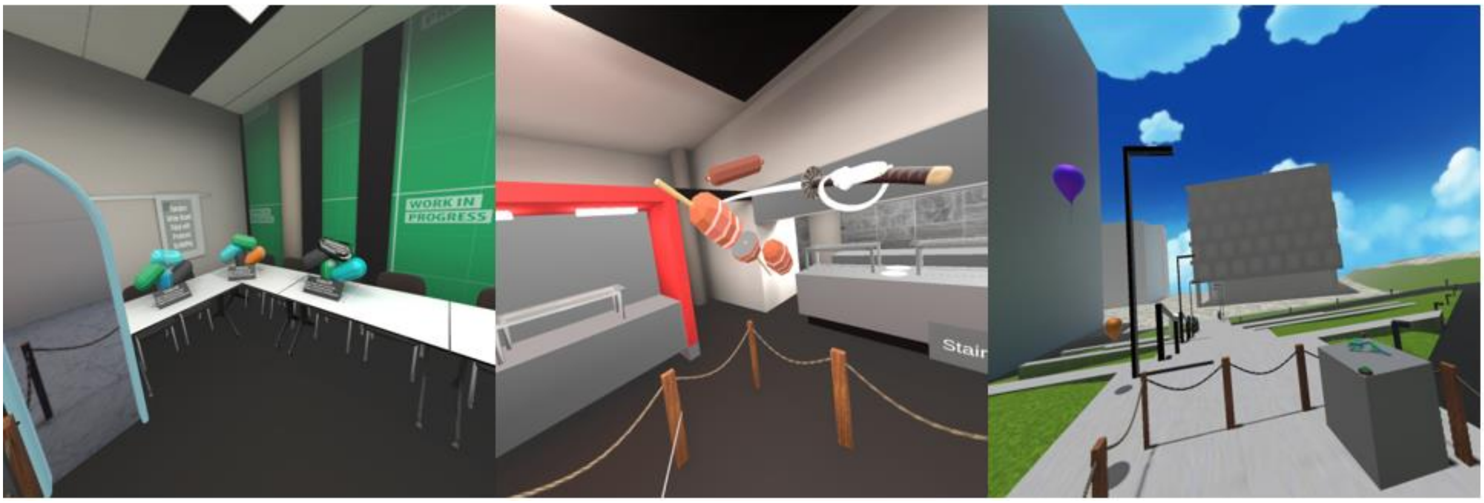
Promotional Interactive XR Experience at the FHNW Campus Brugg

An interactive virtual reality experience to promote technology study courses at the FHNW campus in Brugg



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Abstract

In this bachelor project, a prototype for an engaging and memorable VR experience was created. The goal of this experience was to leave an impression of the FHNW campus, arouse interest in the FHNW School of Engineering's study courses and therefore attract new students. To reach this goal, it was researched how high user engagement and memorability can be influenced, achieved, measured, and tested. Additionally, research was done into the impact of texture realism on user engagement and memorability in a VR experience. A user study, conducted to examine the influence of texture realism on user engagement and memorability suggested a correlation between high texture realism and high user engagement as well as high texture realism and improved memorability. The findings of this user study were used to develop the prototype of the experience. The final application features three locations of the FHNW campus in Brugg. It offers space to showcase projects of students and research institutes of the FHNW, allows to promote the food options, prices and diversity as well as leisure and sports activities offered by the FHNW. The player can freely explore the three locations in virtual reality using real-world walking within a three-by-three meters play area. User tests showed an improvement in user engagement during development and a high user engagement in the final stages of development of the application.

Gender-Neutral Language

In order to respect the linguistic equality of all genders, this thesis uses gender neutral language.

Table of Contents

List of Figures

List of Tables

1. Introduction

This chapter describes the achievements of this project as well as the three major research questions, teases the results of said research questions, describes the initial position and objective of this project and offers a short reading guide for this document.

1.1. Achievements

The goal of creating an engaging and memorable VR experience to leave an impression of the FHNW campus and arouse interest in the FHNW School of Engineering’s study courses has been achieved and the impact of realistic textures on user engagement and memorability was shown. The created application features three locations of the FHNW campus in Brugg, that were 3D modelled according to the real world. Within a three-by-three meters game space, the player can freely explore the three locations in virtual reality using real-walking movement, which allows a motion-sickness-free VR experience. The application is designed for VR newcomers and therefore easy and fast to learn. It offers space to showcase projects of students and research institutes of the FHNW, allows to promote the food options, prices and diversity as well as leisure and sports activities offered by the FHNW. With this application, prospective students can have an interesting and fun insight into life on the FHNW campus in Brugg, without needing to visit the campus during business hours. Furthermore, this application can be used as an attention grabber at events, which helps to further promote and advertise the FHNW.

In order to reach the goal of this project, the following three research questions were answered:

- How can a high user engagement be achieved, measured, and tested in an interactive XR experience? User engagement is influenced by a number of factors such as immersion, presence and coherence and can most easily be tested and measured using the generalized User Engagement Scale. As the third research question implies, realism is one part of these influencing factors.
- How can a high memorability of the experience be achieved, measured, and tested in an interactive XR experience? To create a highly memorable experience, the created memory needs to be saved into the long-term memory of the user. This can be achieved by strong emotions, new and valuable information and by grabbing attention during the whole experience. Testing and measuring memorability turns out to be quite difficult and not often done in VR experiences. Therefore, an own method was developed.
- How can realism such as high-resolution or photorealistic textures of 3d models impact user engagement and memorability in an interactive XR experience? Texture realism is one of many factors, that influence user engagement and memorability. In a conducted user study it was shown, that realistic textures benefit user engagement slightly and improve memorability visibly.

1.2. Initial Position and Objective

The goal of this project was to create an engaging and memorable XR experience for prospective students to leave an impression of the FHNW campus, arouse interest in the FHNW School of Engineering’s study courses and therefore attract new students.

The aim of this work is the development and implementation of a game concept for an interactive XR application that is attractive, engaging, and memorable for future students (teenagers, young adults) and stands out by a good user experience and high usability. The developed concept can be used as a marketing and promotion tool for events. In order to offer the aforementioned target group a vivid insight into the offers, the premises and the life at the campus, certain locations at the FHNW campus were 3d modelled and played a central role in the experience.

The main use-case is on events to promote the FHNW School of Engineering's study courses through an engaging and memorable experience. Prospective students will get to know the FHNW, its campus in Brugg-Windisch and see special places and projects within roughly five minutes of playtime.

1.3. Document Reading Guide

In the following chapter "2. Background", all the theoretical background of this thesis, as well as the three main research questions about user engagement, memorability and realism in VR, background about VR marketing, a short target group analysis and the major design decisions, are covered in detail. In chapter "3. Methodology", it is described how and with what methods this project was managed, how user tests were conducted, and how the three locations were chosen. For those interested in the development of the Test Research Scene as well as the final application, a detailed view will be granted in chapter "4. Development". In chapter "5. Usability and User Experience", it is described how the engagement and memorability user test in the Research Test Scene as well as the user tests of the VR Tour were set up and conducted. The results of these user tests can be found in the following section, chapter "6. Results User Tests". Chapter "7. Discussion" elaborates on the achievements and results of this bachelor project as well as possible future work. In the final section chapter "8. Conclusion", a more personal review of this project is granted. User study questionnaire templates and other additional material can be found in the "Appendix".

2. Background

In this section, all the theoretical background of this thesis as well as the three main research questions about user engagement, memorability and realism in VR, background about VR marketing, a short target group analysis as well as the major design decisions are covered in detail.

2.1. User Engagement

The idea of user engagement is taken into consideration by many different research fields, both scientific and commercial. However, the definition of user engagement varies, overlaps and is often ambiguous. For instance, the relationships between a variety of related terms, such as interest, sustained attention, immersion, and participation, are often unclear. (Peters et al., 2009) According to literature, engagement can be referred to in a number of different ways, such as a process, a stage in a process or the overall process, an experience, a cognitive state of mind, an empathic connection or a perceived or theorised indicator describing the overall state of an interaction (Peters et al., 2009). User engagement can also be defined as a quality of user experience characterized by the depth of the user's investment when interacting with a digital system (Heather O'Brien, 2016), which in return means that in order to create a high user engagement it is necessary to identify how to influence the depth of a user's investment.

To identify how the depth of a user's investment can be influenced in a virtual reality system, two concepts that seem to have a big impact are immersion and presence. While immersion refers to the objective level of sensory fidelity of a VR system and is easily measurable, presence refers to the user's subjective psychological response and is an individual and context-based user response, related to the feeling of "being there". (Bowman & McMahan, 2007) In literature, it is highly discussed how this psychological response can be measured and what factors influence it and many different approaches have been made to create accurate measuring techniques, for example, according to Jung & Lindeman, the metric "user preference" could better contain all the metrics influencing a user's overall evaluation, combining immersion, presence, engagement and realism of a VR experience. (Jung & Lindeman, 2021)

In this thesis, we decided to mainly focus on user engagement and therefore also mainly measure engagement using the widely used User Engagement Scale (UES) first published by O'Brien and Toms. (Heather L. O'Brien & Elaine G. Toms, 2009) The UES is a multidimensional scale that tests the focused attention, the perceived usability, the aesthetic appeal, the endurability, the novelty and the felt involvement of a user during the test. (O'Brien et al., 2018) As the UES is with 31 questions rather long for a questionnaire, we also use the shortened UES (UES-SF), which was published by O'Brien, Cairns and Hall to provide a more practical approach to measuring user engagement, with the needed time to fill out the questionnaire reduced from 15 minutes to five minutes. (O'Brien et al., 2018)

2.2. Memorability

With the goal to create a highly memorable experience, one must first understand what memorability means and how it can be affected. According to the Merriam-Webster Dictionary, memorability is the "quality or state of being easy to remember or worth remembering" (Merriam-Webster, 2023). But what factors make things memorable, or worth remembering? According to Dr Gemma Calvert, a world-renowned neuroscientist, the three most important factors that play a role in determining what people remember are the amount of attention being paid to the information, the novelty of the information and the nature and strength of the emotions that are evoked by the information (Gemma Calvert, 2015). The Oregon State University describes making a memory as a multi-step process, that includes taking interest in the information that should be learned, seeing value in that material, committing attention to it, and making connections between the newly learned information and what is already known (Oregon State University, 2023).

