equally. Testing with a larger group size and the correct target group would however have been more time consuming, so doing tests with a smaller group and more easily accessible age groups was a necessity to be able to complete the number of iterations that was done - that being said, one more ambitious intermittent evaluation with the correct age group and group size would have been good to better be able to tailor the application to those conditions.

5.3 Suggestions on Future Work

This report has presented one solution for an asymmetrical VR game being used in a group for learning. For the future it would be interesting if reference tests were conducted with different set-ups, for example comparing the use of fact sheets and no fact sheets, comparing different video content and possibly also comparing the set-up in VR to a PC or physical game. How the quality of the discussion could be improved is an interesting area. Things of interest to explore

there would be a different fact sheet, perhaps fewer or only one fact sheet could increase the chance of deeper discussions as less time would have to be spent on understanding and communicating the information. Another possible variation that might give the players a better experience, given that the players in VR were much more positive towards their experience with the game, is that more than one person is in VR, possibly all. Something else that could be interesting to explore is how one person being in VR influences the discussion in a group as compared to conversations where all members are physically present and can see each other.

In the validation test there was too little data to draw any conclusions on for example which fact sheets that were the best. Doing the same validation tests with more groups could lead to more detailed trends being uncovered.

The game could also be adapted to cover other topics. Related to this project for example the relationship between groundwater and surface water is an interesting balance which would be well suited to be visualized in a similar way.

5.4 Discussion on Using VR

In this section the pros and cons of using VR in the game. This application used the set-up of one user in VR and the rest outside, seeing what was done in the game on a TV screen. Two realistic alternatives to VR are: A PC game and a physical game.

The main advantage of using VR is being able to use 360 video content to be able to give the person in VR an increased feeling of meeting the farmer's and experts. Also wearing the VR headset makes the person in VR and those outside dependent on cooperating to execute the task respectively exchange information. Compared to a PC game, a VR game might be seen as more exciting due to being a less used medium. Compared to building a physical game the VR game can give more instant feedback (as with the pillars showing how much food has been produced and how much water is left) or be quicker and easier to build (as compared to building the instant feedback physically). Compared to a physical game a VR game can also easily be moved and installed in multiple places.

A disadvantage of using VR in a group is that the sound can not be spatially mapped to suit both the person in VR and outside still having them within distance to speak. A problem with the asymmetric set-up with one player in VR and the rest outside was that their experience was very different. As seen in the results from the user verification, the players in VR had a much better time playing the game than those outside.

Using Oculus Go in particular gave some problems. For example casting was

not fully supported, but had to be solved for sound with an external transmitter and a Bluetooth loudspeaker for sound and a third party script for image. Also, the Oculus Go became overheated a few times.

5.5 Credibility of Results

There are some limitations to the validation method. For example all student in the validation tests were from the same school. The students' prior knowledge on the subject and how accustomed they are to cooperating in larger groups is for example something that could influence the results and be different between schools.

In comparison to how the game will be used in reality the leader of the game at the validation was constrained from saying what she liked. That might have influenced the game from what it would be like if she could have said what she liked. Also having a different instructor could have had a large effect on the results due to subtle unconscious hints for example.

There were some differences in conduct between the different groups. The person taking notes on how much the student's spoke also moved between the first test and the two others from behind the students to in front of, which could have changed their perception of how controlled they were. The different groups got different instructions on how to fill out the survey. All three groups were instructed to fill out the survey individually, but in the last group they were not observed during the whole time they filled in the survey and some answers in that group had apparent likenesses. Lastly, group 1 and 2 were more strongly encouraged to watch videos than the last leading to them watching all videos, and the last group none.

Lastly, in the notes on how much the students spoke one line represented talking once. That does not take into consideration how long the person spoke and thus how much the person spoke. Being able to note this could maybe have brought more insight in the levels on the discussions and engagements of the groups.

5.6 Conclusion

Water scarcity is an increasing problem and it is already a challenge for today's farmers. With the creation of an asymmetric virtual reality game on the issue, awareness could be raised. This project focused on how this type of a game could be design to work as an educational tool.

A game was created with the intention of encouraging discussions. The solution

consisted of one person wearing a VR headset and several other players helping from outside VR. The players outside VR had fact sheets to their help and the possibility to see what was done in VR on a screen. From the user evaluations it was shown that this conceptual design led the students to communicate. However opinions on the quality of the discussion on water scarcity was divided.

