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Augmented Reality with Image Tracking using Unity Game Development

Master's thesis in Electronics Systems Design and Innovation
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NTNU

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Preface

I am submitting this thesis to fulfil the requirements for a Master of Science (MSc) degree at the Norwegian University of Science and Technology (NTNU). The work related to this thesis has been done over five months, from January to June 2023. The thesis is a continuation of the project[1] for the class Electronic Systems Design and Innovation Specialization Project. Some text in the Introduction and Background chapters are used and continued from this project, as well as one figure. Several people have helped me with this project and I would like to thank them. I want to thank my main supervisor, Professor Andrew Perkis for keeping watch over the project and for valuable feedback. I would also like to thank my co-supervisor Wendy Ann Mansilla Obiri. She has acted as the Art Director for the project and has been my day-to-day contact for any help I need.

Abstract

Interactive Digital Narratives (IDN), which allow audiences to participate in or interact with digital narratives, is a new system for digital storytelling. One way of expressing an IDN is through augmented reality (AR), which allows users to superimpose virtual objects onto the real world. This paper explores how to create a specific IDN AR experience through an AR app that conveys the story of water symbiosis. Exploratory research is also done on the created AR app to uncover what components of the AR app change the enjoyment level of the user. Two app versions were created to examine the difference animations and sounds had on enjoyment. Thirty participants were asked to test the app. Fifteen participants tried one version and the other half, the other. After this, the participants answered a questionnaire where we analysed the inferential statistics we obtained. We found that regardless of our components in the AR app, there was a high enjoyment level for all participants. The results show no significant differences in determining if our components affected the enjoyment level. The work is closely connected to the ULTIMATE project, a Horizon 2020 project. They aim to incorporate AR into their methods of working and co-creation to create engagement through participation to create economic value and increase sustainability within the water cycle.

Sammendrag

Interaktive Digital Narratives (IDN), lar publikum delta i eller samhandle med digitale fortellinger, og er et nytt system for digital historiefortelling. En måte å uttrykke et IDN på er gjennom utvidet virkelighet (AR), som lar brukere legge virtuelle objekter over på den virkelige verden. Denne artikkelen utforsker hvordan du kan lage en spesifikk IDN AR-opplevelse gjennom en AR-app. AR-appen formidler historien om vann symbiose. For å avdekke hvilke komponenter i AR-appen som endrer gledesnivået til brukeren, gjøres det utforskende forskning på den opprettede AR-appen. To versjoner av appen ble laget for å undersøke forskjellen animasjoner og lyd hadde på nytelse. Tretti deltakere ble bedt om å teste appen, der femten deltakere prøvde den ene versjonen, og den andre halvparten, den andre versjonen. Etter utprøvingen ble deltakerne bedt om å svare på et spørreskjema der vi analyserte den innhentende statistikken. Vi fant ut at uavhengig av komponentene våre i AR-appen, var nivået for nytelse høyt for alle deltakerne. Resultatene viser ingen signifikante forskjeller når det gjelder å bestemme om komponentene våre påvirket deltagernes nytelsesnivå. Arbeidet er nært knyttet til ULTIMATE, et Horizon 2020-prosjekt. ULTIMATE har som mål å inkorporere AR i deres arbeidsmetoder og samskaping for å skape engasjement gjennom deltakelse, for igjen å skape økonomisk verdi og øke bærekraft innenfor vannets kretsløp.

Table of Contents

List of Figures

List of Tables

Acronyms

Chapter 1

Introduction

The rapid pace of technological innovation has transformed society in unprecedented ways. Thirty-seven years after the first moon landing, the first iPhone was released, a small electronic device with the same computing power as the Apollo 11 space mission. Since 2007 there have been 34 iterations of this phone, getting more powerful and streamlined. With the arrival of new and exciting technology, our society is trying to change as fast as possible to catch up, affecting our day-to-day life. When the first iPhone was released, TV and newspapers dominated the news world. Today we are in a phase where the traditional media is being set aside for newer and more streamlined methods of sharing news and information. Our handheld devices are the gateway to a world of connectivity and interaction, engaging us differently than traditional media. This has changed how we convey stories[2][3]. From old storytelling with verbal communication and written books to a new age with digital media. Digital storytelling with the radio and TV has made it so widespread to convey your own stories, and it has never been faster or easier to do than without the introduction of the internet and personal phones. This has made digital storytelling very personal and has opened up possibilities for users to interact indirectly or directly with the narrative, paving the way for Interactive Digital Narratives (IDN). IDNs are a new concept for modelling digital stories as computer systems. They allow the audience to participate or interact with the stories. This can be done with branching narrative paths or with gameplay elements. IDNs can take many forms, such as video games, interactive web-based stories or apps. The goal of an IDN is to engage the audience to immerse them in the story.

eXtended Reality (XR) technologies have proven to be a powerful way of implementing IDNs. XR is an umbrella term for technology used to create an immersive experience by mixing virtual elements into the real world or to immerse the audience directly into the virtual world. Technology like this includes Augmented Reality (AR) and Virtual Reality (VR). AR can be utilized through your handheld device to superimpose virtual objects onto the real world. Azuma defines AR as, ""An AR system supplements the real world with virtual(computer-generated) objects that appear to coexist in the same space as the real world""[4]. We define an AR system to have the following features: real and virtual objects interplay in a real environment, runs interactively and in real-time. This technology is already being used in many different sectors of our society [5][6][7][8] and for a good reason, as it gives us new ways of explaining complicated problems simply and new ways for expressing creator's ideas. Among other things, it has been shown to increase enjoyment and engagement for learning for students[9][10] and creates greater novelty and immersion for e-commerce[11]. AR has come a long way, and now there are many tutorials, guides and libraries to help you create your own AR experience[12][13][14][15][16][17][18][19][20].

We have now seen that AR is being used in many different sectors and there is much investigating into the effects of using AR in specific activities. *Attractiveness of game elements, presence, and enjoyment of mobile augmented reality games: The case of Pokémon Go*[21] investigates the attractiveness of various game elements of Pokemon Go on its players. They looked at factors like sense of presence and length of gameplay. Another paper[22] investigates how AR apps affect consumer engagement, and looks at customer flow and attitude towards AR. *Exploring the relationship between presence and enjoyment in a virtual museum*[23] investigated if there was any

correlation between prior experience in Information and Communication Technologies (ICT) and AR presence. They also investigated if there was any correlation between enjoyment and AR presence. They found a positive correlation, but did not investigate what contributed to the feeling of presence which led to more enjoyment. This is a common thread through these papers, there are a lot of positive attributes attached to using AR, but few papers investigate what components in their AR experience directly influence the enjoyment of their users. This is a core factor that will be further investigated in our work.

In this paper, we developed an AR app in collaboration with the ULTIMATE[1] project[24][25]. The ULTIMATE project wants to incorporate AR into its methods of co-creation and engagement. The ULTIMATE project is a Horizon 2020 project that wants to create economic value and increase sustainability within the water industry. This project involves many stakeholders through its 9 case studies throughout Europe[26][27]. The case studies are there to showcase the improvements of ULTIMATE through new and innovative technologies.

The following chapter, chapter 2, will explain AR and its possibilities in more detail. It will also explain IDNs and an essential component of it, enjoyment. With this and an idea of previous research in this field, we will formulate two research questions we want to investigate. Looking at similar projects, we get an idea of what we can create and will showcase the AR app created for this thesis in chapter 3. The creation of this AR app will hopefully uncover two things for us. One, it will showcase how to create a personal IDN AR experience and secondly, what components of this AR app affect the enjoyment of the users. We will be doing both confirmatory and exploratory research to answer these questions. The confirmatory research will examine the implementation of our IDN and AR experience. This is done in chapter 3 and the exploratory research will be done through user tests we conduct. These tests are explained in Section 3.5 and the following chapter will showcase the results and discuss these. This ultimately leads to our conclusion in chapter 6.

Chapter 2

Background

The Sense-IT team[28] located in NTNU Gløshaugen, is a research team created to explore the creation of art and technology through different installations. They want to create new digital narratives and asses the experiences and effectiveness of them. Their work is utilized in different domains and can be used to improve engagement with complex issues. The team is led by Andrew Perkis, with multiple researchers and PhD students working on the team. Through NTNU, the Sense-IT team is working with the ULTIMATE project to create an engaging digital narrative. The Sense-IT team is working with a student from NTNU to create his masters thesis and this digital narrative. This project is also led by Andrew Perkis as supervisor and Wendy Ann Mansilla, a senior researcher in the Sense-IT team, as co-supervisor and Art Director. This thesis will introduce the audience to the ULTIMATE project, the cooperation with NTNU and the implementation and results of the project created by this student during the spring semester of 2023.

""ULTIMATE is a 4-year Horizon2020 project under the EU Water in the Context of the Circular Economy programme. The aim is to create economic value and increase sustainability by valorizing resources within the water cycle""[24]. This is the core goal of the ULTIMATE project. To work towards this goal, ULTIMATE wishes to be a catalyst within a unique industrial symbiosis termed Water Smart Industrial Symbiosis (WSIS). Within this term, there are three key areas they want to work on. To **reuse** water and wastewater, to **extract and exploit** energy within industries and municipalities within the water cycle and lastly to **recover materials** also within this cycle. To be this catalyst, ULTIMATE is working to demonstrate the effectiveness of new technology, smart tools and innovative ecosystems[25]. They also want to show how to create strong partnerships, matchmake market groups and demonstrate circular solutions[25].

Within the ULTIMATE project, there are 27 partners from 11 different countries, and NTNU is one of these partners. Inside the ULTIMATE project are nine different Water-Smart Industrial Symbiosis case studies[26]. The objective of the case studies is to demonstrate the performance of the symbiosis goal of the ULTIMATE project. The case study we will focus on in this project is Case Study 9 (CS9), Kalundborg, because they are directly involved in developing ULTIMATE's Playbook. Kalundborg has a symbiosis where they recover and reuse certain materials, although there is still room to extend their circular economy-related strategies.

One aspect Kalundborg focuses on is wastewater treatment, done by two companies, Novozymes and Kalundborg Utility[27]. ULTIMATE plans to use digitization to increase the energy efficiency of its treatment process. Lastly, ULTIMATE wants to engage stakeholders and the public to learn and create new solutions for their goals. To do this ULTIMATE needs people to come together and create solutions. One way of doing this is through what they call a Playbook.

ULTIMATE defines Playbooks as ""approach-oriented documents which can provide any team consisting of various participants with both a structure and plan to guide them with the best possible approach to situations, activities, or in this case co-creation""[29]. This means a Playbook is a step-by-step guide, with carefully thought out activities and discussions to be had between the

participants. Participants can be stakeholders or the general public, with a goal for them to come together and co-create new methods and ideas for ULTIMATE to use. ULTIMATE is a massive project with many stakeholders and case studies throughout Europe. Therefore there are many teams and people involved. To more easily engage and create co-creation between stakeholders and citizens, Playbooks are a handy tool.

NTNU's involvement with ULTIMATE is to create an immersive narrative experience using the Playbook and Interactive Art Installations. To utilize new digital media for reflection and co-creation, ULTIMATE wants to create an interactive immersive narrative as a part of this Playbook. This job is put upon the Sense-IT team at NTNU to create. The installation should use new technology like augmented reality, but should at the same time also be an art installation. This way, ULTIMATE can create an installation where participants can be more immersed than in a traditional Playbook to create reflection and co-creation.