This creates a strong foundation for what is important to build in the final application and to which factors the application should appeal. The application has to be attention-grabbing, new or valuable to the user, awake emotions of any kind and create a connection to something the user already knows. All of these factors will try to help shift the experience from short-term memory, which only lasts for about 20 to 30 seconds or even less, to long-term memory, which can hold information for up to several years. As humans can only store four to seven chunks of information in short-term memory, and as the process of shifting memory into long-term usually includes repetition (Kendra Cherry, 2022), it is important to try and create already longer termed memories by having high emotions, or high levels of before mentioned factors to support a quick shift. Brain imaging studies done while subjects were making choices or selecting between various cues have revealed that the emotional centres of the brain light up first. This is particularly true if the decision has a reward or a penalty as a result. Memory works in a similar way. Although studies have shown that paying attention and elaborating (actively repeating the material) aid in the transfer of information into long-term memory, highly emotional events or images can occasionally skip short-term repetition strategies and go directly into long-term memory, from which they are easily retrieved. Emotions have such a significant effect on these so-called "flashbulb" memories, that they leave a long-lasting imprint in the brain's memory systems. (Gemma Calvert, 2015)

Apart from creating emotions, how can an attention-grabbing experience or information be created? One possible approach is to look at biological attention and understand, that based on evolution, a simple and strong way to create attention is by movement. Being able to detect the movement of a possible predator was a vital capability of humans, deciding between life and death, therefore this skill is hardwired and creates not only attention but also emotions. (Gemma Calvert, 2015) Attention can further be created by using high contrast stimuli, for example using black letters on a white ground or using contrasting colours in general. The human visual system is best at recognizing high contrasts because the contrast and contours of the different layers of information, e.g. text on paper, are stronger than those of low-contrast information. (Gemma Calvert, 2015)
Further, the human brain loves to solve visual puzzles, which means, that if a piece of information is novel, erroneous or simply ambiguous, the brain tries to resolve this information into something which is already known or tries to understand what information there is. This process also creates more attention, as the brain has to work more than just accepting this new information. (Gemma Calvert, 2015)

How can memorability be measured? In general, there are three memory storages, sensory memory, short-term memory and long-term memory. Sensory memory offers a storage duration of ¼ to ½ of a second and stores all sensory experiences, such as touch, sound, heat, etc. Short-term memory offers a storage duration of 0-18 seconds (varying durations depending on the research, but in general below 30 seconds) with a capacity of four to seven chunks of information as mentioned before. This information is usually lost through displacement or decay. Long-term memory offers unlimited storage and unlimited capacity but is harder to reach. (Saul Mcleod, 2023) To get the user to remember our application, we want to save the experience into long-term memory. In long term memory, it can be differentiated between declarative or explicit memory and non-declarative or implicit memory. Implicit memory contains all unconscious memories as well as certain abilities or skills. Explicit memory refers to consciously invokable information, which can further be differentiated into episodic and semantic memory. Episodic memory stores personal experiences whereas semantic memory stores information about facts. (Eduardo Camina Paniagua & Francisco Güell, 2017) In this project, it is, therefore, necessary to create and save a memory into the episodic memory for the general experience as well as into the semantic memory for information about the offers and benefits of the FHNW. Both episodic and semantic memories can be called conscious, therefore the simplest way to measure, if a memory has been created and saved, is by specifically recalling that memory. If the user had to learn a certain skill or memorize a certain pattern during the experience, the memory could be recalled by letting the user repeat the experience at a later time and measuring, if the skill or pattern improved or could be identified faster.

2.3. The Impact of Realism in VR

Realism in virtual reality can be described as the extent to which the virtual environment emulates the real world (Amy Alexander et al., 2005). There are a number of acceptations on how realism can be established and even more factors that play into it. According to Perroud et al. (2019), realism takes five possible acceptations:

- Realistic looking: An experience must have very detailed shaders and materials and the lighting must be optimized to create a realistic look.
- Realistic construction of the virtual environment: The virtual world must follow the same scientifically-proven models such as gravity or dynamics as the real world.
- Physiologic realism: Inputs received by the body are the same as those it would receive in a real situation, even if it seems completely strange to the observer.
- Psychological realism: What's implemented seems realistic to the user, even if it is not in the real world (e.g., walking speed, room orientation).
- Presence: The higher the feeling of immersion and presence, the more realistic the experience feels, even if it is not looking realistic. (Perroud et al., 2019)

Each of these acceptations are defined by a wide range of factors, such as audio, haptics, visual environment, interactions, camera settings, lights or physics. In general, theses realism factors can be divided into two main categories, content and system. Content relates to the content of the virtual experience, such as self-avatar, virtual agents, audio clues, texture or mesh quality, while system relates to the equipment capabilities to synthesize the virtual experience such as the type of haptic device, different audio setups or different illumination models such as raytracing. (Guilherme Gonçalves et al., 2022) If looking at the impact of realism on this top level, there is no doubt that high realism will create a better experience.

In this project, one of the research questions is, if realistic textures influence engagement and memorability. Texture realism, therefore, is only one factor within the acceptation, that realism in VR means a realistic-looking environment. When investigating the use of realistic, specifically photorealistic textures in VR, the next important part is the goal of the experience. In literature, most research shows a positive correlation between increased texture realism, but not always (Jung & Lindeman, 2021). If the goal is for example route learning in a virtual city, full realistic texturing of all buildings and streets will have the same effect as no textures at all,

as the user will have either too much or too few details about the environment. If realism is however only used for important landmarks, the process of learning the route is much easier, as detail is only where needed. (Lokka, 2020) In this case, the impact of realism in VR is great but has to be limited in order to get the optimal result.
In another case, a study conducted to show the role of visual detail during situated memory recall within a virtual reality environment, it was found, that despite major visual differences between the two environments, both groups with high and low visual details described a similar amount of information, which suggests that even a minimally detailed environment may be sufficient to provide appropriate context to users for effective memory recall in an elicitation setting (Joel Harman et al., 2020).

In summary, while high-texture realism can benefit the realistic look and the psychological realism, it may not always have a positive impact on realism, the goal of the experience or the experience itself.

In summary with the previous two sections "2.1 User Engagement" and "2.2 Memorability", realism still plays a major role in defining the quality of a VR experience. As shown in Figure 1, increased realism could improve the chances of achieving a stronger feeling of presence, partially if the given realism satisfied context, but not necessarily. In theory, realism can therefore also be used to create a strong coherence by providing high physical, functional and psychological realism. (Jung & Lindeman, 2021)

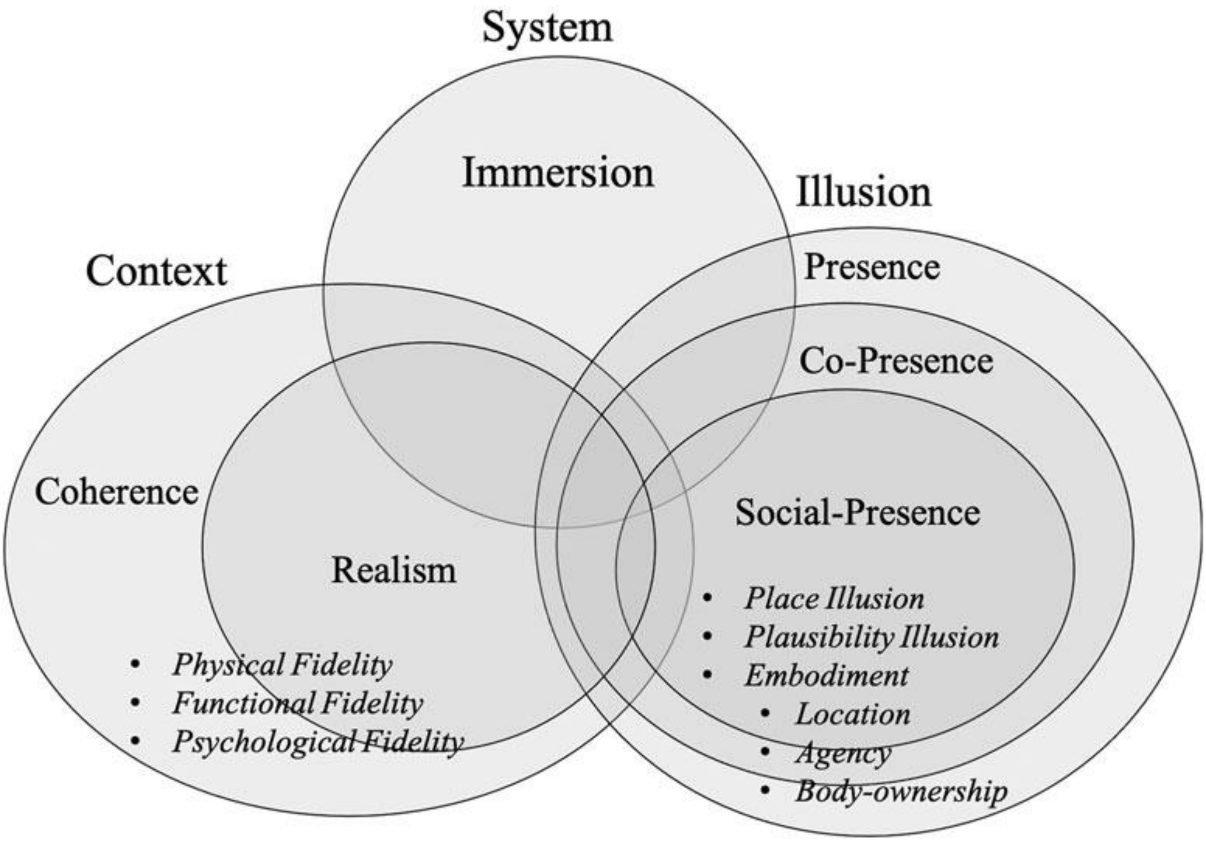

Figure 1: Venn diagram model defining the quality of a VR experience by (Jung & Lindeman, 2021)

2.4. VR Marketing State of the Art

Before taking a closer look into the current state of the art of VR marketing, it must be explained, what the term VR marketing means. As marketing can best be described as the entire process of bringing a product or service to market (Max, 2022), virtual reality marketing is a marketing strategy that incorporates VR technology in marketing campaigns (Geri Mileva, 2022). VR marketing allows brands to tell their story more uniquely and memorably, as VR is still a very new technology to most consumers. Further, VR experiences are often a more fun way of advertisement, as it usually contains some kind of task, movement, or interaction rather than 2D advertisements. A major benefit of VR marketing seems to be the extended possibilities the seller has. By creating branded digital worlds, the seller can showcase their product or service and offer digital experiences in lieu of physical ones. This allows the customer to virtually experience a product or service without the need to actually own the product or go to a place, where the product or service can be tested physically. (Geri Mileva, 2022) For example, if a company wants to market its high quality production line and wants to show that to possible customers, it can hardly invite the customers to the factory and show them the production line in person, but it can create a VR experience for the customers to walk through on their own.