The game engaged all players to some extent although those in VR reported being more satisfied with the experience. The result showed that the game could work as an educational tool. It could be improved, for instance by helping the students structure the discussions better. The fact sheets played a major role in making all players engaged in the game, but the design failed in making all players feel equally engaged.

The solution worked well as an asymmetric multiplayer game and showed possibility in increasing the knowledge on a complex problem on students. However the level of the discussions on water scarcity could have been better, and the experience was not comparable between those inside and outside of VR.

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APPENDIX A

Fact Sheet Crops Lo-Fi Prototype

Crop	**Crop water need**
	(mm/total growing period)
Sugarcane	1500-2500
Banana	1200-2200
Rice (paddy)	1000-1200
Citrus	900-1200
Alfalfa	800-1600
Cotton	700-1300
Pepper (swe: paprika)	600-900
Sunflower	600-1000
Sugarbeet	550-750
Maize	500-800
Peanut	500-700
Potato	500-700
Soybean	450-700
Olives	450-700
Barley/Oats/Wheat	450-650
Tomato	400-800
Melon	400-600
Onion	350-550
Cabbage (swe: kål)	350-500
Pea	350-500
Bean	300-500

APPENDIX B

Fact Sheets Final

In the final prototype five fact sheets were included: rules and crops in the game, water footprint of foods per calorie, water footprint of foods per kilogram, country facts and main cultivated crops in Jordan.

In the Game

Rules

- You may place as many crops on each country as you like
- You do not have to place all crops
- The game is won when you feed both countries populations without running out of water in either of the countries

Crops

Cheese 

Egg 

Bean 

Apple 

Beef 

Potato 

Carrot 

Banana 

Bread (wheat) 

Water melon 

Water Footprint of Foods Per Calorie

Food type	**Water per calorie (litre)**
Potatoes	**0.4**
Wheat	**0.6**
Carrot	**0.6**
Water melon	**0.8**
Banana	**0.9**
Green peas	1.0
Avocado	1.1
Tomato	1.3
Pumpkin	1.4
Beans	**1.7**
Soy beans	1.8
Apple	**1.9**
Eggplant	2.1
Green pepper	2.3
Cheese	**2.3**
Eggs	**2.6**
Cucumber	3.0
Lamb	3.7
Beef	**8.1**

Sources

https://waterfootprint.org/media/downloads/Mekonnen-Hoekstra-2011-WaterFootprintCrops.pdf
https://waterfootprint.org/media/downloads/Mekonnen-Hoekstra-2012-WaterFootprintFarmAnimalProducts.pdf
Livsmedelsverket http://www7.slv.se/SokNaringsinnehall/

Water Footprint of Food Per Kilogram

Food type	**Water per kilo (litre)**
Carrot	**215**
Tomato	236
Water melon	**259**
Potatoes	**316**
Pumpkin	370
Cucumber	389
Eggplant	399
Green pepper	418
Green peas	656
Banana	**871**
Apple	**906**
Wheat	**2013**
Avocado	2183
Soy beans	2364
Eggs	**3598**
Beans	**5568**
Lamb	6197
Cheese	**6507**
Beef	**16987**

Sources

https://waterfootprint.org/media/downloads/Mekonnen-Hoekstra-2011-WaterFootprintCrops.pdf
https://waterfootprint.org/media/downloads/Mekonnen-Hoekstra-2012-WaterFootprintFarmAnimalProducts.pdf

Country Facts

Sweden

Population: 10.1 Million (2017)
National dish: Meatballs and potatoes (inofficial)

Hottest and coldest month and average temperatures 1901-2016
Hottest: July, 14 °C
Coldest: January, -9 °C

Month with least and most rain 1901-2016
Most: August 77 mm
Least: April 33 mm

Source: https://data.worldbank.org/country/sweden

Jordan

Population: 9.7 Million (2017)
National dish: Mansaf, a lamb dish served with fermented dried yogurt served with rice or bulgur

Hottest and coldest month and average temperatures 1901-2016
Hottest: August, 27 °C
Coldest: January 9 °C

Month with least and most rain 1901-2016
Most: January 22 mm
Least: September 0 mm

Sources: https://data.worldbank.org/country/jordan, https://en.wikipedia.org/wiki/Mansaf

Main Cultivated Crops in Jordan

- wheat
- barley (for livestock fodder)
- potatoes
- pulses (alfalfa beans, broad beans, fava beans and chickpeas)
- vegetables like: tomatoes, okra, eggplant, sweet pepper, spinach, onions, parsley, lettuce, cauliflower, carrot, cucumber
- bananas
- citrus
- water melon
- strawberry
- other perennial crops and horticulture (olives, date palm, grapes, pomegranate, almond, pistachio nuts, apples)

APPENDIX C

Manuscript for Introduction

You are in the future and the world has collapsed because of drought. Humanity has starved to death because the framers couldn't grow anything and you are the last few survivors. You have invented a time machine that can take you back to the year 2018 - when farming was still possible to save.