2.1 Augmented reality

XR is an umbrella term for augmented, mixed and virtual reality. These three "realities" can be placed on a Reality-Virtuallity spectrum as seen in Figure 2.1. XR technologies allow users to immerse themselves and interact with digital media in a new way. XR technologies are being used in a variety of fields, including gaming, news, entertainment, health and much more [5][6][7].
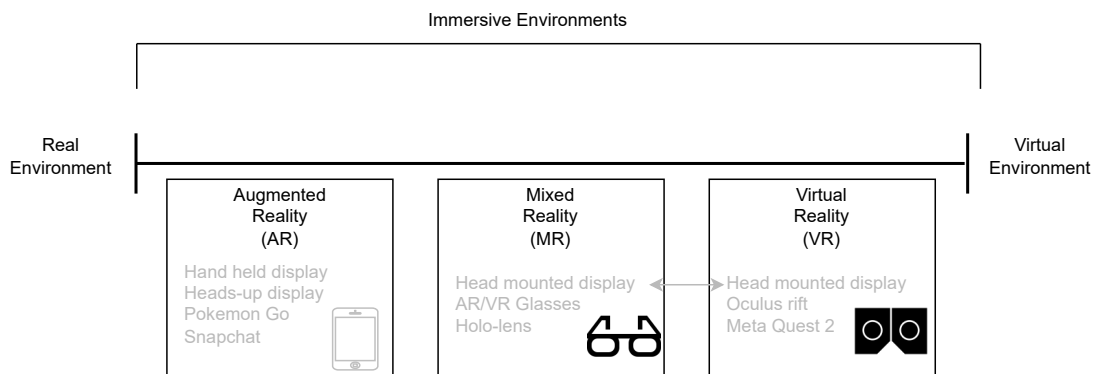
Figure 2.1: "A taxonomy of mixed reality visual displays", inspired by [6].

This spectrum makes it easier to understand what AR is. As the introduction states, augmented reality supplements the real world with 3D objects. This is done by creators coding or using engines like Unity 3D to create apps and websites that utilize and augment our surroundings. AR is often used through smartphones, where the camera is used to view the surroundings and digital objects placed on the screen. For many citizens, augmented reality may seem like a niche tool, but augmented reality is already all around us. Snapchat and Tiktok, being some of the most prominent social media applications out there, use augmented reality to create fun and exciting filters for users to play around with.

Pokemon Go is a super popular AR game with over 500 million downloads total[30], showing just how popular AR is and that it is already all around us. However, AR can be used for more than just social media and games. It can be used for medicine[7], tourism[7], education[7] and much more.

There are multiple ways of creating an AR application. One way is to use Unity 3D[17]. Unity 3D is a popular game engine which can be used to create AR apps. Using the game engine, you can make and customize 3D objects and add components to make them interactive. To create custom interactions, you can create C# scripts and attach them to your scene or objects. With already curated packages built for augmented reality, AR app development is much more effortless. ARFoundation[20] for Unity 3D is a multi-platform package enabling easy AR development integration. Basic AR features such as plane detection and image detection are built-in. Instead

of coding applications from the ground up, more drag-and-drop features are built into Unity for rapid development. ARFoundation also supports ARCore and ARKit, meaning it is possible to build applications for both Android and IOS. Although there are different ways of creating AR applications, they still use the same core ideas.

Within the scope of augmented reality, there are multiple ways of rendering in our 3D models. Two ways of doing it are either **marker-based** or **marker-less**. Within **marker-based** tracking, you use predefined images and markers for the camera to calculate and understand the scene and then project our models onto these markers. There are predominantly two ways of doing this, either through the fiducial method or natural feature selection[31]. The fiducial method has superior accuracy and robustness in changing environments. Examples of these are in Figure 2.2.
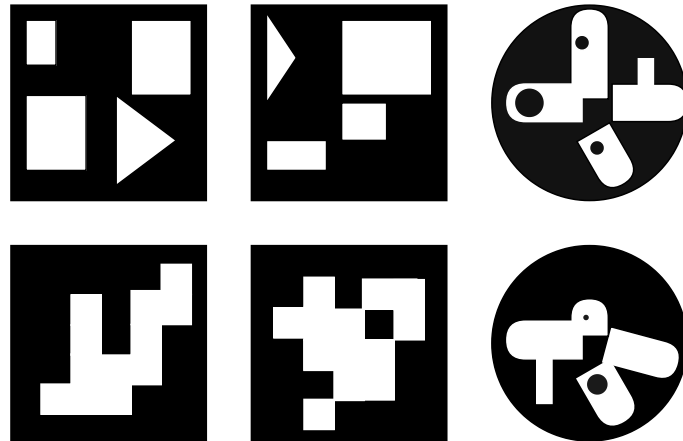
Figure 2.2: Different planar pattern marker systems, inspired by figure (2) in [32].

On the other hand, natural feature tracking has a broader range of applications. As the name suggests, this method uses natural features such as curves, edges and borders to recognize and track an image. Therefore we can use more natural images to track, leading to more possibilities for images and easier integration into sectors like art.

Instead of markers, the **Marker-less** method relies on perceiving and understanding the surrounding environment. With no preknowledge of the environment, this AR method can be used anywhere, but will therefore be very costly to run. This can be utilized to create AR experiences around the user's phone or at specific locations. This tutorial here[18] showcases both aspects of marker-less AR.

2.2   Interactive Digital Narratives

A brief explanation of IDNs has already been given. We understand that IDNs are conveyed to us through a digital medium like a podcast, a website or through our phone. The narratives told to us are also interactable to some degree[3]. This interaction will change the story and make it personal for the user. IDNs can be used to increase engagement in the user[33] and can be used to convey complex ideas. One way to make IDNs interactable is by adding gamified elements to your story. This is the use of adding game elements to a nongame context. It is believed that the use of gamification improves learning[34], increases enjoyment[35] and engages students[36] in education. An essential factor of any IDN is the enjoyment of the user.

2.3 Enjoyment

The objective description of a subjective feeling can often be difficult and many papers have different definitions[37]. The paper *A multi-dimensional model of enjoyment: Development and validation of an enjoyment scale (ENJOY)*[37], created a definition of enjoyment. To create a definition for a construct such as enjoyment, the paper looked at previous definitions and explored many related factors to enjoyment, such as interest, satisfaction and pleasure. This paper stated that enjoyment is multi-dimensional, where multiple aspects influence a person's enjoyment. Through rigorous testing and expert review, they created a multi-dimensional model for enjoyment. They found that to measure enjoyment, you can investigate five sub-scales influencing a person's enjoyment. These are pleasure, engagement, competence, challenge/improvement and relatedness. With these factors in mind, their definition of enjoyment is ""a positive feeling, when engaged in a pleasurable and challenging activity, which allows for skill improvement, makes you feel connected to others, and makes you feel proficient with the activity""[37]. This definition can also be put more simply based on the amount of variance of each factor too,

> ""a positive feeling, when engaged in a pleasurable activity"".[37]

2.4 Similar projects

The use of AR to create IDNs is prevalent in many sectors of society. It has been used for museums to elevate the experience and explain high scientific content more understandably and engagingly[8]. This project used Unity 3D to create a marker-based AR experience. The museum had stickers placed next to the already established exhibitions where users could use the personally created app to scan the images and view 3D objects and information about the exhibition the images were representing. They successfully created an engaging and exciting way of experiencing the information the museum wanted to convey.

Another similar project that pursues to understand the effect AR had on students regarding the enjoyment of learning[9] is called *Effect of augmented reality-based virtual educational robotics on programming students*. This project also utilised Unity 3D to create an AR app, which again used marker-based tracking. The project created several cards with information and images on them, and when you tracked the images with a phone, different challenges, games and gamified information panels appeared on the screen. Furthermore, they assessed the effect of this AR app on students learning against a website with gamified learning elements. They found that the students utilising the AR app had higher enjoyment of learning and algorithm design skills.

2.5 Research questions

Thus far, we have explained IDNs and about AR and its possibilities. What we want to accomplish is to understand how we can create our own IDN using AR technologies. To do so, we will need a narrative we want to convey. This falls in line with the Sense-ITs' mission with the ULTIMATE project. As mentioned in chapter 2, this mission is to create an immersive narrative experience ULTIMATE can utilize in their Playbook. Therefore, we will create an AR experience for ULTIMATE and convey their narrative of water symbiosis. Our first research question is therefore,

1. How can AR be used to convey an immersive digital story about circular water symbiosis?

Looking at other projects using AR experiences to enhance their goal, we see that they usually investigate what effect their experience has on the user, but do not investigate what factor of their AR experience is important for the user's enjoyment. Therefore we also want to investigate what factors of an AR IDN make users enjoy it more. Two components that can be easily implemented into an IDN are visual models and sound to enhance the experience. Hence we want to investigate,

2. Will the addition of animated 3D models and sounds to the AR experience change the enjoyment of the app?.

We will do this by investigating two of the dimensions of enjoyment mentioned in[37] that best fit our created app.

Chapter 3

Method

3.1 Research methodology

To investigate the research questions in this thesis, we will first showcase the implementation of the AR IDN we created. As part of the masters thesis, the author collaborated with ULTIMATE in investigating the technology and development of the introductory app that will narrate the story of the industries connected to water symbiosis using AR. This will work as confirmatory research for our first research question *1. How can AR be used to convey an immersive digital story about circular water symbiosis?* The following sections will explain how we created our narrative and used interactive functionalities to create an IDN.

After that, we will collect and analyse data using our created app, to investigate our second question, *2. Will the addition of animated 3D models and sounds to the AR experience change the enjoyment of the app?* We will conduct exploratory research using user tests to collect qualitative and quantitative data. We will do this through a Likert-scale and open-ended questions. We will sample this data from engineering students going to NTNU as they are the most readily available demographic to sample from. The data collection method will be in the form of a Google form that the user will answer after having experienced the AR app that was created. After this, the data will be analysed using descriptive statistics through means and variances. As well as looking at the inferential statistics using the one-way ANOVA test. The qualitative data will also be discussed.

3.2 Creation of the IDN

The creation of the IDN for the ULTIMATE project is twofold. Firstly, we have to create a narrative to convey to the user. Secondly, we have to use new technology to help us convey the narrative in an engaging and fun way. Since we are creating an IDN for Kalundborg, we must convey their narrative, water symbiosis, to the user. We cannot create an IDN with real industries and numbers for data security reasons. Therefore we will create a fictional world representing a place like Kalundborg. This place will be called Groblundak. We can divide our narrative into three blocks, as in Figure 3.1. These blocks represent what we want to convey in our narrative. Firstly, we need to show the world of Groblundak to the user. Secondly, we need to tell them about the symbiosis happening within Groblundak and how water is being circulated. Thirdly, we need to make the users feel in control of the narrative.
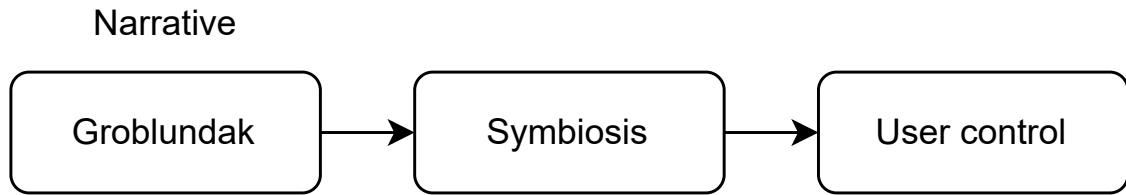
Narrative

Figure 3.1: Narrative blocks.