There are multiple ways of VR marketing, from simple 360° images or videos over virtual tours using connected 360° images to fully branded VR minigames and experiences. While it is also possible to create photorealistic models by laser scanning the room or location that should be promoted, most of today’s marketing applications use 360° images or videos, as they are easier to create and can be displayed using a simple smartphone, or a cheap cardboard VR headset and not a complete VR headset. In the following part, some examples of state-of-the-art VR marketing will be discussed. (Omnia360, 2020)
One example is the Volvo Reality App, with which Volvo showcases the Volvo XC90 model. Themed around a weekend escape, Volvo Reality lets the user experience the interior of the car and a car ride through Vancouver. The experience uses a 360° video and Google Cardboard (Google, 2023). (Framestore VR Studio, 2023)
A second example which is widely used, as it is easy to implement and can also be displayed on non-VR devices, are 360° virtual tours. They can be implemented in different ways, once using static points of interest, where the user can click on to switch to the next 360° image, or in a Google Maps integration, where the user can freely move around on predefined lanes. These virtual tours can be used for basically all thinkable locations, from promoting a cruise line, an industry complex, a car house over a hotel complex, a restaurant, a fitness studio or different real estates. (360-Virtuell, 2023)
A third example, the IKEA Place App (IKEA Schweiz, 2023), uses mobile augmented reality (AR) to showcase furniture in the user’s own apartment. While AR shouldn’t necessarily be discussed in this section, it still takes a huge portion of extended reality (XR) marketing.

2.5. Current Marketing at the FHNW

As the FHNW includes nine different schools in seven different locations in four cantons of north-western Switzerland, this section focuses mainly on the marketing of the FHNW School of Engineering.

In general, the FHNW has a broad selection of marketing strategies. Apart from several social media platforms like Facebook, Instagram, and LinkedIn, where news gets shared and

promoted, the main place to find information about the FHNW is their website. It promotes study courses, features news, informs about events and locations and contains promotion videos and images of the FHNW as a whole as well as the schools and study courses themselves. One major strategy are information events and the presence on vocational training fairs or career fairs. At these events, the event personal of the FHNW can advertise and promote the study courses or the school itself and distribute branded gifts like bags or pens. On the study information events in Brugg, each stand features a pinboard with a branded poster and if possible an attention grabber, for example, an LED cube or an automatic RC race car.
In regard to the previous chapter, the FHNW features a virtual tour of the FHNW campus Brugg as well as images or videos of all locations. (FHNW, 2023)

The FHNW’s marketing is spread widely in regard of the target group, as for example, the branded train in Basel targets the broad public, but in general, the target group for the bachelor study courses are prospective students aged 18 to 25. A closer look into the current marketing strategies of the FHNW is not part of this project, as the target group and use case of the final application does not target the whole FHNW.

2.6. Navigation Patterns in VR

As the final application will feature three different locations for the user to explore, a navigation pattern must be implemented to move the player between locations. This section discusses different navigation patterns used in current VR applications. In this section, navigation patterns and locomotion techniques are used synonymously.

In virtual reality, all navigation patterns or locomotion techniques can be sorted by interaction type, VR motion type, VR interaction space and VR locomotion type. Based on this sorting as seen in Figure 2, four locomotion types can be identified:

- Motion-based: physical movement to enable interaction, while supporting continuous motion in open VR spaces, such as in walking-in-place, e.g. used by omnidirectional treadmills.
- Motion-based teleporting: physical movement to enable interaction with non-continuous movement, e.g. used in gesture-based teleportation, where instead of a controller, a certain gesture triggers the teleportation of the player.
- Room scale-based: physical movement to enable interaction, supporting continuous motion in open VR spaces, however, the VR environment’s size is limited by the real world’s environment size, e.g. used in real-walking.
- Controller-based: artificial movement induced by the controllers, while supporting continuous movement in an open VR space, e.g. used in head-directed movement.
- Controller-based teleporting: artificial movement induced by the controllers with non-continuous movement in an open VR space, e.g. used in point & teleport. (Boletsis & Chasanidou, 2022)

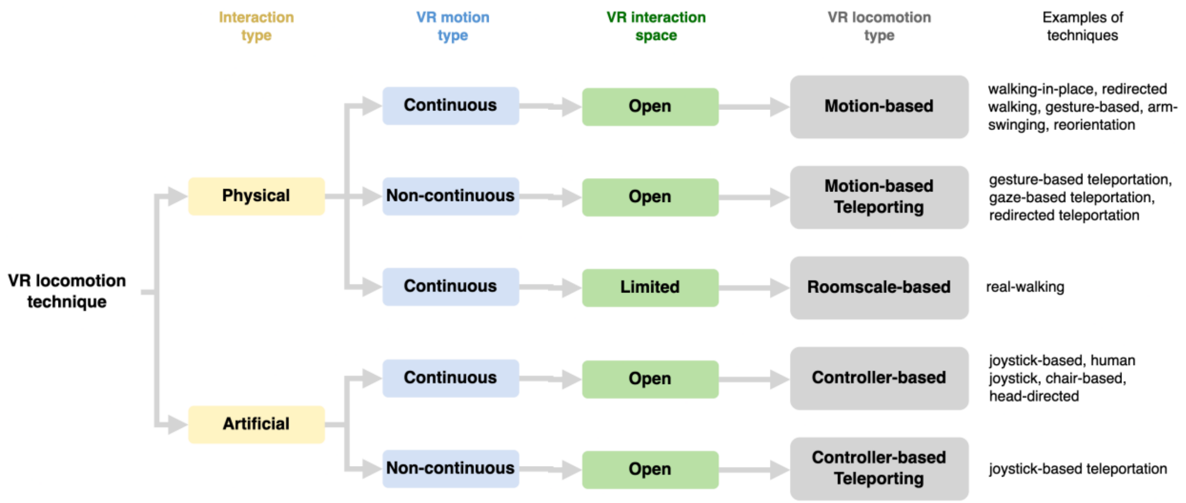

Figure 2: Typology of VR locomotion techniques by (Boletsis & Chasanidou, 2022)

2.7. Target Group

The target group of the final application are prospective students of age 18 to 25, currently absolving or with an already absolved vocational baccalaureate and technical interests or basic technical background.

Based on FHNW internal data on the target group collected by the communications and marketing department and based on personal experience of the development team, a good understanding of the target group was already given and was not further analysed.

2.8. Design Decisions

Throughout this project, major issues that required a decision that would affect the design and basic structure of this project and the final application were encountered. In this section, it is described why each major decision was made.

2.8.1. Standalone VR

It was decided to use a state-of-the-art standalone VR device rather than a PC VR device in order to fulfil the customer's needs of having a simple, mobile and easy-to-set-up solution for events and fairs.
Standalone VR headsets are VR glasses that work without being connected to a computer. This makes them very easy to use, however, the disadvantage is that there is usually fewer graphics power in the VR headset and the VR content is limited to the mobile VR glasses. PC VR glasses are - as the name suggests - connected to a computer. The advantage of PC VR glasses is that the graphics power of a computer instead of the graphics power in the glasses is used. This allows a smoother and far more visually appealing display of graphically demanding applications. Of course, PC VR glasses also have their disadvantages. For example, the headset must be wired to a computer all the time. While there are wireless options, in general, the player will feel a cable over their headset and will possibly have less immersion that way. The wireless option reduces this issue, however, they are usually more expensive. There is also the practical

aspect of the computer. Apart from the fact that the computer must be "VR-enabled", it also has to be near the place where the VR application is used. If that is a stationary place, this is usually not a problem, however, if you are on events and have to constantly change your location, this can be impractical. (Unbound XR, 2023)

As it was established in section “2.1. User Engagement”, user engagement can benefit from a high immersion. Looking at the standalone VR headset market in the low to mid-price segment, the two most fitting devices are the Meta Quest 2 and the PICO 4 VR headset. In this project, it was decided to use the PICO 4, as it is the newer headset, therefore has newer hardware and with a higher display resolution or a slightly bigger field of view, in theory, the Pico 4 should be able to provide a better immersion (Bowman & McMahan, 2007) than the Quest 2. With the newer hardware of the PICO 4, it should also be able to provide higher frames per second, which again is clearly related to a higher level of immersion (Selzer & Castro, 2022). For better visualisation and additional details, Table 1 shows the comparison of immersion metrics between the PICO 4 and Meta Quest 2 VR headset.

	PICO 4	Meta Quest 2
Price	CHF 425.-	CHF 419.-
Max. Image resolution	4320 x 2160 Pixels	1832 x 1920 Pixels
Field of view	105°	100°
Refresh rate	90 Hz	90 Hz

Table 1: Comparison of immersion metrics between PICO 4 and Meta Quest 2 VR headset

Sources for Table 1: (Digitec Galaxus AG, 2023), (PICO Global, 2023), (Meta, 2023)

A further benefit of the PICO 4 headset is, that it uses so-called Pancake Lenses. These lens types have less weight and provide a bigger sweet spot, the spot where the lens is the sharpest. This means that, unlike other lens types, the correct positioning of the headset on the user's head is not as important. (David Heaney, 2021)

2.8.2. Locomotion & Interaction

As discussed in section “2.1. User Engagement”, user engagement can benefit from high immersion. It was a requirement of this project, to create a highly engaging experience, therefore it was important to create a highly immersive locomotion and interaction system. VR locomotion is a technology that enables movement from one place to another within a virtual reality environment (Ivy Wigmore, 2018).

In VR applications, there are usually three different locomotion systems: real-world movement, joystick movement and teleportation. Based on literature and experience, the highest immersion is produced by real-world movements (Selzer & Castro, 2022), therefore it was decided to implement a real-world movement system. Using real-world movement, or real walking, the physical movement of the player in the real world directly corresponds to the movement of the player in the virtual world. This locomotion system is the easiest to learn for newcomers, it has a lower risk of creating motion sickness and it has an increased sense of presence, as all movement directly corresponds. (Aleatha Singleton, 2020) The biggest issue with real walking comes with the space required for the player. The virtual world and the real world have to correspond in its size. To create a reasonable game space, it was decided to limit the player's game space to three-by-three meters, which is enough space to move around in virtual reality and still feel free enough, but also a reasonable size for events and fairs. For this project, the limitation of three-by-three meters creates a further problem. As described in the next chapter, the player can visit multiple locations, while having to only move within the limited space. To keep high immersion and presence, it was decided to use a portal system rather than teleportation from one room to another, to enable the player to simply walk into the next room. The implementation of this portal system will be described in detail in section “Locomotion”.

For the interaction system, it was decided to maintain a high level of immersion by creating an interaction system that was as close to reality as possible, yet very simple and intuitive to use. The interaction system consists of a simple button press to grab and hold objects and a button release to let the grabbed object go, for example, to create a throw motion to experience object destruction.

2.8.3. Locations

In this chapter, it is described, which locations were chosen for this project and why. In chapter “3.3. Locations”, the methodology of how it was chosen is described and in chapter “4.2.2. Locations”, the implementation of these locations is described in detail.

It was decided to implement at least three different locations in order to represent the three main themes that are most important for our target group. These three main themes are “Study”, “Food” and “Leisure” and have been evaluated as described in section “5.1. Engagement and Memorability Test”. “Study” represents the learning environment at the FHNW campus in Brugg, “Food” represents the food options and “Leisure Time” represents the activities that are possible to do in a student’s free time or after school activities.
For the first theme, “Study”, it was decided to display a generic classroom of the FHNW, as it can display the normal learning environment, in which classes will take place and can promote the technical infrastructure and give users a general sense of the class sizes.
For the second theme, “Food”, it was decided to display the mensa, as it can display the wide range of cost-friendly, healthy, and diversified food options.
For the third theme, “Leisure”, it was decided to display the outdoors stair set between building 1 and 5 of the campus, as it not only shows the outside of the campus and therefore creates a better sense of connection to the real-world campus but also offers enough space to display different sports and free time activities that are possible at the FHNW.