Unfortunately, in the time machine there is only room for one person. However the person who goes back in time will be able to communicate with their friends in the future.

Time is short so you only have time to go to two countries. You have therefore chosen to go to Sweden and Jordan. Sweden used to be a country with a lot of water, but was in 2018 hit with a major drought whereas Jordan was one of the world's driest countries since long. If you succeed in solving the problems in these countries, all other countries can follow the country that has the most similar situation to theirs and the world drought can be avoided.

Now, who wants to go back in time? Put the headset on!

APPENDIX D

Evaluation Questionnaire

The questionnaire was filled out during the user evaluations. It was filled out in Swedish. Here an English translation is also included.

Enkät om Save the Basin VR-upplevelse

----------**Kryssa i hur mycket du håller med följande påståenden**----------

Jag kände att jag förstod vad spelet gick ut på

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag kände att de andra spelarna lyssnade på mig

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag kände mig delaktig i spelet

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag upplevde att vi hade en bra diskussion relaterad till vattenbrist

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag tycker att spelet var roligt att spela

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag tycker alla var lika delaktiga när vi spelade

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag känner att jag fått ökad förståelse för vattenbrist

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag känner att jag fått ökad medvetenhet om vattenbrist

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag har tidigare känt mig orolig angående vattenbrist

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag känner mig mer orolig angående klimatet och vattenbrist efter att ha spelat spelet

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

Jag skulle rekommendera spelet till mina kompisar

Helt och hållet ❍ ❍ ❍ ❍ ❍ ❍ ❍ Inte alls

----------**Ange ditt svar med kryss respektive fritext**----------

Spelets längd var

❍ För kort

❍ Lagom

❍ För långt

Det viktigaste jag lärde mig från spelet var

_____

_____

_____

Det jag tycker var mest intressant från spelet var

❍ Lyssna på bönder och experter

❍ Se hur mycket vatten olika grödor kräver

❍ Spela ett VR-spel

❍ Att diskutera

❍ Annat: _____

Min roll i spelet kändes

❍ Viktigare än de andras

❍ Lika viktig som de andras

❍ Mindre viktig än de andras

----------**Rollspecifika frågor**----------

Jag hade rollen

❍ Bar VR-headset

❍ Utanför VR-headset

Endast till dig i VR-headsetet	Endast till dig utanför VR-headsetet
Såhär upplevde jag det att interagera (t.ex. göra val och flytta på objekt) med världen i spelet ❍ Det var enkelt att göra det jag ville och det funkade direkt ❍ Det funkade bra, men krånglade ibland ❍ Det var svårt att göra det jag ville	Jag höll i faktabladet/faktabladen ❑ Inget ❑ Crops - vattenåtgång per kalori (Water Footprint of Foods Per Calorie) ❑ Crops - vattenåtgång per kilo (Water Footprint of Food Per Kilogram) ❑ Regler och bilder på crops (In the Game) ❑ Landsfakta (Country Facts) ❑ Grödor i Sverige Jordanien (Crops in Sweden and Jordan)

Questionnaire on Save the Basin VR Experience

----------**Make a check for how much you agree with the following statements**----------

I felt that I understood what the goal of the game was

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I felt that the others in the group listened to me
Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I felt involved in the game
Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I experienced that we had a good discussion related to water scarcity
Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I thought the game was fun to play
Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I thought all were equally involved when we played

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I feel like I have gotten a deeper understanding for water scarcity

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I feel like I have gotten an increased awareness about water scarcity

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I have felt anxious about water scarcity before

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I feel more anxious about the climate and water scarcity after having played the game