To create this narrative, we can use AR to create an experience for the user to explore the world of Groblundak. This can be done utilizing marker-based tracking like in the projects we have seen. That means we need to create a system that can perceive and track an image and then project a 3D object on top of it. This system can look like the system in Figure 3.2.
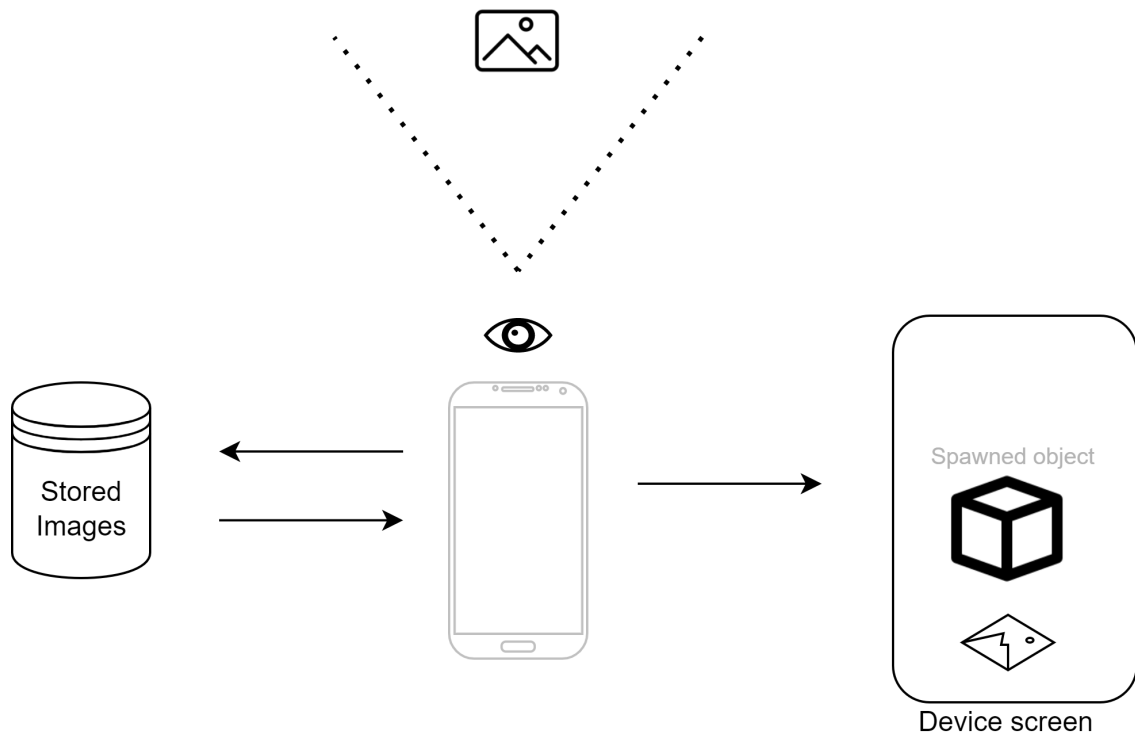
Figure 3.2: Diagram over workflow of the application[1].

The functionality of our app will be divided into three blocks seen in Figure 3.3. These blocks are connected 1:1 to our narrative blocks in Figure 3.1. We will create different images to track that will be placed over a fictional map of Groblundak. This will allow the users to explore Groblundak. Secondly, to convey the message of symbiosis, if the user tracks a specific image, information panels will appear. Lastly, to get the user to feel in control, we will implement river panels where the user can control the amount of water sent around in Groblundak.
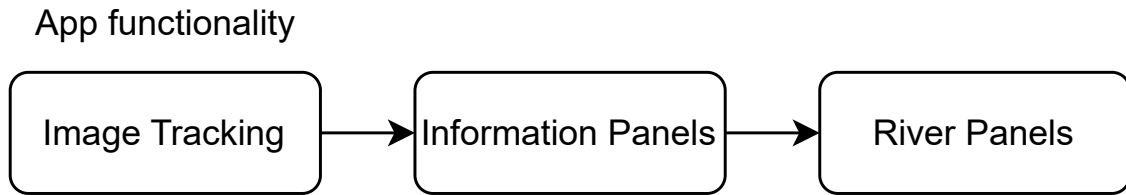
App functionality

Figure 3.3: App functionality.

In the next section, we will explain in more detail the different functionalities of the app and how they represent their respective block in Figure 3.1.

3.3   Functionality of the IDN

To help us create the IDN, we will use Unity 3D. Throughout the process, Unity updated multiple times and the latest version of Unity 3D the app was created on was *Unity 2021.3.24f1*. The app was also built onto a Samsung Galaxy S21, hence, the user tests were also done on this phone. Using Unity 3D, we added the ARFoundation package. This comes with many helpful out-of-the-box functionalities like image tracking and plane detection. ARCore was also added as the app was built onto an Android device, meaning the app is compatible with any Android device using *Android Version 8.0 Oreo* or later.

3.3.1   Image Tracking

Image tracking in Unity is simple, as with its integrated *Image Reference Library*, we only need to create the images for it to track. For this project, we had four trackable images, seen in Figure 3.4. These images were designed on Canva.com[38].
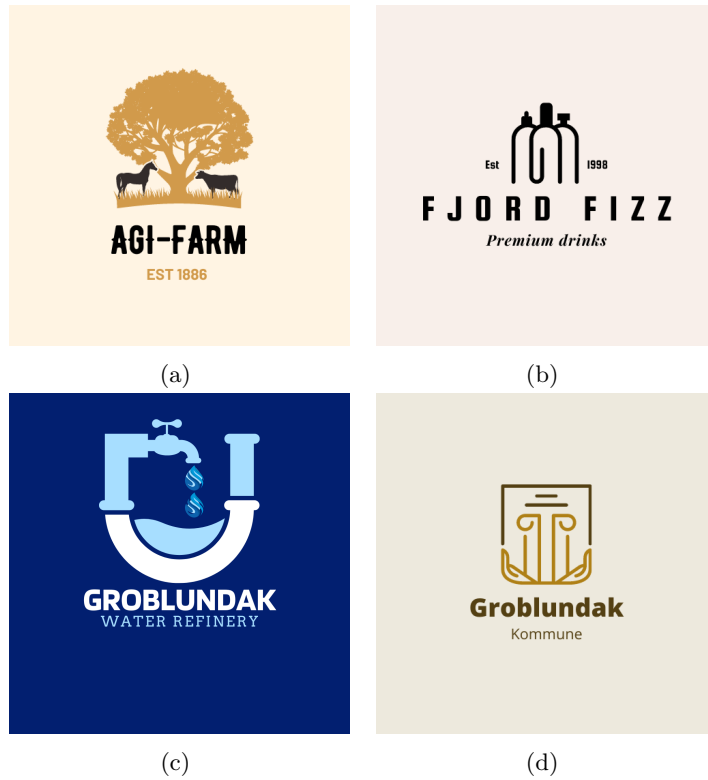
Figure 3.4: Tracking Images created on Canva.com[38].

Figure 3.4a represents an agriculture industry, Figure 3.4b represents a industry creating beverages, Figure 3.4c represents a industry that can clean water and lastly Figure 3.4d represents the fictional municiplaity called Groblundak. Agi-Farm and Fjord Fizz are industries within Groblundak which need water to create products. The population of Groblundak also needs water for everyday use. Groblundak Water Refinery is an industry which cleans wastewater. These images will then be placed over a fictional map representing Groblundak which the user can explore. When you use the app and point the camera to one of these images, 3D objects will appear, this functionality is the exploration part of the narrative block.

3.3.2   Information Panels

After creating the images and the app recognises the images, a representative 3D model should appear over the image like in Figure 3.2. The user can examine the model, but also interact with it. Touching the 3D model will bring up informative panels for the user to examine. These will appear approximately at the hip height of the user and can be read like an exhibition at a museum. The model will also appear behind the panels so the user can more easily examine it. This idea is showcased in Figure 3.5. On the panel to the left, Info Panel 1, we will have general information about the industry that was scanned. The panel in the middle will have information about what water sources the industry needs to take from and what it will be used on. Lastly, the panel to the right will have information on how much water the industry can send back into circulation. Exploring all the images and models will give the user a sense of how much water all these different industries need and how they contribute to water recycling. This should give the user a sense of the water symbiosis happening in Groblundak.
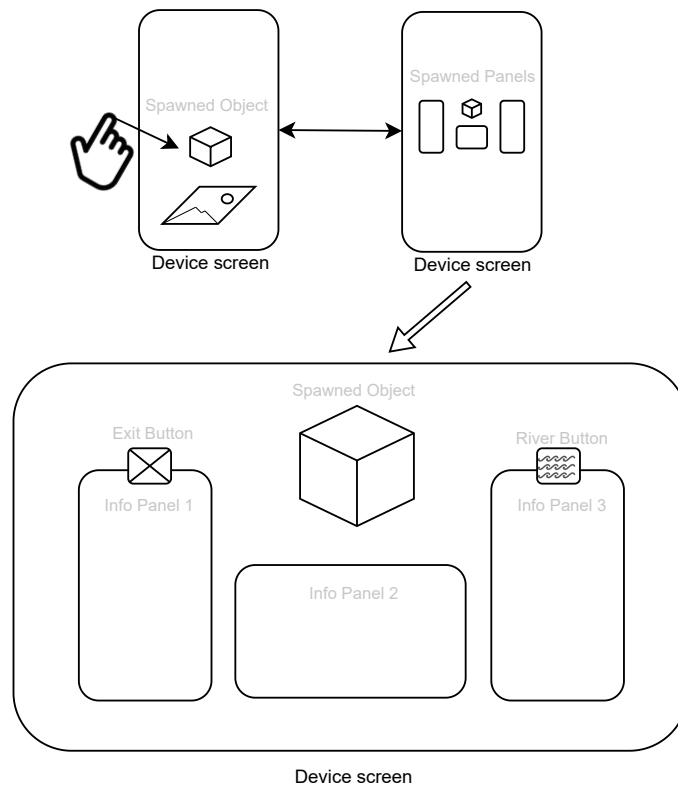
Figure 3.5: Diagram over base functionality of the AR experience.

As we see in Figure 3.5, on the panels are also buttons to interact with. The one on the left-hand side will be the escape button. When satisfied, the user can close the panels and move on to the next image. The button to the right is the *River Button*. This button is explained in Section 3.3.3

3.3.3 River Panels

When the river button is pressed, a river model on the floor will appear as seen in Figure 3.6. The user can then follow this river to come across another set of panels located elsewhere in the 3D space.
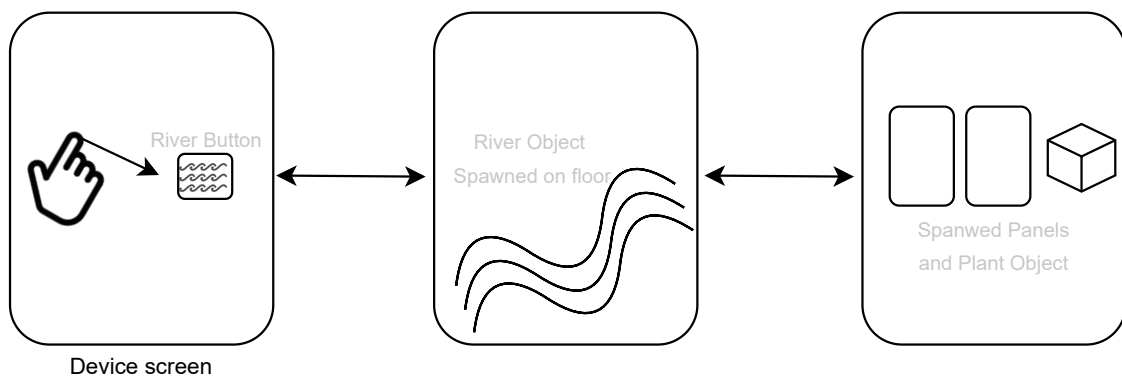
Figure 3.6: Diagram over river function.

The river panels will consist of two panels and a 3D plant object. As seen in Figure 3.7. To create a sense of ownership over the narrative, the user can control the water divided in the municipality.