Figure 3 shows a situation plan of the three locations, each red dot marks one location. On the situation plan, the red dots from top to bottom are Mensa, Classroom and Stairs. The pictures taken of the real locations on the right side of the compilation are Classroom, Mensa and Stars, from top to bottom and correspond with the player's room navigation in VR.

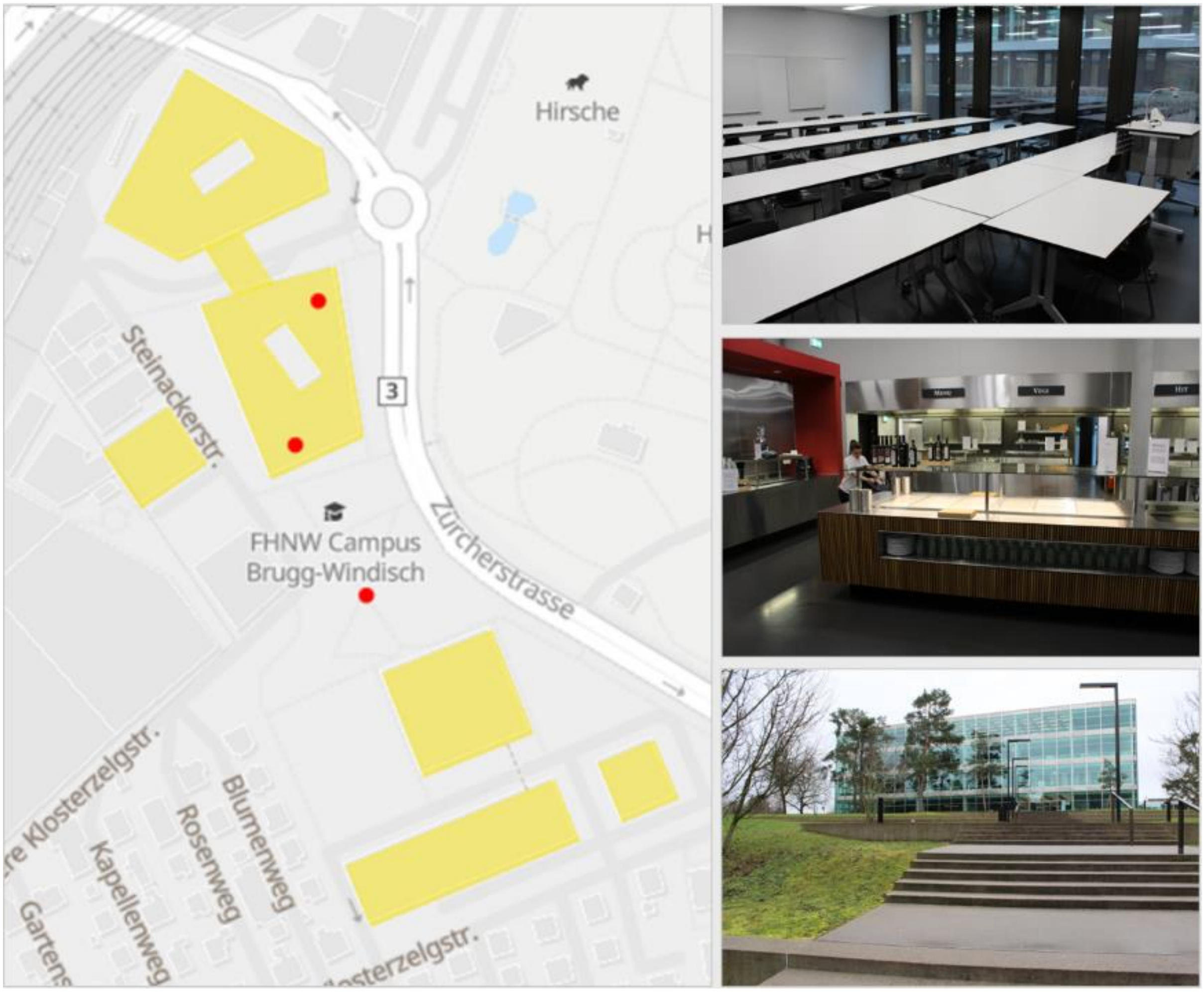

Figure 3: Compilation of the three locations (right) and a situation plan (left); Classroom (top), Mensa (middle), Stairs (bottom)

3. Methodology

In this chapter, it is described how and with what methods this project was managed, how user tests were conducted, and how the three locations were chosen.

3.1. Project Management

For this project, agile project management was used, as it allows for closer collaboration with the customer and faster response to changes. The main priority was to create a working prototype as fast as possible, which is best achieved by using agile software development. Further, it is the most comfortable and familiar management method for all involved parties.
The project was supported by a rough timetable, a planning that contains the most important work packages as well as milestones. For this project, milestones were mostly the main events, where the current version of the prototype can be tested with the target group in the later field of application. This helped to keep the project on track, keep focus on the main work packages and allowed fast rescheduling as changes like new requirements or delayed work packages appeared.
Additionally, a biweekly meeting was held to communicate the state of the project and obtain confirmation, validation and feedback from the customer and supervisors.
During the semester (project-time with lectures running parallel to the project), the developer team met at least once a week to communicate the progress and further steps to each other, outside of the semester, the team met at least once daily. This is to ensure the project stays on track and that the smaller iterations between the biweekly meetings are driven forward.
While agile project management was used for this project, it was not run in a strict framework like SCRUM, XP (extreme programming) or Kanban. As the developer team has prior experience in working together, the best working methods of all tested frameworks were extracted and used together.

3.2. User Tests

To conduct the user tests and gather validation and feedback, multiple methods were used. At the beginning of the project, mainly open dialogue was used, sometimes with guided questions to gather general feedback and broad validation of the first versions of the prototype. For the analysable user tests covered in section “5. Usability and User Experience”, all tests were conducted as a lab usability test, providing a controlled environment for the tester with a moderator at place all the time, usually followed by a questionnaire. As the tests usually were run at FHNW events, the end user’s environment and the target group could be met perfectly.
The usual test setup was to have the tester explore the application, guidance by the moderator was only given if needed, with an open dialogue during and mostly afterwards, followed by a digital questionnaire that the tester would fill out at site.
For these questionnaires, different methods were used. How and where which one was used will be described in detail in section “5. Usability and User Experience”. To generate general feedback about specific features or to validate the concept, a questionnaire with open answers was used, where the testers could describe how they experienced or perceived the application and its features. For testing user engagement, the User Engagement Scale was used, the long form for the research-based test environment, and the short form to gather feedback on the different prototype versions. The User Engagement Scale is a widely used tool to determine and compare user engagement in digital domains. (O’Brien et al., 2018)

3.2.1. Testing Memorability

To test user engagement, a generalized questionnaire could be used. In literature, no suitable, generalized method to test a user's memorability of a VR experience could be identified. Thus an own method was developed. As described in section "2.2. Memorability", a user should memorize not only a certain method, task, object, or functionality, but the experience as a total. While it is difficult to validate the existence of a whole memory, it was decided that it should be possible to validate, if a memory of the experience was created, by letting the user recall certain objects that were used both consciously and unconsciously during the experience. During the experience, the user was given a task that forces interaction with the virtual room and its game objects, minimal interaction to successfully absolve the given task is to interact with five game objects. While in the game room, the user is surrounded by many more game objects that can be interacted with, which is supported by the test session moderator by giving the tester time to explore the virtual room during and after finishing the given task. Using this approach, the tester builds a memory based on attention and emotions, created by interaction, and recalls this memory by checking all game objects that are remembered after a longer period of time. It was decided to wait for seven days to test the memorability, as by this time short-term memories should be long lost or overridden (Saul Mcleod, 2023) while the tester can still be contacted easily, as the test session itself should still be present.

3.3. Locations

In order to choose the three locations described in section "2.8.3. Locations", in a first step, interesting locations of the FHNW campus in Brugg were brainstormed by the developer team using input from the customer as well as current students and sorted by feasibility (estimated amount of modelling time to implement the suggested location). At the same time, it was discussed with the customer (communication and marketing background at the FHNW) and validated with students, what the most important themes or topics are while studying. The locations were then additionally grouped by the three main themes, "Study", "Food", and "Leisure", which allowed to identify the easiest to implement and to select only one location per group.

In the following table Table 2, all locations are listed, ordered by feasibility (1 – high feasibility, low time to implement; 5 – low feasibility, high time to implement) and grouped by theme.

Location	Feasibility	Theme
Classroom	1	Study
Open Working Spaces	1	Study
Media-Lab	2	Study
Library	3	Study
Maker Studio	3	Study
PC-Workshop Lab	5	Study
Engineering workshop	5	Study
Stairs 5-1	1	Leisure
Art Installation (eg. Clock)	2	Leisure
Rooftop Building 5/6	4	Leisure
Sportshall	4	Leisure
Mensa/Canteen	2	Food
Coffee corner	2	Food

Table 2: Interesting locations on the FHNW campus Brugg sorted by feasibility and grouped by themes

This method not only allowed to choose the three best-fitting locations but also shows which locations would be most preferable to be implemented in future extensive work.

4. Development

For the development of both applications, Research Test Scene and VR Tour, the Unity engine was used. Unity provides a 3D environment for scene and asset management, scripting, lighting calculation and more. Since Unity does not support modelling objects, most 3D models were created in Blender, an open-source 3D modelling application. Both the Research Test Scene and VR Tour were developed for the PICO 4 VR headset.
As many concepts and actions in a 3D environment, especially with VR, are hard to visualize in images alone, a walkthrough of the tour can be found here:
https://tube.switch.ch/videos/ILRhh7DQDP.

4.1. Development of the Research Test Scene

Since the Research Test Scene was necessary for the user tests at the beginning of the project, it needed to be developed quickly. Thus, primarily models under the public domain license (Creative Commons, 2023) were used to create a virtual, three by three meters room which contains many different mundane objects. All the objects in the scene can be grabbed, moved and thrown around, following the physics simulation.

To familiarise users with the room, five objects were placed on the floor for users to put away. Each object has a designated spot on the shelves. To help drop off these objects, zones have been created where the objects are snapped to a reasonable position and rotation if let go. This also functions as confirmation to the user that they placed the object in the correct spot. As can be seen in Figure 4 below, both the starting position of the objects and the designated spots on the shelves are marked with numbers.

Two scenes with identical content but two levels of detail were implemented. One scene features realistic textures and shading for all objects, as well as detailed shadows. In the other scene, textures were replaced with a single colour or a texture with drastically reduced colour variety. To complement this change and keep a consistent style within the scene, toon shading (Dmitry Chalovskiy, 2020), as well as low-resolution shadow casting was used. Toon shading, also known as cel shading is a rendering method that achieves a cartoon-style look with dark outlines. Figure 4 shows the visual effects of both versions.