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

I would recommend the game to my friends

Completely ❍ ❍ ❍ ❍ ❍ ❍ ❍ Not at all

----------**Give your answer with a cross or text respectively**----------

The length of the game was

❍ Too short

❍ Good

❍ Too long

The most important thing I learned from the game was

_____

_____

_____

What I found most interesting from the game was

❍ Listening to farmers and experts

❍ Seeing how much water different crops need

❍ Playing a VR game

❍ Discussing

❍ Other: _____

My role in the game felt

❍ More important than the others'

❍ As important as the others'

❍ Less important than the others'

----------**Role specific questions**----------

I was

❍ Wearing the VR headset

❍ Outside the VR headset

Only for you in the VR headset	Only for you outside the VR headset
This is how I found interacting (making choices and moving objects etc) with the world in the game ❍ It was easy to do what I wanted and it worked immediately ❍ It worked well, but was sometimes cumbersome ❍ It was hard to do what I wanted	I held the fact sheet/fact sheets ❑ None ❑ Water Footprint of Foods Per Calorie ❑ Water Footprint of Food Per Kilogram ❑ In the Game ❑ Country Facts ❑ Crops in Sweden and Jordan

APPENDIX E

Questionnaire: The Most Important Thing Learned

The following presents the students' exact answers to what the most important thing they learned from the game was.

Group 1

Att vi måste spara på vatten och att olika länder har olika mycket vatten.

Att vi måste hjälpas åt med att försöka få bort vattenbristen.

Hur allvarligt detta med vattenbrist är.

Bröd tar mycket vatten men ger mycket mat. Vi kan lösa vattenbrist av att bli veganer.

Hur mycket vatten all mat tar att producera.

Att vattenbrist är viktigt.

Hur mycket vatten som gick åt till olika matvaror.

Hur mycket vatten som egentligen finns i olika grönsaker och annat. Det är mer än man förväntar sig.

Hur mycket vatten olika grödor tar, och ökad fakta om vattenbrist i tex Jordanien.

Att veta hur mycket vatten innehåller och att vattenbrist är allvarligt.

Group 2

Hur det är i olika delar av världen.

Det är viktigt att vara uppmärksam och inte slösa vatten eller ta för givet (att det finns tillgängligt) när det gäller vatten.

Att man måste tänka mer på hur man ska leva om det blir klimatförändringar. Också att man måste sammarbeta.

Det är viktigt att tänka på hur mycket vatten man gör av med och vad som kräver mycket vatten.

Att det är så pass allvarligt med torka. Och om vi inte gör något åt det så kommer det resultera i det som dem beskrev i början av spelet.

Att det är ett stort problem med vatten brist. Det är allvar nu.

Att man kan komma på en lämplig lösning medans man e medveten om vattnet.

Att jag fick lära mig mer om vattenbristen

Vet inte

Group 3

Inget

Ge allt vatten till Sverige

Att jordanien är ett av världens vattenfattigaste länder och att du inte har möjlighet till samma mat som vi i samma mängd

Att det går att dela ut vatten till länder som har vattenbrist och få tillräckligt med mat till alla

matte. vatten och mat till Sverige

Förmodligen hur akut läget faktiskt är i både Sverige och Jordanien

Hur mycket vatten olika saker tar

komprimisa

Att vissa saker tar extremt mycket vatten och så kanske det inte ens ger mycket mat

inte så mycket, krävs tydligare siffror och info, men att kött och ost tar mycket vatten

APPENDIX F

Images of the Final Prototype

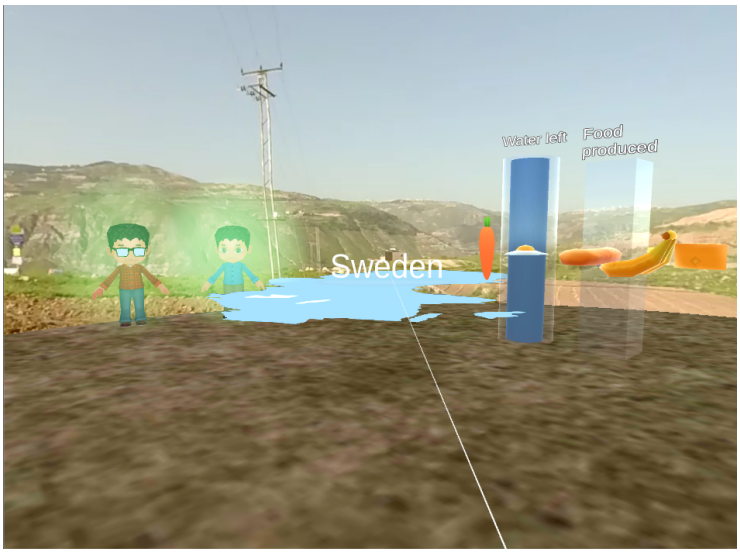

Figure F.1: Showing the set-up for Sweden in the interactive part of the game. Clicking on either figure leads the user to the video content. The figures have a blinking aura around them to bring the attention to them.