As shown in the figure, the top slider will indicate the water available in the municipality. This slider will be connected to the plant model next to the panels. If the amount of water decreases, the plant next to it will wilt and die. This gives the user the sense that there is a limited amount of water in the area, and we cannot use it all up since then the nature and ecosystems around Groblundak will die. The two sliders under the total water amount can be interacted with by the user. The user can decide how much water they will allow the Groblundak population to use and how much water will be used by the industries in Groblundak. The last slider will be hidden from the user. This slider will control how much water Groblundak Refinery will clean. It will only be visible to the user if they have explored the municipality and scanned the image of Groblundak Refinery. This functionality is added to increase the gamification of the whole system and give the user a sense of control over the narrative. As we have stated, gamification can lead to enjoyment and engagement.
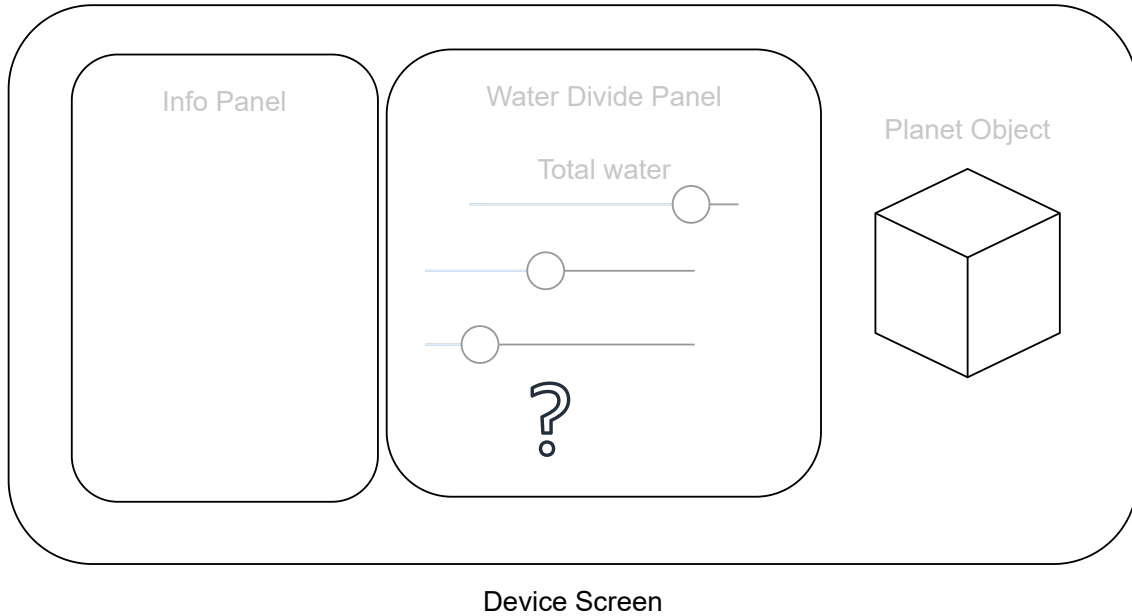
Figure 3.7: River panels.

3.4 Showcase of Symbiosis app

After the functionality and narrative of the app is created, the next step was to create the app in Unity. We will now go through each functionality block again and show images of the app's appearance.

3.4.1 Image Tracking

When starting the app, you will be met with a start screen to introduce you to the app. This will give some information about what you can do. When the user is ready, they can press start and explore Groblundak. The images we created should be placed on a printed-out map representing Groblundak, but this still needs to be created, so the trackable images are placed on the floor in front of the user to scan. The user can go towards them and scan them, and as shown in Figure 3.8 (c-f), 3D models are placed on top of the image when the app recognises the image.
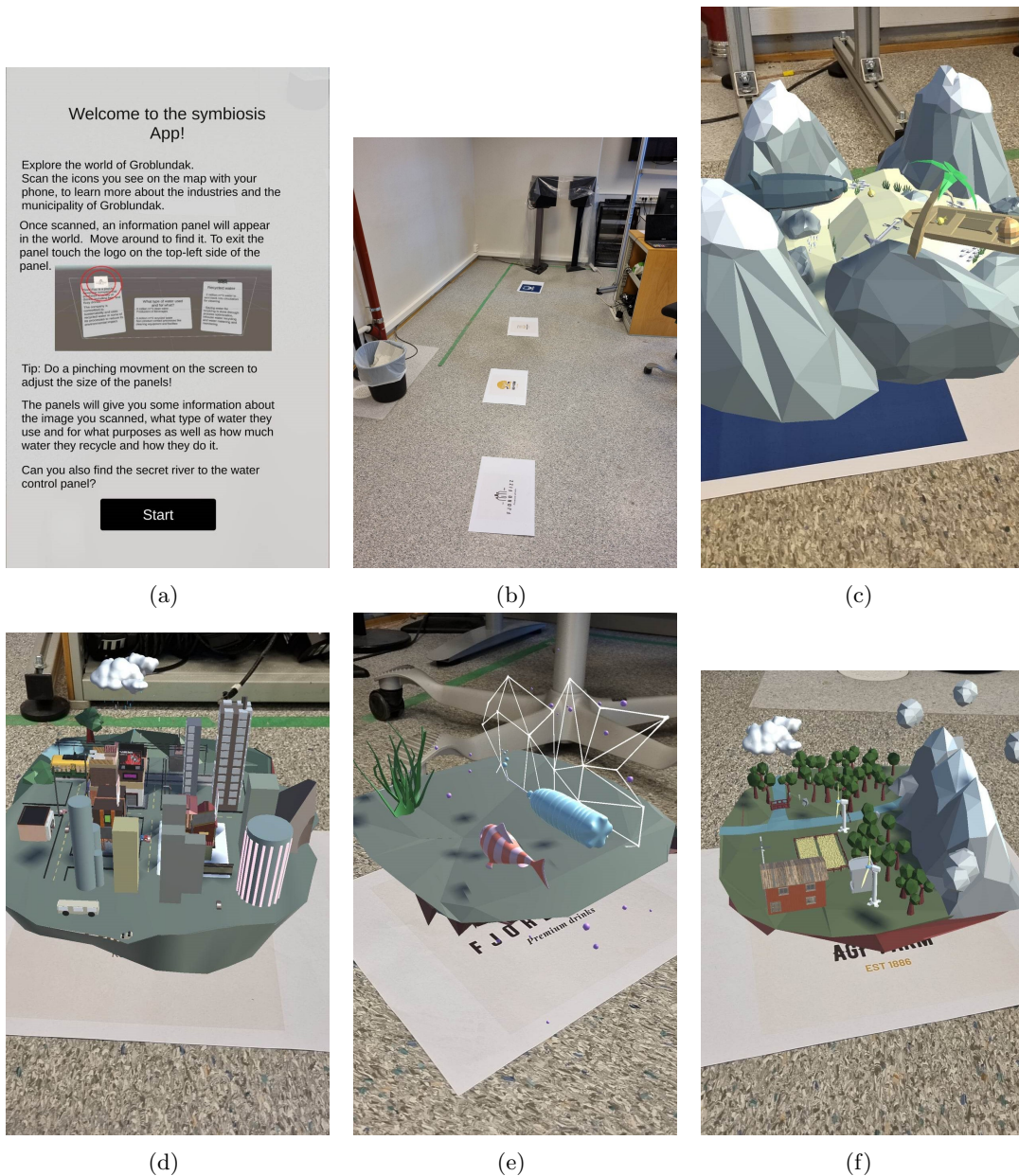
Figure 3.8: (a) Start screen, (b), Images to track placed on floor, (c)-(f) 3D models placed on the scanned target image.

The 3D models were created by the co-supervisor and Art Director, Wendy Ann. The 3D models were created to represent the images to some degree. Figure 3.8c is a model of a water biome to represent water, Figure 3.8d is a model of a city to represent Groblundak. Figure 3.8e is a model of a fish and a beverage bottle to represent the beverages that FjordFizz create. Lastly, Figure 3.8f is a model of a small farm to represent the agriculture industry of Agi-Farm. All models were created in Blender and imported into the Unity project.

3.4.2 Information Panels

When the 3D models are tapped, the information panels appear. The panels are shown in Figure 3.9. Here we see the three panels, the exit button, the river button and the 3D model behind the panels for more exploration.
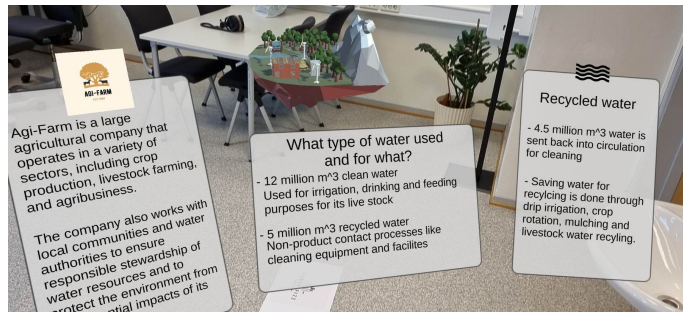
(a)
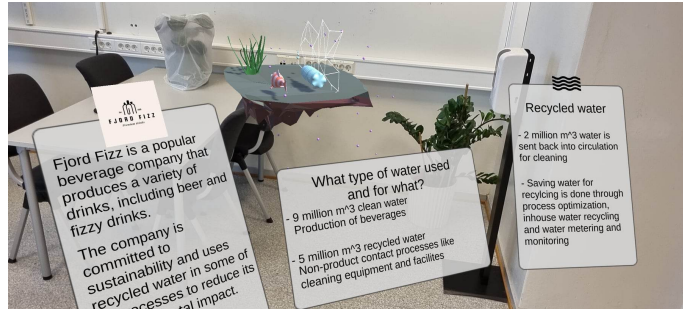
(b)
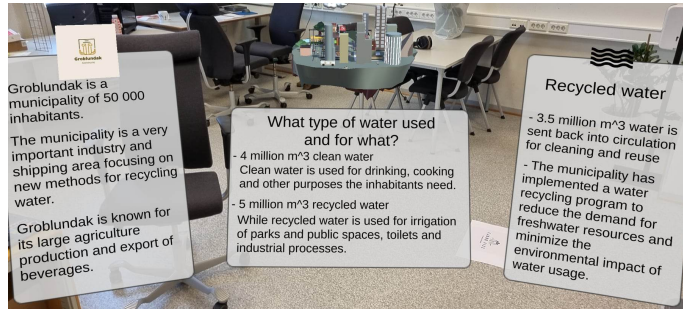
(c)
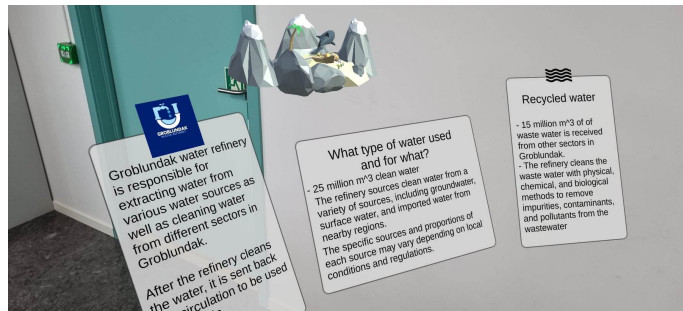
(d)

Figure 3.9: Panels for each industry.

The models are also animated and have 3D sound effects added, so when you move further away or closer, the sound adjusts. The animations are created by the student, while the sounds are sourced from freesound.com[39]. The sounds also match the models, so we have bubbles and wave sounds for the water biomes and farm and city sounds for the other two models. The links to all the sounds and what is animated on each model are shown in Table 3.1 and Table 3.2.

Sound	Link
Bubbles	https://freesound.org/people/InspectorJ/sounds/398808/
City ambience	https://freesound.org/people/habbis92/sounds/240233/
Waves	https://freesound.org/people/pulswelle/sounds/339517/
Farm	https://freesound.org/people/ChristiKuhn/sounds/91255/

Table 3.1: Table over sounds used from freesound.com[39].