Figure 4: Screenshot of the scene in both the simple, cel-shaded and the fully textured version

To switch between the two scenes, the XR Simple Interactable component of the XR Interaction Toolkit was used to allow a cube in the scene to be activated by moving the controller within its boundaries and pulling the grip button. This triggers a script that then changes the scene. This cube has been hidden behind a wall to prevent users from triggering the effect themselves.

4.2. Development of the VR Tour Prototype

For the prototype of the VR Tour, most models needed to be created from scratch as there are no available models of the locations on campus. This was done in Blender (Blender, 2023), with the exception of a few models that were created in Fusion 360 (Autodesk Inc., 2023).
To facilitate portals and destructible objects, plugins form the Unity Asset Store were used. These will be discussed further in “4.2.4 Plugins”.

4.2.1. Concept

The basic concept is a tour that visits important locations of the FHNW Campus in Brugg. The decisions of locations are discussed in detail in chapter “2.8.3 Locations”. Each of the rooms consists of a three-by-three meters space that is bounded by a fence and contains one or two portals leading to a different location.
Each location and its activities showcase a different aspect of FHNW. Figure 5 gives an overview of the three sites. The portal connections are shown as arrows.

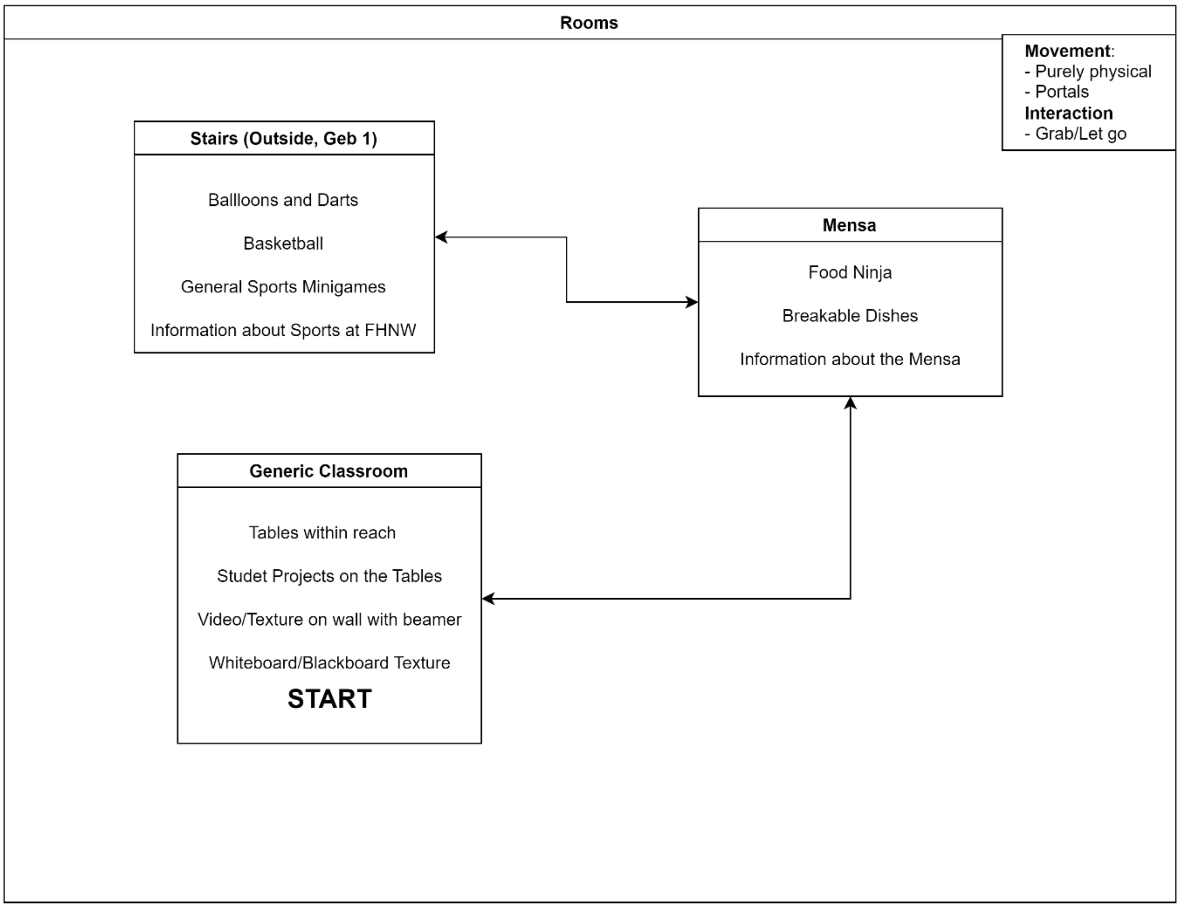

Figure 5: Overview of locations with their content and connected activities

Locomotion

To reduce the risk of motion sickness and minimise the learning curve for users, locomotion is purely physical. As this is identical to real-world movement, it creates little sensory dissonance (Aleatha Singleton, 2020). Using walk-through portals allows for the creation of impossible spaces and the traversal of different virtual areas while staying withing the same physical space. Portals in this case means a door that can be seen and stepped through. This can be seen in the video linked in chapter 4, and seen in Figure 6.

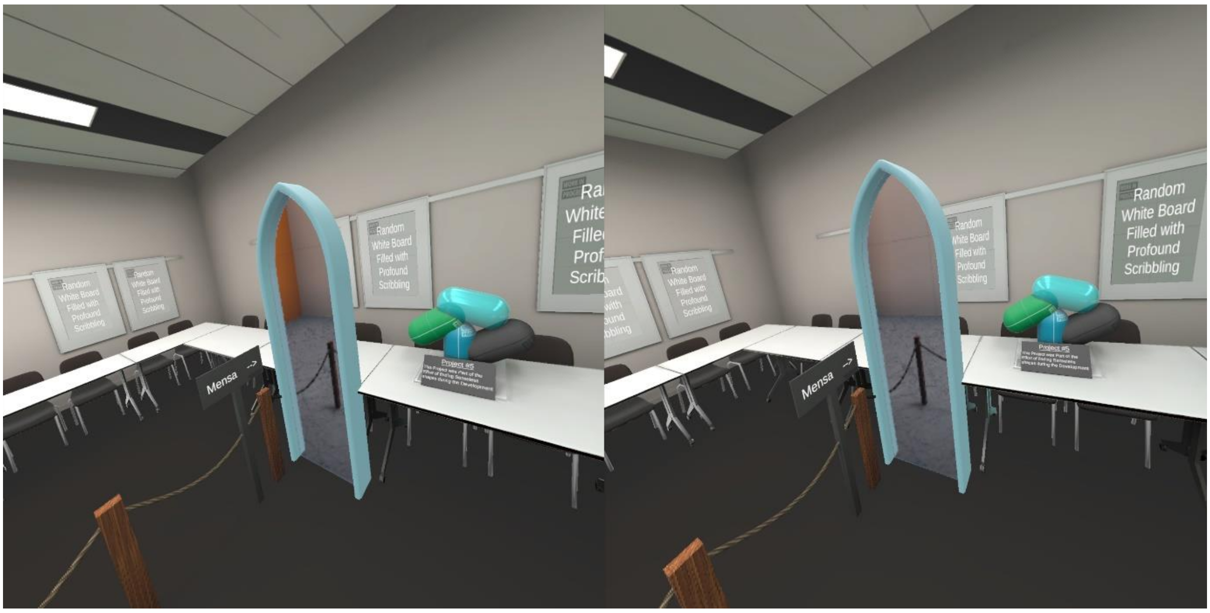

Figure 6: A portal from two angles

Different versions of portal placement were developed and tested.
Version 1 connects the rooms directly, version 2a connects the rooms with an intermediary connector corner. Version 2b connects the rooms with an intermediary hallway. This is visualized in Figure 7 below.

With version 1 portals, there is no need for the user to walk a lot and the user can directly see which area they are moving to, reducing the need for artificial user guidance. Besides these advantages, there are significant downsides as well. One of these is the performance loss with this version. Every portal in view adds the performance cost of rendering everything on the other side of it as if the user was there. This means that directly connecting portals approximately doubles the rendering cost. Another downside is that some portals face the play boundary and as such are hard to see when standing in the middle of the room. The portals in the centre room also take up a lot of space, making about half the area unusable for other purposes.

Version 2a alleviates the issues of space consumption by moving the portals to one corner of the room. It also reduces the timeframe the other room is visible through the portals, thus reducing the time when the performance is impacted. The connector is a corner and does not allow for good use of that space for any other purpose than traversal.

Version 2b has the same position of portals in the rooms as version 2a, but instead of a corner, the user has to pass through a hallway. Since the portals are not within each other's view, the user cannot see two rooms at once. This reduces the impact on performance to an acceptable amount. Another advantage is that the hallway can be used to show simple and static content, similar to an art gallery.