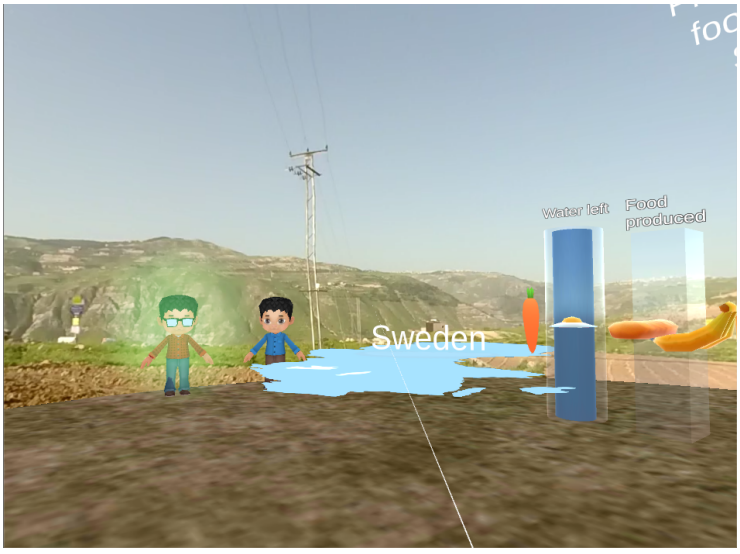

Figure F.2: The figures where the video of the right figure has been seen and the aura around the figure has been removed.

Figure F.3: Capture from one of the videos from Jordan where a dairy farmer is talking about his farm.

Figure F.4: Capture from one of the videos from Jordan where dromedaries are seen.

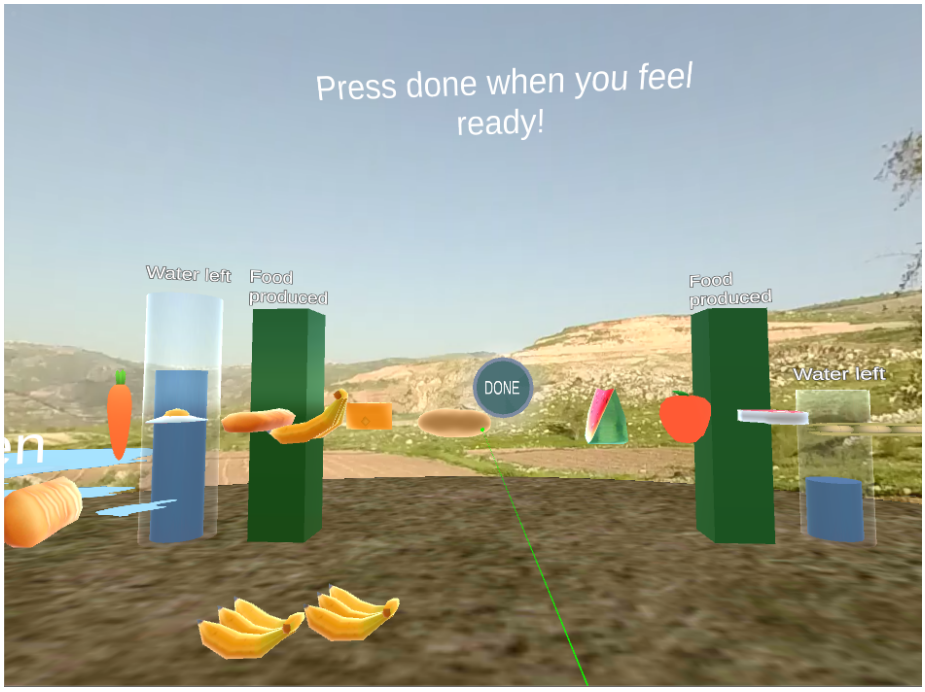

Figure F.5: A view of the game set-up when a sufficient amount of food which consume little water has been added. When the pillar for food are filled for both countries, and the water has not run out for either of the countries, the game could be finished by pressing done.