Model	What
Fjord Fizz	Animated fish and bottle
Groblundak	Animated tram
Groblundak Refinery	Animated shark
Agi-Farm	Animated clouds and wind turbines

Table 3.2: Table over what aspects of the model are animated.

3.4.3 River Panels

The river model will appear on the floor after the user touches the *River button*. Also attached to the river model is an animated arrow model that follows the river as a guide for the user to do the same. The *Water control panel* is at the river's end. Here the user will be shown an intro screen to explain to them that they have the power to divide the water flow of Groblundak. These elements are shown in Figure 3.10a and Figure 3.10b. Here we also see the plant model that we used. The source file for the flower model is used from PolyToots project[19] and the model for the arrow is gotten from Vikashmurmoo's project[40].

(a)   (b)
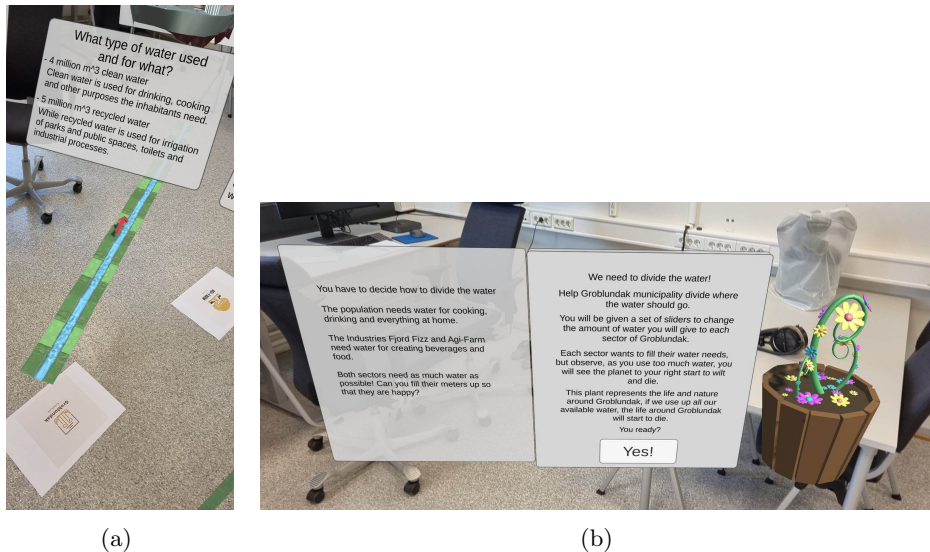
Figure 3.10: River model leading to river control panel start.

Once the user presses start, they will be shown the panel where they can decide to give water to the population or the industries. If they change these sliders, they will notice two things. The total available water slider will decrease and the plant will slowly wilt. They will not have the last slider available if they have yet to scan Groblundak Refinery. If they use too much water, the plant will die and they will be given a warning message that says they need to clean water and find the industry responsible for that. We can see the water control panel in Figure 3.11a, and in Figure 3.11b we can see that half of the water has been used and the plant is alive, but has lost all its flowers. In the last image, Figure 3.11c, we see that all the water has been used up and the error message has been shown to the user.

(a)
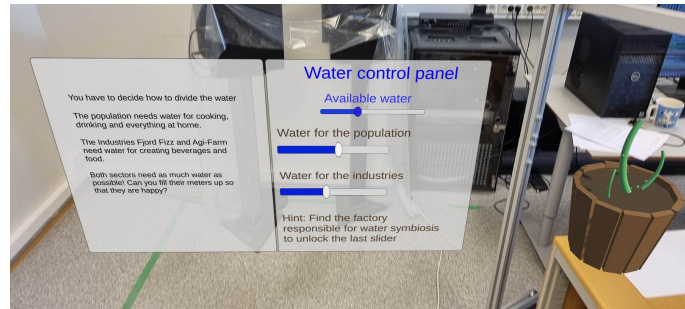
(b)
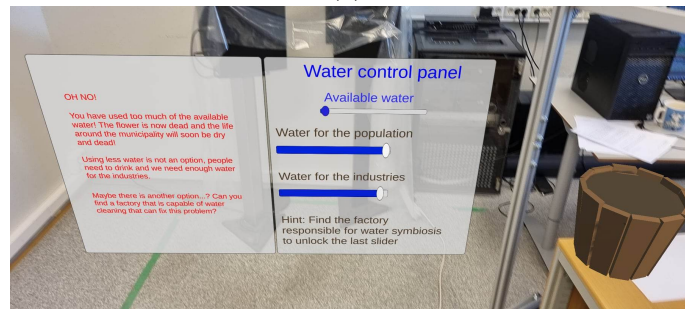
(c)

Figure 3.11: (a) Water control panel, (b) Used half of the available water, (c) Used all available water.

If the user has not found and scanned Groblundak Refinery, they will not have the last slider responsible for water cleaning available. When the user finds the refinery and returns to the water control panel, they will have the last slider available. As we see in Figure 3.12 they have maxed out the amount of water to clean, and we can see that the flower looks so much better than Figure 3.11b where the flower only has a stem.
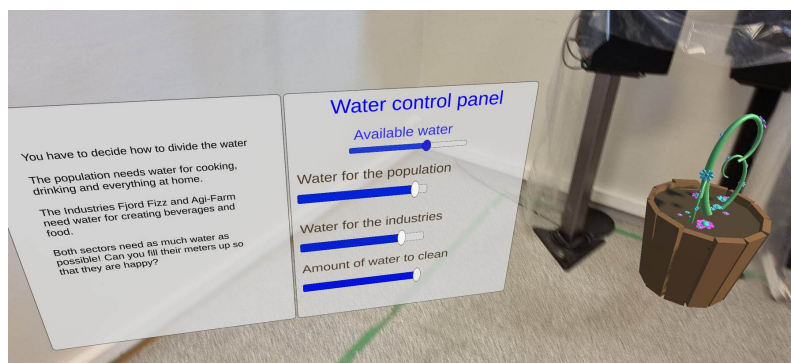
Figure 3.12: River panel with water cleaning slider available and maxed out.

The final version of the app is saved in a Google drive link which is attached in Section A.

3.5 User tests

After the app is completed, we can go through with the user tests. Our research questions are *How can AR be used to convey an immersive digital story about circular water symbiosis?*, and *Will the addition of animated 3D models and sounds to the AR experience change the enjoyment of the app?*. We want to conduct user tests to verify our second question.
For conducting user tests, we want to have two test groups, one group testing our app with sounds and animations added to the experience and one group not experiencing this. Since many factors can change the outcome of a subjective user test, we want to minimise all these factors. We will therefore, not include the Water control panel in the user tests. Consequently, the users will only experience the Image tracking and Information panels part of the experience, where one group of test subjects will have the animations and sounds of the 3D models turned off.

3.5.1 Questionnaire

The questions used in our questionnaire were adopted from the ENJOY questionnaire created by Shayn Davidson in the paper *A Multi-Dimensional Model of Enjoyment: Development and Validation of an Enjoyment Scale (Enjoy)*[37]. The ENJOY scale was created to evaluate the enjoyment of any activity. They created five dimensions of enjoyment; for this project, two were deemed relevant. These were pleasure and engagement and have both five questions connected to them. The paper *Measuring engagement in video game-based environments: Investigation of the User Engagement Scale*[41] investigated user engagement specifically for video game-based environments. From this paper, we created an additional five questions. We took inspiration from table 2[41] and found questions linked to Aesthetics and Focused Attention, that could be used for our models in our project, we call this sub-scale Enjoyment of Models. This gives us a total of fifteen questions that we set up in the format of a 7-point Likert scale. These questions were answered in a Google form after the users used our app. The questions are attached in Section D. It is explained in the ENJOY scale[37] that the ratings of each question (1-7) can be averaged to get a score for the dimension the questions are connected to. These sub-scale averages can also be summed to get an average of the total enjoyment of the experience.

3.5.2 Execution of tests

For the user test, thirty candidates (n=30) were tested. The tests were done between 01.05.23 - 05.05.23 in the Sense-IT room at NTNU. Fifteen candidates tested the app with sound and animations added to the models. The candidates did not know what difference there was between the app versions. The tests started with the users reading and signing the Introduction paper (Section C) and the consent form (Section B). After this, the users could freely experience the app, which lasted approximately 5-10 minutes. Finally, they answered the prepared questionnaire. The only difference between the questionnaires was the question *"The models were visually (and audibly) pleasing."*. The difference was that the candidates using the version without sound and animations did not have *"(and audibly)"* added. In Figure 3.13, we see an example of one of the user tests.
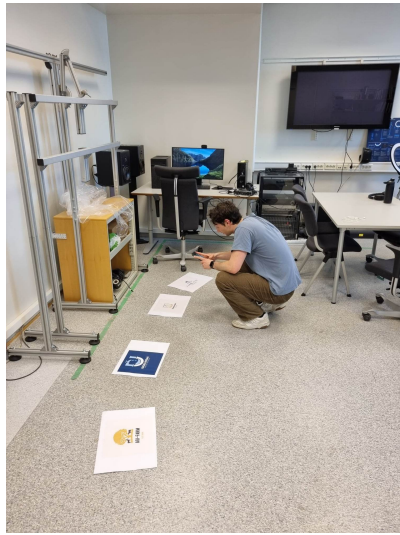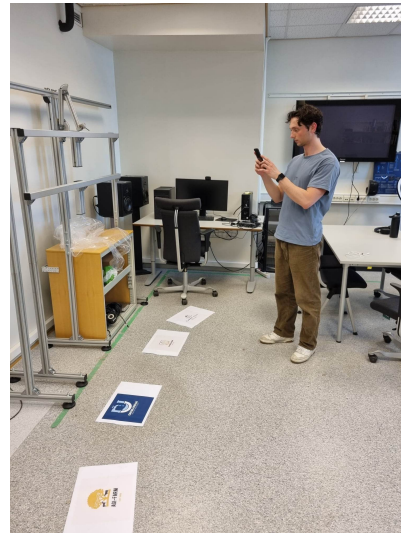
(a)   (b)

Figure 3.13: A participant experiencing the app.

Chapter 4

Results

In Figure 4.1a, we see the distribution of gender of the thirty participants and in Figure 4.1b we see their ages. All participants were engineering students at NTNU.

(a)

(b)
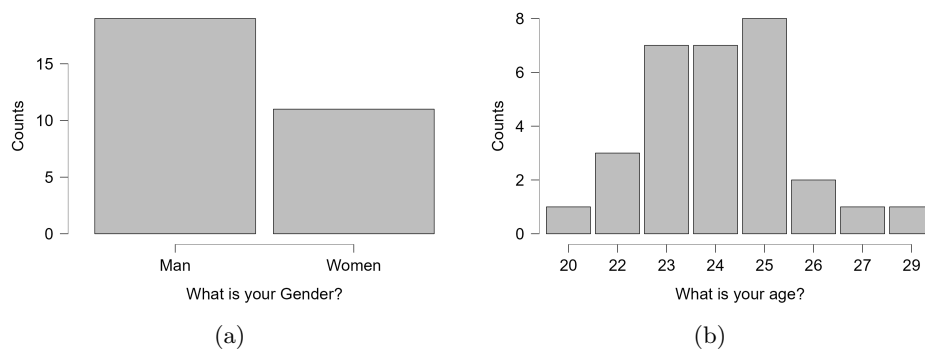
Figure 4.1: Distribution of Gender and Age.

As already mentioned, we have fifteen questions to map out the total enjoyment of the user and three sub-scales, engagement, pleasure and enjoyment of models. These fifteen questions were set up as a 7-point Likert scale and can be translated to a value between 1-7 depending on the answers. We can sum the answers together for each subscale for each participant and get an average score for the corresponding subscale. Starting with the sub-scale of engagement, we used JASP[42], an open-source statistical analysis program, to analyse the descriptives of the subscale. In Table 4.1, we can see the mean, Standard deviation (SD) and variation within the sub-scale for both test groups. The mean JASP calculates is the same as the average to determine the enjoyment score.