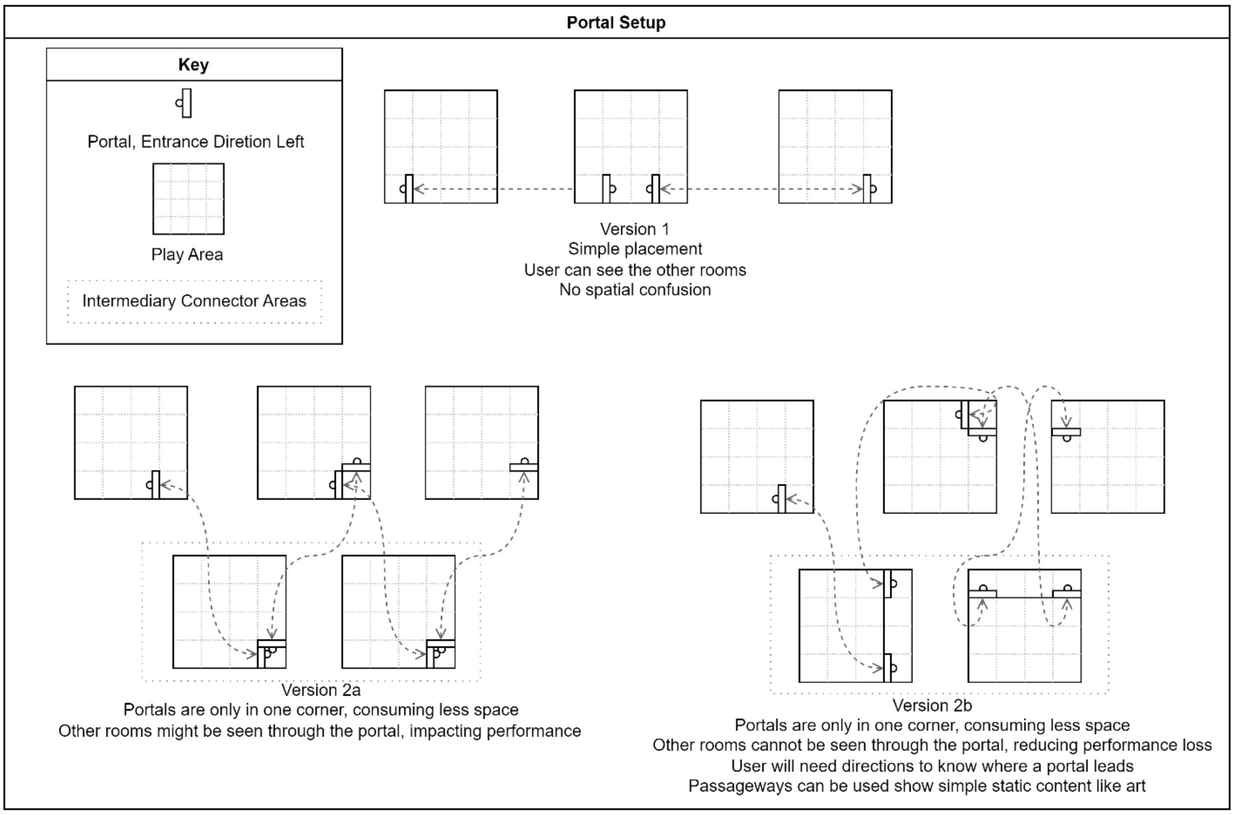

Figure 7: Versions of portal connection and placement

Interaction

Interactions are kept minimalistic for the sake of ease of access. To this end, either the grip or trigger buttons can be used to grab and hold objects. Once they let go, the object is dropped or thrown, depending on the movement of the controller while letting go.
All other interactions are achieved by using real-world logic. For example, there are virtual buttons to reset certain game features that can be interacted with by pushing them down using the virtual controller. This and other physics-based interactions are described in "4.2.5 Features".

4.2.2. Locations

Three locations were implemented in the prototype. All three locations were modelled in Blender (Blender, 2023). For each location, around 40 pictures were taken as a reference and modelling guide. For the classroom as well as the mensa, the floorplan of the FHNW campus was used for further reference. All locations were then modelled in separate Blender files.

Classroom

A generic classroom, representing studying at the FHNW.
The current iteration contains placeholders for textures on whiteboards, blackboards and the beamer. The play area is positioned in a manner that allows for some tables to be reached. On these tables, placeholder models for the presentation of student projects are placed. For example, there could be an animated robotic arm that is sorting cubes by colour.

Figure 8 shows the rendered classroom in Blender, Figure 9 shows the implemented location in Unity.

Figure 8: Classroom modelled and rendered in Blender

Figure 9: Classroom implemented in the final application

Mensa

The canteen, commonly referred to as the mensa.
The mensa is a less stern place than the classroom. To reinforce this, it contains a minigame that is food themed. More about the minigame can be found in chapter “4.2.5 Features”.
Despite the playful interaction, the mensa area is meant to provide useful information on pricing, diversity and quality of food provided. An additional feature that was added on behalf of user feedback are breakable bowls and dished.

Figure 10 shows the rendered classroom in Blender, Figure 11 shows the implemented location in Unity.

Figure 10: Mensa modelled and rendered in Blender

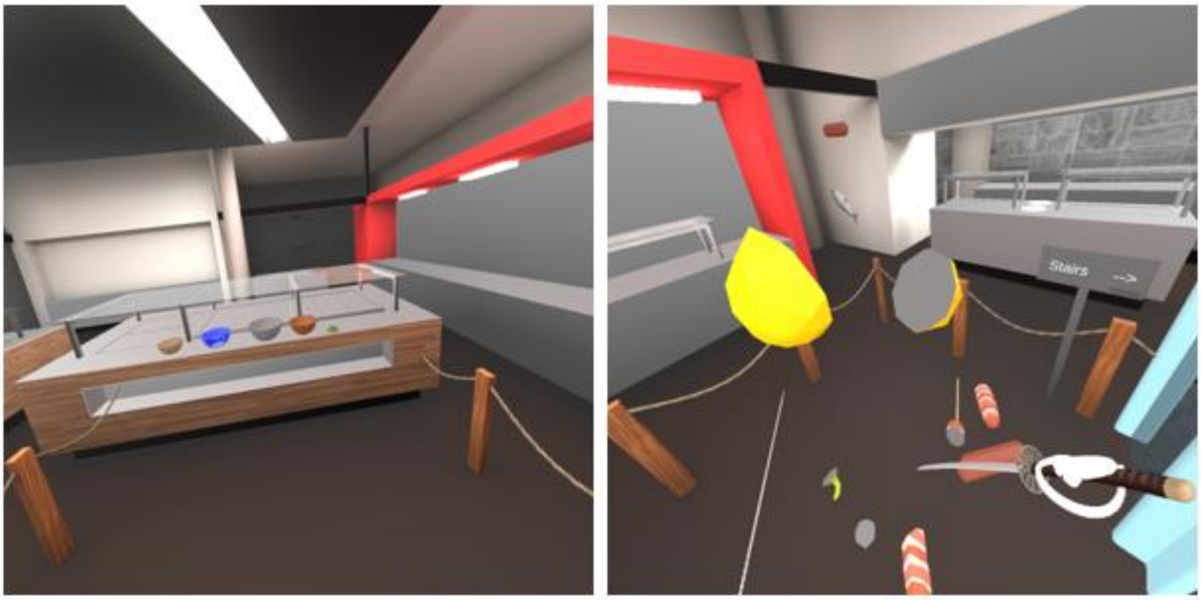

Figure 11: Mensa and Food Ninja implemented in the final application

Stairs

The stairs leading from building 5 up, to building 1 on the campus.
This location represents the leisure and sport activities students at FHNW can use.
To represent this in the application, there are dart arrows and balloons that can be popped, which will be explored in “4.2.5 Features”. More leisure and fun activities need to be implemented, and the general area needs to be populated, to achieve a satisfactory level of liveliness.
In the future, this location should also inform the user of the available sports activities.
A difficulty of this location is the size of the area. Modelling would take a long time and a lot of expertise, both of which were not available during the development of the prototype.

Figure 12 shows the rendered classroom in Blender, Figure 13 shows the implemented location in Unity.

Figure 12: Stairs modelled and rendered in Blender

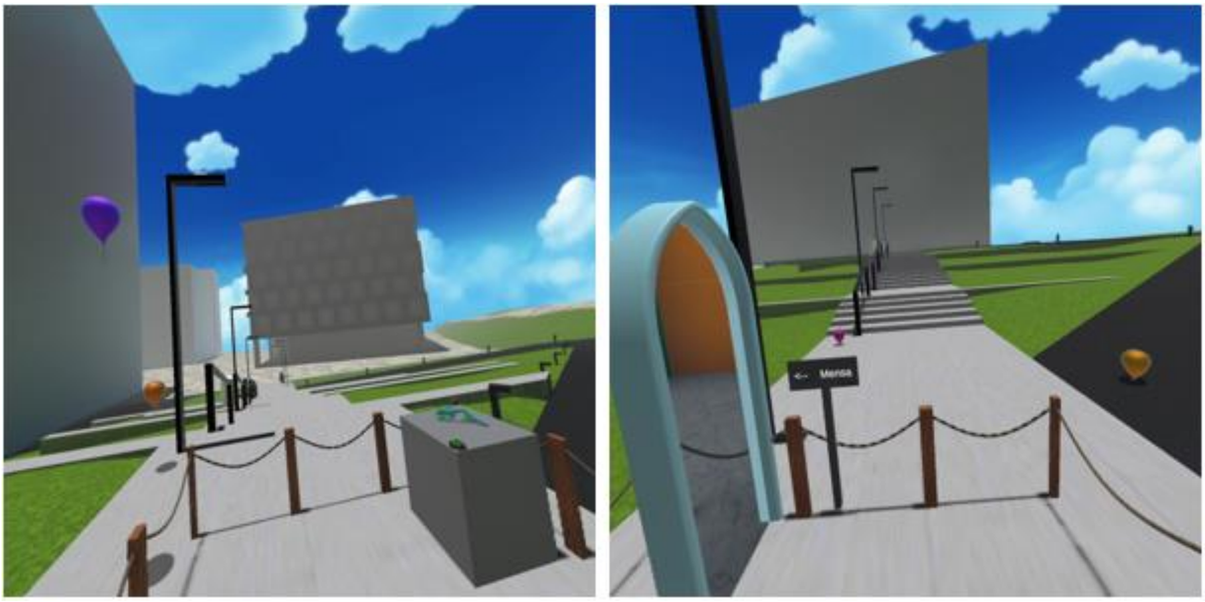

Figure 13: Stairs implemented in the final application

4.2.3. Architecture

This part goes more into the programmatical structure and architecture of the application. During the development of the app, two major principles were used: Singleton Game Managers and Self-Contained Scripts, which will be discussed after a brief introduction to the Unity engine.

Unity engine

Unity uses an object-oriented approach. This means that the virtual world consists of objects, called game objects which contain components. Game objects have a parent and can have a child. This creates a hierarchical structure in the shape of a tree. Developers can add their own components, which are called scripts. A script is written in C#.

This means that developers can add game objects to the scene, arrange and organize them. They can then add components to any game object, thereby adding functionality, logic and data to the game object. Scripts are developer-made components that allow for programmatical control.

Singleton Game Managers

A singleton is a class that exists exactly once in a whole application, allowing for safe exposure of the instance as a static variable. This allows other classes to access this instance from anywhere within the code, as visualized in Figure 14.
Singleton Game Managers uses this to create a single point of access to all managers in the application. The singleton is called GM, short for Game Master, it’s instance “I”. The GM holds references to all managers. Managers provide services like the playing of a sound or the activation of other objects. This structure allows for quick, persistent, and uncomplicated access to managers, without the need for manual referencing.

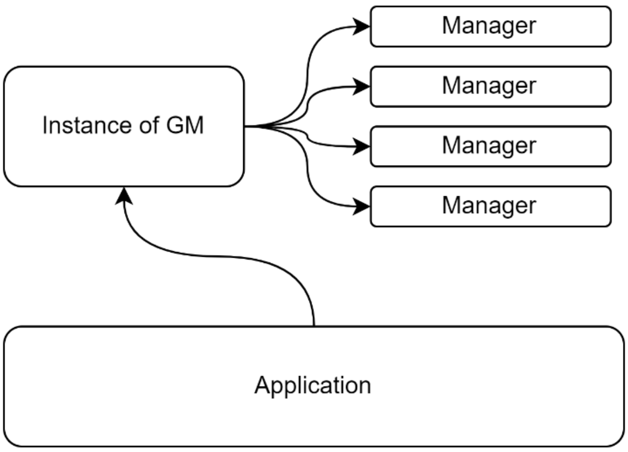

Figure 14: The Singleton Game Managers architecture

The application contains the following managers:

- Tag
    - A custom tag system that allows for applying multiple tags on a single object
- Debug
    - A system to switch debug functionality on and off
- Audio
    - A system with a pool of spatial and a single non-spatial audio source
- Minigame
    - A system for various minigame-related tasks
- BadMesh
    - A system that catches and handles an exception from the Rayfire plugin

Self-Contained Scripts

This describes the principle of writing scripts that do not need any outside references, reducing interconnectivity within the app. Leading to better extensibility and refactorability, as changes in one script or objects of the scene does not influence the functionality of Self-Contained Scripts.

4.2.4. Plugins

This chapter discusses some of the plugins that were used for the application.

RayFire

RayFire is a tool for the dynamic or precalculated destruction of virtual objects. RayFire is not Unity specific but is available for Unity in the form of a plugin. RayFire is a powerful tool and is used for professional movies and games. It allows for a plethora of options and customizations on each component. The application only uses very basic RayFire components, as many of the more complex functionalities take a lot of performance which is not readily available on a standalone headset. An issue with RayFire is, that while cutting is supported, only the cutting of stationary objects with moving blades functions flawlessly. The way RayFire blades are implemented is not specifically well suited for VR, as the free movement of blades during a swing is not considered for the way an object is cut.

RayFire is used in the feature Food Ninja and can be used to implement further smashable dishes or objects in a later iteration.

Portals for VR

As was discussed in “4.2.1 Concept”, chapter “Locomotion”, portals play a vital role in the application. Portals for VR (Tom Goethals, 2023) at the time of this iteration the only portal plugin that allows for flawless VR use.

XR Interaction Toolkit

Unity provides an official XR interaction framework. While it does not support specialized interactions, it provides a solid baseline. It allows for locomotion, activation, grabbing and throwing of objects. In the prototype, the XR Interaction Toolkit is used for grabbing and throwing objects in the features Food Ninja and Darts.

4.2.5. Features

The following subchapters discuss some of the features of the prototype that are of note.

Food Ninja

Inspired by the well-known game Fruit Ninja (Halfbrick Studios, 2023), this feature allows the user to wield swords and use these to cut food items that fly towards them. This feature allows for a fun experience and interaction with the world. It also allows the user to play with food in a way that is not possible in the real world.

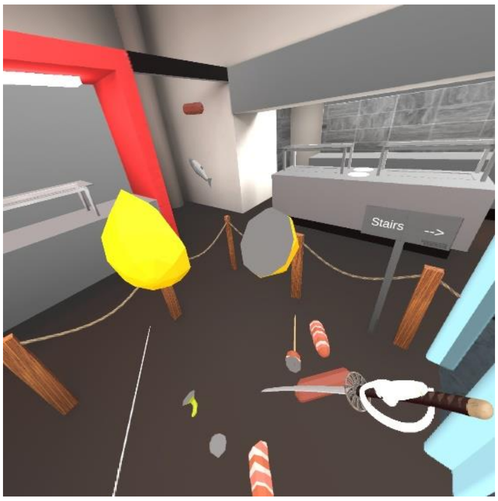

Figure 15: Food Ninja feature in action

Food Ninja uses food models from a free demo package (Mumifier Studio, 2022) on the Unity asset store. The swords were reused from the test scene described in “4.1 Development of the Research Test Scene”.

As visualised in Figure 15, when the user grabs a sword, a script is notified and starts catapulting randomized food items in a cone. These items are affected by a custom gravity to make them fly slower, making it easier for the user to hit them with the swords. Each food item has a timer that deletes the item and its pieces after a set amount of time.
The current state of the feature is a prototype. It currently does not feature any models for the origin of the food items, nor does it have an intriguing visual or auditory effect when cutting the items. Adding these should improve the engagement of users.

Darts and Balloons

Figure 16: Darts & Balloons feature in action

Balloons can be popped by darts, as seen in Figure 16, swords or by touching a portal. A balloon that touches a trigger with the tag “BalloonPopper” will be deleted and a particle effect and sound will play at that location to give the illusion of a bursting balloon.

Balloons are either placed in the world to provide a challenge, or they rise from a balloon fountain. All balloons have a custom gravity, which is set to none for the challenges and to a negative value for the fountain ones, making those rise up into the air.
Any balloon that reaches a certain height will burst. This is done to prevent the existence of an unreasonable number of balloons in the world, which would negatively impact performance.

Darts can be thrown and can pop balloons with their tip. Similar to the food items they have a custom gravity to allow them to move in a more perceivable and playful manner. With the use of a script, the darts turn their tip towards the direction they move, mimicking real-world darts.

Lighting

The lighting of the scene has a substantial influence on its realism. The lighting for objects in the Application is precalculated. This allows for area lights and emissive materials to contribute to the lighting without taxing the performance. Most objects are static, meaning they do not move, allowing to apply shading directly when baking. To shade non-static objects, each play area is equipped with light probes that capture the lighting information when then light is baked. These light probes are then used to shade the objects by interpolating the information from the closest four light probes.
Light baking works by simulating light rays that bounce around the scene and collect colour information. This information is then saved in a texture that can be used to get the lighting data during rendering. Given enough time, this method can achieve photorealistic lighting.

Baked lighting needs each object to have a UV map, which is a texture that defines the resolution of the object's baked lighting. A UV map can be added and modified during the modelling process, or it can be generated in Unity. When generated, the UV map will normally have an equal resolution on each surface. This is an issue with large objects, as those would need detailed UV mapping on areas close to the user, and rougher UV mapping on remote areas. Thus, large objects with no specifically prepared UV maps will take up a lot of memory to achieve satisfactory lighting.

Lighting has a lot of potentials to awe the user.

5. Usability and User Experience

This section describes how the engagement and memorability user test in the Research Test Scene as well as the user tests of the VR Tour were set up and conducted. Usability and user experience testing provides us with extremely useful information about the major and minor issues with the functionality of our application, as well as the opportunity to identify key pain points and structural weaknesses within the application architecture.

5.1. Engagement and Memorability Test

The engagement and memorability test was created to get insight into the influence of realistic textures on user engagement and general memorability of a VR experience. As described in section “4.1. Development of the Research Test Scene”, a separate VR test scene was created for this user test.

5.1.1. Preparation & Planning

The goal of this user test was to get insight into the influence of texture realism on user engagement and general memorability of a VR experience, as well as gain first insight into what students want to see during a virtual tour. As this research section can be treated separately from the final application, the target group could be widened from prospective students with technical interests to students in general. This allowed to find the targeted number of 20 testers more easily. The conduction was planned to take place during project week, as more students are available on campus to be recruited as testers. The user test was prepared in three parts, a task-based VR experience, a first questionnaire covering the user engagement as well as the first locational insights for the final application, and a second questionnaire testing the general memorability of the experience, distributed exactly seven days after the test session. All three parts are described in detail in the following chapters. The task-based VR experience was created using two different texture settings, once normal, close-to-reality-looking textures, once low, cartoon-styled textures, as described in detail in section “4.1. Development of the Research Test Scene”.

5.1.2. Test Group

The test group consisted of a total of 20 participants, mostly current computer science students at the FHNW campus Brugg. Using two different texture settings, two test groups with ten participants each were built. As shown in Table 3, the tester's prior experience, sex and age are nicely distributed. The test group includes 13 male testers, six female testers and one tester of other sex with an average age of 24. Nine testers show no previous experience, 8 little to no experience, and three with advanced prior experience in VR.

Test Person	Sex	Age	Prior VR Experience
Person 1	m	24	Newcomer (1-10 hours)
Person 2	m	19	Newcomer (1-10 hours)
Person 3	m	17	Layman (0 hours)
Person 4	m	22	Newcomer (1-10 hours)
Person 5	m	23	Enthusiast (11-100 hours)
Person 6	other	28	Enthusiast (11-100 hours)
Person 7	f	20	Layman (0 hours)
Person 8	f	22	Layman (0 hours)
Person 9	m	24	Layman (0 hours)
Person 10	m	25	Newcomer (1-10 hours)
Person 11	m	22	Layman (0 hours)
Person 12	f	29	Newcomer (1-10 hours)
Person 13	f	22	Newcomer (1-10 hours)
Person 14	m	39	Layman (0 hours)
Person 15	m	27	Layman (0 hours)
Person 16	m	22	Expert (100+ hours)
Person 17	m	18	Newcomer (1-10 hours)
Person 18	f	21	Layman (0 hours)
Person 19	f	22	Layman (0 hours)
Person 20	m	30	Newcomer (1-10 hours)

Table 3: The test group's demographics and prior experience with VR

5.1.3. Conduction

The first part of this user test was conducted within one week, the second part of the user test was closed three weeks later.

After a brief introduction into the purpose of this user test, without mentioning the purpose of testing memorability to not raise special awareness of specific tasks or objects, the tester was given the PICO 4 headset and controllers as well as a short introduction on how to move and interact with the virtual world. After a short orientation phase, the tester was given the task to sort the five objects laying on the floor onto the corresponding numbers in the virtual room. Once the tester finished this task, time was given to freely discover the virtual room. For both the task as well as the discovery phase, no exact time limit was given, however, a time of ten minutes maximum was targeted.
After the VR experience, the tester was asked to fill out part one of the questionnaire, covering demographics, expectations, and engagement. Once finished with part one of the questionnaire, the tester was engaged in an open discussion with the moderator to gain open and more personal feedback. To finish the session, the tester was informed about part two of the questionnaire and that it would be sent by email in seven days exactly and that it would be important to fill out this second part.

5.1.4. Questionnaire Part One – Engagement

The first part of the questionnaire consists of a short written introduction, a demographics part, an expectations part and a user engagement part.
The demographics part asks for the name, sex, age, prior VR experience and email address of the participant. The name is needed for later identification with the second questionnaire and the email address is needed to contact the tester for the second questionnaire.
The expectations part consists of an open question, asking about the expectations of an application featuring a virtual tour through the FHNW campus, specifically asking for interesting projects and locations.
The user engagement part consists of the User Engagement Scale - Long Form, featuring 30 generalized questions asking for the user's engagement in different dimensions.

5.1.5. Questionnaire Part Two – Memorability

The second part of the questionnaire was distributed by email after exactly seven days of the tester's session and consisted of a short written introduction, a demographics part and a memorability part.
The demographics part only covered the name for identification with the first part of the questionnaire.
The memorability part consists of a list of 45 objects, of which 12 objects were added later and were not in the virtual room during the test session. The tester must check all objects that have been memorized since the session.

5.2. VR Tour User Test

This section describes how the concept and the different versions of the prototype described in section "4.2. Development of the VR Tour Prototype" were tested. The VR Tour was tested with end users in three different versions on a total of four events (two events used the same version, it will be considered as one event in this chapter unless noted differently). The first event was used to validate the basic concept of the application, featuring a basic prototype version with the three empty locations, simple concepts of minigames and default lighting. The second event was used to validate a version without optimized lighting but with some more implemented minigame ideas, and the last event was used to validate the final version of the application, with optimized lighting and only the necessary content. The three versions and how each of the versions was tested is described in the following three chapters. During development, smaller features and changes were tested by co-workers or other students, using open dialogue or a given task, mostly undocumented.