Table 4.1: Descriptives - Total Engagement.

Group	N	Mean	SD	SE	Coefficient of variation
No Sound/Animation	15	23.933	4.383	1.132	0.183
Sound/Animation	15	23.800	5.659	1.461	0.238
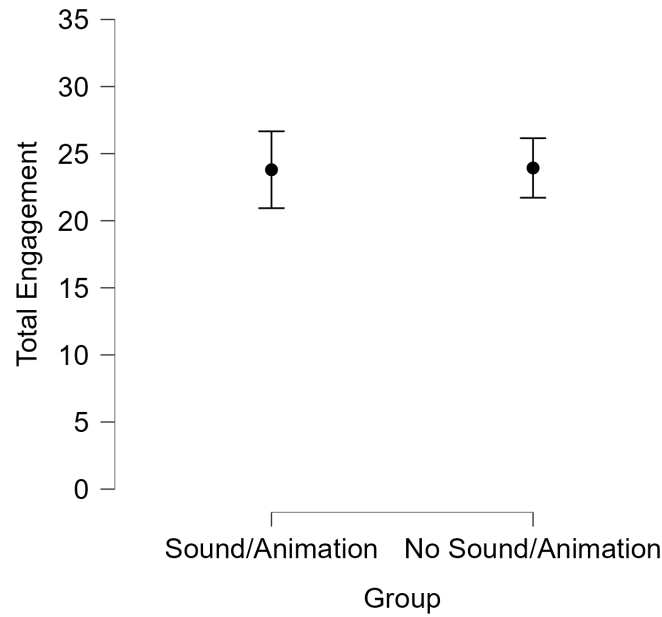
Figure 4.2: Interval plot of average Engagement within each group with a 95% confidence interval.

The average was also plotted with a 95% confidence interval in Figure 4.2. Using JASP, we also performed a one-way ANOVA test between the groups with sound and animations and those without sound and animation. The test is shown in Table 4.2 where we have a p-value of 0.943.

Table 4.2: ANOVA - Total Engagement.

Cases	Sum of Squares	df	Mean Square	F	p
Group	0.133	1	0.133	0.005	0.943
Residuals	717.333	28	25.619		

The next sub-scale is the enjoyment of the models. The mean, SD and variation are shown in Table 4.3. Figure 4.3 shows the average answer of the Enjoyment of Models plotted with a confidence interval of 95%.

Table 4.3: Descriptives - Total Enjoyment of Models.

Group	N	Mean	SD	SE	Coefficient of variation
No Sound/Animation	15	27.000	1.890	0.488	0.070
Sound/Animation	15	27.067	1.486	0.384	0.055
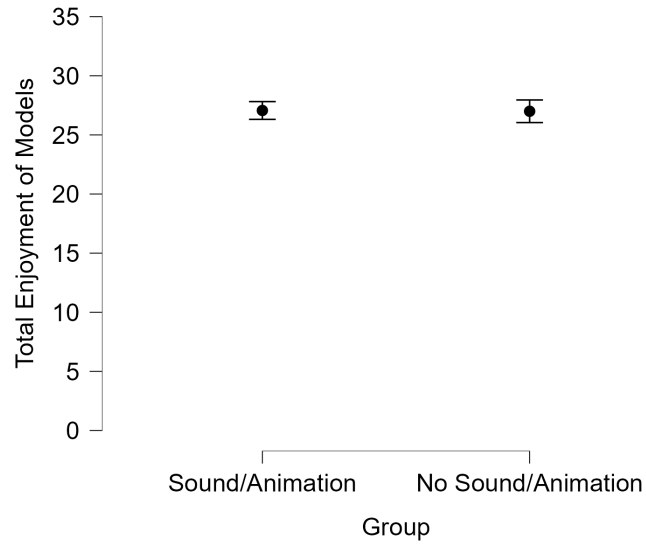
Figure 4.3: Interval plot of average Enjoyment of Models within each group with a 95% confidence interval.

Table 4.4 shows the ANOVA test done between the groups. Here we have a p-value of 0.915.

Table 4.4: ANOVA - Total Enjoyment of Models.

Cases	Sum of Squares	df	Mean Square	F	p
Group	0.033	1	0.033	0.012	0.915
Residuals	80.933	28	2.890		

The last sub-scale is pleasure. Table 4.5 shows the descriptive values within the two groups. The average answers are plotted against each other in Figure 4.4.

Table 4.5: Descriptives - Total Pleasure.

Group	N	Mean	SD	SE	Coefficient of variation
No Sound/Animation	15	27.867	3.701	0.956	0.133
Sound/Animation	15	28.667	3.331	0.860	0.116
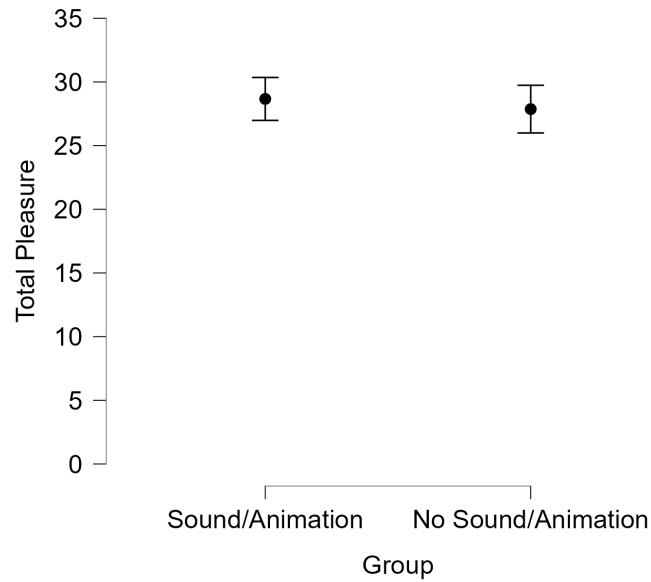
Figure 4.4: Interval plot of average Pleasure within each group with a 95% confidence interval.

Table 4.6 shows the ANOVA test with a p-value of 0.539.

Table 4.6: ANOVA - Total Pleasure.

Cases	Sum of Squares	df	Mean Square	F	p
Group	4.800	1	4.800	0.387	0.539
Residuals	347.067	28	12.395		

Lastly, we analyse all the summed answers and look at the descriptive statistics. The mean, SD and variations within the groups are shown in Table 4.7. The averages between the groups are plotted in Figure 4.5. We finish with a one-way ANOVA test between both groups and all the questions. The results are shown in Table 4.8 where we have a p-value of 0.775.

Table 4.7: Descriptives - Total Enjoyment.

Group	N	Mean	SD	SE	Coefficient of variation
No Sound/Animation	15	78.800	6.971	1.800	0.088
Sound/Animation	15	79.533	6.937	1.791	0.087
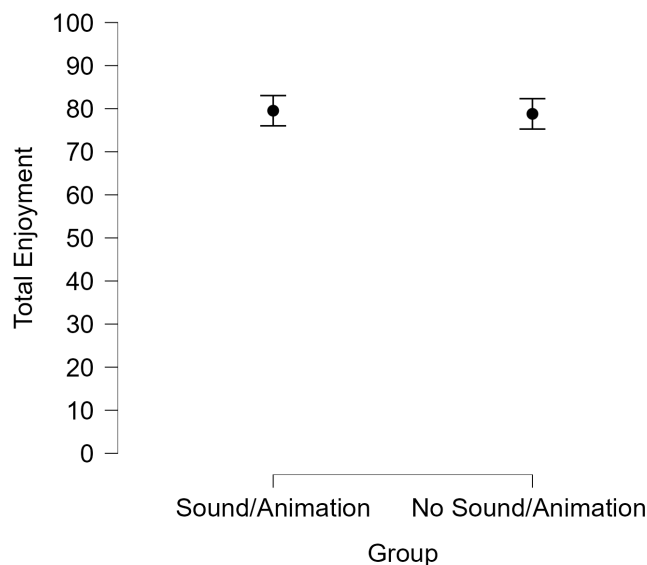
Figure 4.5: Interval plot of average Enjoyment within each group with a 95% confidence interval.

Table 4.8: ANOVA - Total Enjoyment.

Cases	Sum of Squares	df	Mean Square	F	p
Group	4.033	1	4.033	0.083	0.775
Residuals	1354.133	28	48.362		

Three of the questions were open-ended questions. They were *1. Have you tried AR (Augmented reality) before? And if so what types of apps, games or media did you use?*, *2. Where there any bugs or comments you have about the app which effected your experience and engagement in a negative way?* and *3. Do you have any comments about the app which effected your experience and engagement in a positive way?*. The answers to these questions are attached in Section D.1, Section D.2 and Section D.3. The question of 'previous AR experience' was also divided into three categories of experience. These three categories were tallied and presented in Table 4.9.

	No AR experience	VR experience	AR experience
Sounds/Animations	2	4	9
No Sound/Animations	0	3	12

Table 4.9: Previous AR experience.

4.1 Data analysis

Firstly, as the ENJOY paper explains, we can get an overall enjoyment score by summing all the sub-scale averages. As we saw in the results, we had an average of 79.533 for the group with sound and animation and 78.800 for those without, the top score is 105. This means there is a high enjoyment level for the participants, but very little difference between the two groups. For engagement, pleasure and enjoyment of models, the max score for the answers of the Likert test is 35 since we have 5 questions. We also had high scores for each scale and little difference between the groups. The averages are collected in Table 4.10 for more accessible examination. As we see, all answers are between 65% to 80% from the max amount of either 105 or 35.

Table 4.10: Descriptives - Averages for all groups.

Group	Sound/Animation	No Sound/Animation
Engagement	23.800	23.933
Enjoyment of Models	27.067	27.000
Pleasure	28.667	27.867
Total Enjoyment	79.533	78.800

Our ANOVA value for Total Enjoyment shows a p-value >0.05, meaning there is no statistical significance between our two groups. This can also be said for all three sub-scales, as the p-values are all larger than 0.05. We have gathered all the p-values in Table 4.11.

Table 4.11: All ANOVA tests.

Group	p-value
Engagement	0.943
Enjoyment of Models	0.915
Pleasure	0.539
Total Enjoyment	0.775

Overall the participants had experience with AR, as seen in Table 4.9, before this test, but as we see in Section D.1, most of this experience is through Snapchat and Pokemon Go. Looking through the negative comments that repeated the most, there were three common factors. These are the placement of where the information panels appeared, that there was no feedback on when the panels appeared and that there was no intuitive way or multiple ways of closing the panels. Going through the positive feedback in Section D.3, we tallied up how many times the models were referenced as being something positive. For the group with sound and animations attached to the models, we got 12/15 positive feedback on the models, while with the other group, this was only 8/15, a 26% difference.

Chapter 5

Discussion

Returning to our research questions in Section 2.5 we wanted to figure out two things. The first is how to create an IDN with a specific narrative, in our case, about water symbiosis. This can be done in multiple ways and we took inspiration from similar projects and created our narrative and AR experience. This we explained in chapter 3 Method. The IDN can be further expanded on by the Sense-IT team or the ULTIMATE project to add more content, as its current version satisfies the requirement for our thesis question, but is still limited in the amount of content it has. Additionally, changes that should be implemented should reflect the negative feedback. When the panels appear should be more intuitive, as well as how to close them. The panels' placement is another factor that should be examined to optimise the experience better. Nevertheless, we were successful in showcasing one method of creating an IDN AR experience.

For the second question, we required exploratory research through user tests. We wanted to know if adding sound and animations to our models would change the enjoyment level of the users. To uncover this, we created a 7-point Likert questionnaire and used JASP to analyse the results. Looking at the averages for the three sub-scales and the total enjoyment, we see that all scales are in the top 65% to 80% of the total score. This means there is an overall high enjoyment in both groups for the whole experience. Since the averages are so similar, we need to do a one-way ANOVA test to uncover if there is any significant difference between our groups. As mentioned, we got p-values larger than 0.05. This means that no significant evidence suggests that sound and animations made a difference. There can be multiple reasons for this.

Firstly, the number of participants can be increased to minimise the effect of high variance. We are conducting tests on minimal changes and would benefit from having more participants. Another possible reason for the outcome we had is that we see the prior experience within AR is limited. The most common experience is with Snapchat and Pokemon Go. This could mean that AR is still a very novel technology and any implementation with AR would give a high enjoyment outcome. Therefore if future tests would be conducted, it is recommended to consider the demographic that partakes in the tests and the possible benefit of having one round of tests conducted with an expert group. This group would consist of qualified people in the XR technologies and IDNs sector instead of the general population. This factor can be backed up by this study [43] that found that the immersion for a gameplay experience was more significant when the gamer lacked experience. Our demographic could have enjoyed the experience too much to be critical enough to understand slight differences that could have impacted the experience.

We used a combination of the ENJOY scale and another questionnaire focusing on video games. The ENJOY scale was created to be applied to any activity where one wants to gauge the enjoyment level. This creates a questionnaire which has comprehensive questions. We therefore paired these ten questions with five questions focusing more on the models. These broad questions seemed appropriate at the time because we wanted to investigate if the overall enjoyment of the experience increased with the slight differences we added. Despite that, the broad questions may have led the users to be less critical of minor differences since they were focused on overall enjoyment, which again was high.

Another possible reason for the lack of difference between the groups could be a lack of content. Since there was not much content, the participants did not need to use the full allotted time. Hence the enjoyment level of this novel technology was high for a short period. If there were more to do, more stimulation would be needed through a more extended experience.

Looking at the qualitative comments, we see that the models were mentioned 26% more for the group with animations and sounds, indicating that they were paid more attention to. Nevertheless, there is a need for more tests to know if they were paid more attention to due to the sound and animations.

5.1 Future work

This thesis was finished at the end of autumn 2023. In cooperation with the thesis, an app was created for the ULTIMATE project, and we took the opportunity to investigate our research questions on this app. The ULTIMATE project is far from over and there is still more implementation to be done with the app for the ULTIMATE project. The app was created by a student over the course of two semesters and will benefit significantly from using more professional designers and programmers to add more content to the app and have a coherent design aspect throughout the whole experience.

Since no significant difference was found in our tests, there is room for work here. Multiple aspects could be improved upon for new rounds of testing. A more extensive and diverse demographic will help to uncover if there are some significant differences between enjoyment in the two versions. Another possibility to explore is multiple rounds of tests with specific demographics, specifically an expert panel. This would build a more rigorous testing model, which could harbour different results.

The idea that the AR experience was too novel for our demographic and thusly led to high enjoyment in all participants, opens the possibility to research different aspects of the AR experience. We investigated the difference sound and animations played, in addition to having some interactions with image tracking and panels appearing in the 3D space in our experience. We could remove all interactions, simplifying the experience as much as possible, to see if sound and animations would then play a difference. If this investigation shows any significance, we could move forward with more components and add more interactions. We could then study if adding more interactions makes sound and animations obsolete in the grand scheme of an AR experience. We could also see if there would be different changes in different demographic groups.

There are many possibilities for AR to be implemented in education, health and many more sectors. Investigating which components of an AR experience change our enjoyment, engagement or attention on a fundamental level would benefit all sectors. This can lead to a fundamental understanding of what components you want to add to your specific experience for your goal. IDNs using AR experiences combine arts, technologies and storytelling and are very complicated to create, therefore understanding the fundamentals of enjoyment within this work could create building frameworks for future projects, which would benefit everyone greatly.

Chapter 6

Conclusion

This thesis showcases the implementation and build of an IDN AR experience. This specific IDN conveys a fictive narrative of water symbiosis that should represent a possible real-life scenario. This was done in cooperation with the ULTIMATE project case study 9, Kalundborg and the Sense-IT team at NTNU. The implementation of the AR app gave room to investigate two research questions. The use of confirmatory research and exploratory research was used to answer these questions. The confirmatory research exposed that it is possible to create an IDN AR experience about water symbiosis and shows the creation of one using Unity 3D. Unity 3D was used as this is an easy-to-use program with already curated functionalities to create AR experiences. Because of the high enjoyment level gathered among the participants, AR as a game or narrative environment was successfully used in the current study to evoke interactivity and enjoyment in an immersive digital story about circular water symbiosis. After the creation of the AR app, exploratory research was conducted to investigate the change in enjoyment with the use of sound and animations on our 3D models. This was done with user tests conducted on thirty (n=30) participants. These participants were divided into two groups, one of which would test the AR experience with sound and animations on our 3D models and the other, without the sound and animations. The participants did not know which version of the app they tested. Following the tests, the users would answer a curated questionnaire with fifteen questions in the form of a Likert scale, some demographic questions and three open-ended questions. The questions were adapted and put together from two different papers investigating enjoyment. The questions were then analysed. We looked at the descriptive and inferential statistics and found a high level of enjoyment among all participants. However, using a one-way ANOVA test, we did not find significant statistical differences between our two test groups. Based on this, we cannot conclude if using sound and animations has created a difference in user enjoyment.

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Appendix

A Symbiosis App

The following link contains the Unity project. The file is in a .7z format and must be unpacked when downloaded. The Unity version the project was last built on was Unity 2021.3.24f1 and the Unity scene to open is called BrukerTest Version.
https://drive.google.com/drive/folders/1B3mR3CIDx6H2E42r2WHRIeH6fPbGqS9q?usp=drive_link

B   Consent Form

NTNU
Norwegian University of
Science and Technology

Consent form

I have read the information for the study AR Masters project. I will participate in this study. I was informed that the following data will be obtained today during this study from me: A Questionnair with 17 questions and basic demographic questions. I approve that all recorded data will be saved and will be used pseudomized (e.g. identification data will stored separately from recorded data and only be accessible to a small circle of authorized personnel) for research analysis. All data I give will be handled confidentially. All information will be used for research purposes only. Personal data will not be given to any third party.

I am aware that participating in this study is voluntary and I can withdraw anytime without giving any reason. Doing so I will not suffer in any disadvantage.

Additionally, I am aware that I will handle everything confidentially, I hear and see today, and I will not give any information to other people.

Name: _____

Date: _____

Signature: _____

Experimenter: Jasper Haug Vandenhove
Tlf: +47 95180314
Email: jasperhv@stud.ntnu.no

C Introduction Text

Augmented reality with image tracking

Dear participant,

Thank you very much for your participation in this experiment. This study will last approx. 15min and will be possibly rewarded with a 200kr Rema 1000 giftcard.

During this experiment you will be trying an augmented reality app on a phone you will be given. Augmented reality is used to superimpose virtual objects into the real world. This will be done through the phone you will be given. For this project, there was created two versions of the app with minor changes to them. The participants will randomly try one of the versions. The participant will use the app for 5-10 minutes exploring the different features it has. After using the app the participant will answer a short questionnaire which will be used to gather information of your response to the app. The responses will be used to discuss if the changes of the two versions of the app had any significant impact on the participants reactions.

The experiment is divided into three main parts:

1) After signing the consent form, you will be given the phone and can freely use the app.
2) Use the app and scan the images you will see on the floor. The app is part of a larger project and therefore there will be parts which seem to not be finished. This does not matter as you will be questioned on only the things you will experience through the app. Focus on what you see and your reactions to them.
3) After using the app you will answer a questionnaire. This will start with some simple demographic questions, followed by 17 questions of your reaction to the app. It is important to answer truthfully and ask the experimenter if any of the questions seem vague.

Please note, **not you are getting tested**, but **you are testing the system**!

All the data that you provide and we are recording during this experiment will be pseudomized.

During the experiment you always have the chance to leave the study without the need to provide any reason. In case you have questions during the experiment at any point please feel free to ask the experimenter.

And now: Have fun during the experiment!

Experimenter: Jasper Haug Vandenhove
Tlf: +47 95180314
Email: jasperhvtud.ntnu.no

D Questionnaire

AR questionnair

This is a survey created to collect data from the users tests. Please answer truthfully.

* Indicates required question

1. What is your age? *

   _____

2. What is your Gender? *

   Mark only one oval.

   ⬭ Man

   ⬭ Women

   ⬭ Other

   ⬭ Wish to not specify

3. Have you tried AR (Augmented reality) before? And if so what types of apps,   *
   games or media did you use?

   _____
   _____
   _____
   _____
   _____

4. Your email (only used to inform winner of their prize)

   _____

   The next section is a likert-scale set up with a list of questions. Please answer
   truthfully with your experience of the app.

35

5. Instructions: Please rate the following statements on a scale from "Strongly Disagree" to *
"Strongly Agree".

Mark only one oval per row.

	Strongly Disagree	Disagree	Somewhat disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
I lost track of time during the activity.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
The experience was more enjoyable with the addition of the models.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
I lost track of what was going on outside of the activity.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
I liked the models used in the activity.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
The activity was fun.	⬭	⬭	⬭	⬭	⬭	⬭	⬭

The next section is a likert-scale set up with a list of questions. Please answer
truthfully with your experience of the app.

6. Instructions: Please rate the following statements on a scale from "Strongly Disagree" *
    to "Strongly Agree".

Mark only one oval per row.

	Strongly Disagree	Disagree	Somewhat disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
The models were visually (and audibly) pleasing.	◯	◯	◯	◯	◯	◯	◯
I forgot what was going on around me during the activity.	◯	◯	◯	◯	◯	◯	◯
The activity made me feel good.	◯	◯	◯	◯	◯	◯	◯
I lost track of what was going on around me during the activity.	◯	◯	◯	◯	◯	◯	◯
The activity made me feel happy	◯	◯	◯	◯	◯	◯	◯

The next section is a likert-scale set up with a list of questions. Please answer truthfully with your experience of the app.

7. Instructions: Please rate the following statements on a scale from "Strongly Disagree" to *
"Strongly Agree".

Mark only one oval per row.

	Strongly Disagree	Disagree	Somewhat disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
The activity was pleasurable to me..	◯	◯	◯	◯	◯	◯	◯
When I did the activity, I thought about nothing else.	◯	◯	◯	◯	◯	◯	◯
I did not pay attention to the models.	◯	◯	◯	◯	◯	◯	◯
I liked doing the activity.	◯	◯	◯	◯	◯	◯	◯
The models helped draw my attention to the activity.	◯	◯	◯	◯	◯	◯	◯

8. Where there any bugs or comments you have about the app which effected your experience and engagement in a negative way?

_____

_____

_____

_____

_____

9. Do you have any comments about the app which effected your experience and engagement in a positive way?

_____

_____

_____

_____

_____

Google Forms

D.1 Experience question

Yes, Pokemon Go
Yes, VR headset with a roller-coaster simulation
A little bit through Posten-appen for iphone and IKEA-appen for demonstrating size of packaging and decorations.
Yes, it was a minecraft game for phones. Think it was called minecraft earth.
Nei, men jeg har brukt VR-briller.
I've tried it through a phone application, but that was back when it was more of a gimmick than useful. There was an app that worked by scanning a milk cartoon, and some cows would appear on the table.
I have not tried I think
A little, with snapchat filters and pokemon go
Pokemon GO, Snapchat
Yes, in games on the phone like Pokemon go
Yes. IKEA placement of furniture in rooms
No
No, I have not. VR i have, an app made to treat psycological traumas such as scared of heights, social anxiety, etc.. Fornix is the name of the company.
Not AR. Only barely tried VR, through Playstation with games like beat saber.
I have tried those games where a small card was placed on the ground and through a camera you could generate a virtual image on top of it
I have never tried it before
Yes, a game called Inzivimals on the PSP in my late childhood/early teen years, Posten's AR visualisation of packages (if that counts), that's all I can remember.
Snapchat only.
I have tried the previous project done by Jasper in the fall of 2022.
Bedpress med visma hvor vi fikk prøve et AR headset
multiple apps but cant rameber, Pokemon Go.
No, I don't think so but I have tried VR.
I have not tried AR before, but VR. (Beat game in VR)
Yes, an app for a milk production company (Tine) to showcase cows around a carton. basically advertisement. Also at museums as a part of an exibition
Posten
Apple har en for sine produkter, slik at du kan se hvor de vil se ut rundt i rommet
Yes, I have played a lot of Pokemon Go. Othervise I am not that familiar to AR. I used mobile devices such as smart phones to play it.
Ja, jeg hadde briller som viste utsikten fra en veldig høy bygning og en planke som jeg måtte gå på uten å dette. Det var en ekte planke på bakken og en vifte for å late som at det var vind rundt meg, så det var veldig realistisk.
Some, but not any major ones. Used the one from ikea, and google's to visualise animals.
Pokemon go

Table D.1: Have you tried AR (Augmented reality) before? And if so what types of apps, games or media did you use?

D.2 Negative Question

The model disappeared sometimes
That the models didn't show up automatically maybe. It would also be fun to be able to walk completely close to the models
Posters dissappeared one time when reading and had to open them up again by scanning the sign. Did not fully understand when i got sound and when there were no sound when reading the posters, could maybe have more continous sound

I could not close the panels when standing behind them. The panels only moved in one directien which made zooming from the side a little weird and not useful. The panels should probably rotate towards the user as the user walks around in addition to move towards the user when the user zooms. Being able to move things around somehow could be useful. Like, moving the models towards yourself, or even the panels. Imagine that you are in a museum or something, and there is a bunch of people there. Then it would be nice to be able to move to the side with the models and panels.
Det var vanskeligere å åpne Groblundak panelet, og det var ikke like "smooth" overgang i lydnivå når man stod lengre unna og gikk nærmere slik det var med de andre panelene.
Sometimes the models would relocate while I was moving the phone/zooming. I also fell like a cross in the corner would be a more intuitive way of closing the models than clicking the symbol.
The exit button, but i was informed before so it was fine:)
Det var tre paneler og om man for eksempel skulle pinche inn for å zoome inn på den til høyre flyttet den på seg (fordi hele bildet ble større) slik at man måtte gå videre for å se nærmere på det panelet (panelet forsvant ut av skjermen). Føler det da er noe "unødvendig" med zoomingen og at man like gjerne kan bare gå nærmere, i og meg at man ender opp med det uansett. Hadde og vært fint om figuren kun kom opp når man hadde trykket på logoen. Er en grei måte å da se om panelene har kommet opp når man ser figuren
The logo had to cover a certain amount of the screen to register, which made me have to crouch to scan. A box showing where to place the logo could help, as well as being able to zoom
Everything seemed to work nicely. I wish it was possible to scale up the models to be bigger. Also, holding the phone up for reading made my arms a little bit tired after some time.
Sometimes the whole poster didn't fit in the window, which ment you had to move to read everything
The height of the models and info screens. I had to bend down quite a bit to closely examine and interact with the models. I am quite tall, but it was a minor discomfort on my part
No
Honestly, no
The pinch zoom felt a little inconsistent (while looking at the models) depending on your angle to the models, but not enough to require anything more than a very minor workaround of moving to the side to get better viewpoints. Could maybe have the models get bigger or smaller around a central point, rather than closer or further away from where you are standing, but again, fairly easy to work around.
No bugs in my case.
I begynnelsen var modellen rett over arket som fikk det til å se ut som en klump med rare greier, men når jeg flyttet meg bort så ga det mer mening. Retningen de arkene og modellen var i forhold til retningen jeg scannet med gjort at jeg måtte bevege meg mer rundt i rommet og fant de ikke med en gang
Did not experience bugs. Would be nice to be able to turn the models manually or somehow interact with them more. Opening and closing the panels could have been done by gestures instead of pressing a hard to find button. Gestures to pan and/or orbit the space would be nice, and the anchor point of the zoom feature could be positioned according to where the pinch originated, as opposed to a fixed centerpoint. However this of course depends on the environment the app should be used in.
The room was a bit difficult to manuver around, especially since the models always opened on one spot. Maybe the text could have had a bit nicer design, instead of using m^3 etc.
Jeg skjønte først ikke hvilken vei jeg skulle lese tekst boksene fra siden de ikke ble vist på en naturlig måte. Jeg mener da at når jeg skanner boksen med logoen mot meg hadde det vært bra dersom teksten var foran meg med en gang jeg løftet kameraet opp. Det kunne også vært en ide at jeg kunne gått ut av modellen på flere måter enn å måtte trykke på logoen. Siden jeg hadde fått vide det på forhånd ga det mening, men dersom jeg det ikke var kommunisert på forhånd tror jeg det hadde vært litt vanskeligere å forstå.

Difficult to see where the panels would show up, they didnt show up where i expected them to in relation to where the images were. Also didnt see the models at first since they were hidden behind the panels. could also be cool if the models fit more in line with the scale of the person so you could feel like you were in the scene. Since i didnt know where the panels were showing up, i didnt know if it worked when i pressed the picture. Also never understood how to close the panels fully, only how to make them smaller. could have some small instructions on the screen to better guide the user
The models appeared somewhat awkward when I was close to the wall (behind me)
Plasseringen av notatene som inneholdt fakta om de forskjellige bedriftene var litt rotete. De var plassert litt rotete, noen var til og med inn i noen av modellene, slik at man ikke kunne lese de.
The models and posters spawned at almost the same positions (at least the orientation of the posters) as when I encountered the first company: Fjord fizz. This was a bit disturbing, and made the "hunt" to get information harder. I would have prefered that the information popped up right above me. Also it would have been nice to have some additional indicators popping up showing me where to look to find the models. Also it would have been nice to have a larger device/screen as there was a lot of information to digest. Or maybe combine the technology with glasses. To wear glasses instead of holding up a mobile device would yield a less cumbersome experience. I also missed out finding the first models in the starting phase of using the application. Mabye this could have been refered to better. For instance one could have a "Check out the model of this city" Logo popping up underneath the posters.
Man må alltid se opp for å vite om det funket når man trykker på arkene på bakken. Det hadde vært bedre om arket lyste for eksempel grønt når man har trykket på det. Da slipper man å trykke flere ganger før man husker på at man må se opp for å vite om det funket. Teksten i de hvite boksene var ikke så spennene å se på fordi det var bare vanlig svart tekst på hvit bakgrunn.
Not any major ones. I feel like the image itself didn't match up quite right to reality when I moved quickly; that was a bit nauseating. Another thing I missed was the ability to rotate the model. I can see why it's not added though. As a final note; maybe make the signs more interesting. They felt a bit bland. -Didn't peak my interest that much, as with the models. Maybe use more colors, and perhaps make them more 3D, instead of just planes.
The island were floating inside of the wall, and I could just resize it to get it to move to the floor. Could be nice to move the whole thing without resizing, to put it where it is free space and still keep it big.
Is seemed like the objects were all appearing in one side of the room. For the first scenario, the objects appeard on the same side of the room of the paper, which made sense relative to where the paper was located on the floor. The paper for the last scenario was lying on the floor, turned towards the opposite side of the room. Then, that scenario appeared "behind" me. This was counter-intuitive and took me a while to figure out. Would be better if the model and the panels appeared relative to the orientation of the physical logo.
Would be nice when you open a model, that the previous one closes by itself, so that they dont go "on top of one another"

Table D.2: Where there any bugs or comments you have about the app which effected your experience and engagement in a negative way?

D.3 Positive Question

Sounds and animation was pleasing. Could immerse myself in the activity
I liked that you had to find the posters like in a proper museum, and that you could interact with them. I really liked the sound level adjusting to how close you were and I loved how you could interact with the models. it was very immersive. the models were very cute and interesting
Easily understandable. Smooth experience. Sounds helped to let you know if you managed to open up the current posters.
The models and the sounds were nice.
Jeg satte pris på detaljene i modellene, de var gøy å studere og se nærmere på.

I really liked the sounds, they helped make the experience more immersive. Also, the animations of the models were nice.
The sound was pleasing, and cool animation
Likte lydene, var lettere å konsentrere seg da og figurene var fine. Var da noe annet enn kun tekst
The quality of the augmented reality system was susprisingly good and help in the inmersion of the activity
I enjoyed the sounds and being able to go close-up in the city.
I liked the sounds from the models and the models. They made me understand more what the poster was about and they were fun to look at!
Very impressive to see how spatially locked the models were!
I liked that the models were placed behind the panels and it felt a bit like a "treat" for reading th information on the panels
The ability to move the mobile phone closer to the models to see billboard and smaller models was very nice. Makes it rather fun to use. The app felt very responsive, and I noticed there was a slight flash of light on the small models on the floor which acknowledged that it had been pressed, which helped interaction.
It was really fun and interesting to test out the functionality, which made me want to read about the different companies/places. The sound really helped with immersion, and the models were super fun and cute, which helped a lot for keeping interest.
The fact that the app worked without any QR codes when scanning the images amazed me.
Synes det var gøy å få tekst å bilder, i tillegg kunne jeg zoome inn som var morsomt. Føltes ekte ved at jeg kunne bevege meg rundt
Models looked good. Panels were easily readable. The app was very responsive. Image tracking were on point. Did not really see any glitches. Noticable latency, but not detrimental.
I liked that the texts were split in different boxes, for easier reading + it looked much cooler when I could move them around. I enjoyed that I could walk around the models and zoom in and out. The models were really cooool
Jeg elsket at det kommer små modeller opp når kameraet kommer over logene, det var utrolig kult med selve modellene. Det var veldig kult at du kan gå nærmere modellene og teksten for å se mere detaljer eller få større tekst.(men veldig bra at du kan zoome også). Fargene på teks boksen var også fine, og det var fint at de var litt gjennomsiktige, og jeg likte at logoen på selskapet var øverst på den første teksboxen. Det var estetisk pleasing at man trykket seg ut av modellen ved å trykke på logoen, til tross for tidligere komentar. Modellene forstyrret heller ikke fra tekst opplevelsen, men ga et positivt bidrag til opplevelsen. Det var en gøy opplevelse, som ga liv til ellers livløse logoer. Likte det veldig godt.
very cool models and well written and concise texts. Fun to walk around and experience new things without being told exactly what to expect!
I really liked the city model, and spent some time exploring it in detail. Very fun to play around with
Likte at du inkluderte fakta notater for de forskjellige bedriftene. Modellene for de ulike bedriftene var også interessante. De gjorde meg mer engasjert til å vite mer
I paid a lot more attention to the logos and companies as the experience og "hunting" the information was fun. I was positivly suprised by the resolution and accuracy of the models. I think that if I was to visit a company with the aim of getting insight, I would have prefered an AR application in comparison to an informatory poster. I also see this approach more adaptable to adding new recent information and getting spesific questions answered since I can possibly choose which information to be displayed.
Jeg likte de landskapene som dukket opp. Jeg synes at det var veldig gøy å trykke på knapper som ikke fins i den ekte verden.
I felt like the tracking was on point; that was cool!
The models were cool
It was fun with sounds and animations!
I thought it was a fun way of learning, would definitely enjoy this app! Loved how the models were moving, and that you could move around to find new information

Table D.3: Do you have any comments about the app which effected your experience and engagement in a positive way?