5.2.1. Concept Validation

The basic concept of the application was validated using a total of 15 testers during a study information event on the 1st of January 2023 at the FHNW in Brugg. The goal was to validate the chosen approach regarding interactions, movement, and environment. This version contained default lighting, portals version 1 and some basic minigame mechanics like destruction and slicing.

The user test was conducted by observance and open dialogue between the tester and a moderator. The tester was given the VR headset and a short introduction on how to move and interact and what the goal of the application is, without further explanation. While the tester explored the virtual world, the moderator would observe and document how the tester interacts with the game world, specifically what works by intuition and where the tester has difficulties understanding a functionality. The main topics of the observation covered movement and the portal system, the rooms and environment and general observations. If the tester had difficulties, the moderator was allowed to give a hint to enable the player to further explore the application.

5.2.2. Prototype Version Default Lighting

After validating the basic concept and implementing feedback of the corresponding user test, this version was tested with a total of seven testers on two study information events in Zürich on the 7th and 9th of February 2023. The goal was to collect feedback on the application, specifically on user engagement throughout the entire application. It contained default lighting, portals version 2a and some minigames.

The user test was conducted by open dialogue between the tester and a moderator as well as a questionnaire featuring the User Engagement Scale - Short Form and an open feedback question. The tester was given the VR headset and a short introduction on how to move and interact and what the goal of the application is. While the tester was exploring the application, the moderator would engage in an open dialogue about what the tester is doing and what feels intuitive, as well as helping to formulate difficulties. If difficulties occurred, the moderator was allowed to give the tester a hint. After testing the application, the tester was asked to fill out the questionnaire featuring the User Engagement Scale - Short Form as well as an open question asking for general feedback and thoughts while playing the application.

5.2.3. Prototype Final Version

After implementing the feedback of the previous user tests, the final version was tested with a total of five testers on a study information event in Brugg on the 9th of March 2023. The goal was to collect feedback on the application, specifically on user engagement throughout the entire application. It contained optimized lighting, portals version 2b and all minigames and content that was implemented as described in section “4.2. Development of the VR Tour Prototype”.

The user test was conducted by open dialogue between the tester and two moderators as well as a questionnaire featuring the User Engagement Scale - Short Form and an open feedback question. The tester was given the VR headset and a short introduction on how to move and interact and what the goal of the application is. While the tester was exploring the application, one moderator would engage in an open dialogue about what the tester is doing and what feels intuitive, as well as helping to formulate difficulties while the other moderator would observe the test session on a separate monitor. If difficulties occurred, the moderator was allowed to give the tester a hint. After testing the application, the tester was asked to fill out the questionnaire featuring the User Engagement Scale - Short Form as well as an open question asking for general feedback and thoughts while playing the application.

6. Results User Tests

This section covers the results of both the user engagement and memorability test in the Research Test Scene as well as the user engagement and general feedback of the VR Tour.

6.1. Engagement and Memorability Test Results

The engagement and memorability test aims to show the impact of texture realism on user engagement and memorability. This section covers the results generated by the three parts of that user test.

6.1.1. Results User Engagement

With 20 testers in total, ten testers per group, all statistical analysis of this user study cannot be considered meaningful and only show a broad overview or insight into what could be determined in a bigger user study with a bigger sample size. The scoring method of the User Engagement Scale – Long Form can be found in chapter “Scoring The User Engagement – Long Form” in the appendix.

As shown in Figure 17, it can be observed that the user engagement score is slightly higher and less distributed using realistic textures. Using realistic textures, an average user engagement score of 16.1 can be reached, while for low texture settings, the average user engagement score is 15.7. Given that a score of 10 means a neutral position, a score of 15 is considered good and a score of 20 is considered perfect.

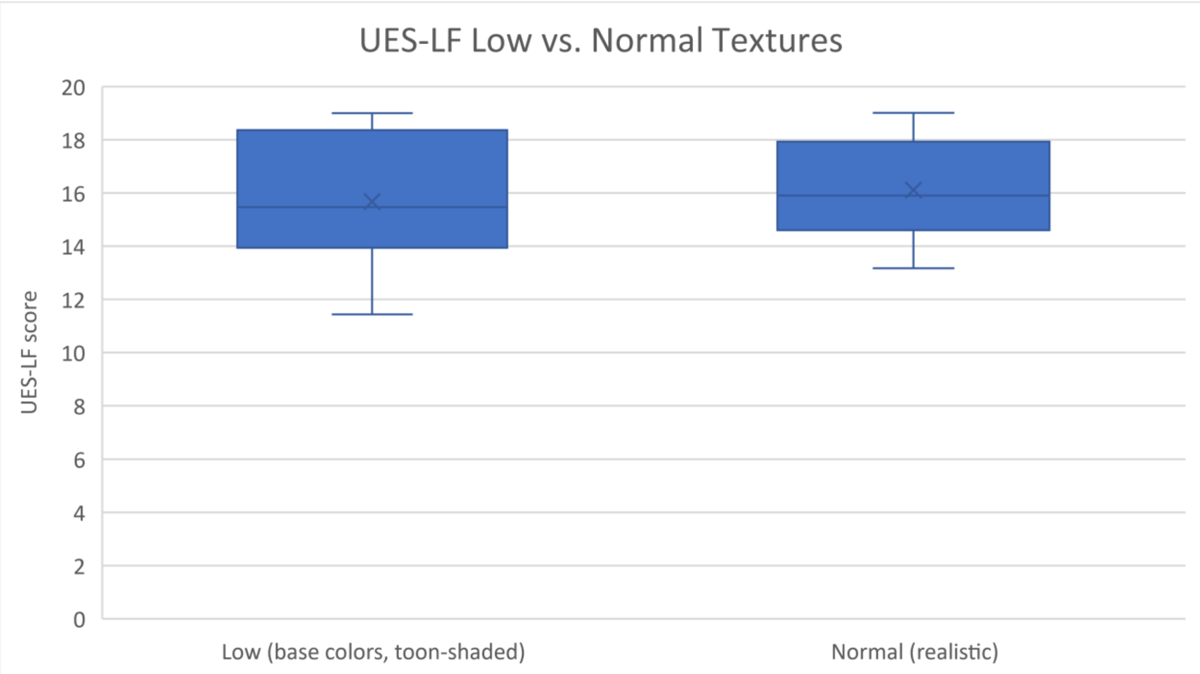

Figure 17: Results UES-LF low vs. normal texture settings

As described before, the User Engagement Scale offers insight into four dimensions of engagement, focused attention (FA), perceived usability (PU), aesthetical appeal (AE) and endurability, novelty and involvement (RW) (O’Brien et al., 2018). As shown in Figure 18, all dimensions except aesthetical appeal show a slightly higher score using a realistic texture setting. It would be interesting to further research, why the aesthetical appeal is lower in realistic settings and if the difference as well as the sample distribution would further validate found results.

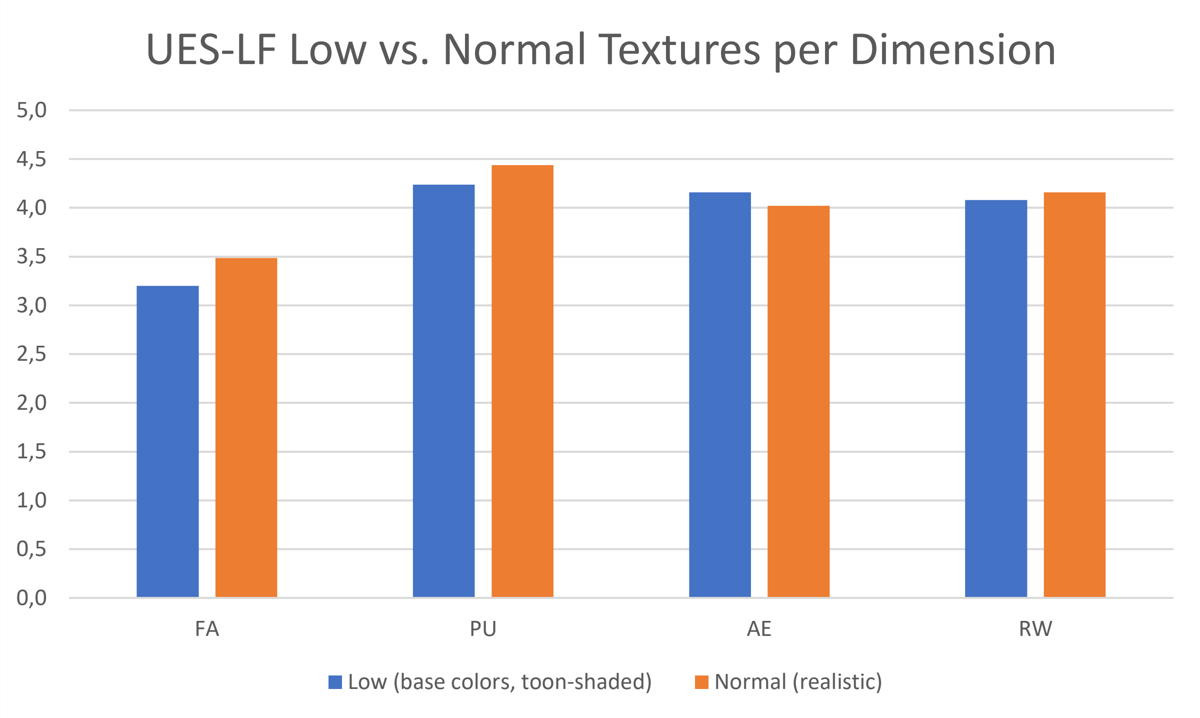

Figure 18: Results UES-LF low vs. normal texture settings itemised by dimension of engagement

In summary, it can be suggested that texture realism has a small but visible impact on user engagement. Therefore, as this study was done at the beginning of the project, for the implementation of the final application, it makes more sense to use realistic textures instead of a low texture setting to further support user engagement.

6.1.2. Results Memorability

With 16 testers in total, ten testers that used the realistic texture settings, and six testers on the low texture settings, all statistical analyses of this user study cannot be considered meaningful and only show a broad overview or insight into what could be determined in a bigger user study with a bigger sample size.

The testers had to check all listed objects that they memorized after seven days. To analyse this data, the answers were converted into a binary matrix, setting one for a checked object, and zero for an unchecked object. The possible answers consisted of 45 objects, of which 12 objects were added later and counted as wrong. The more correct objects the tester can remember, the stronger the created memory, and the better the result.

As shown in Figure 19, using realistic texture settings allows the user to memorize an in average higher number of objects than using low texture settings. Using realistic textures, testers checked an average of 9.6 objects, with an error rate of 8.3 %. Testers using low texture settings only checked an average of 6.5 objects, however, the error rate of only 5.1 % is also lower. As Figure 19 also shows, the distribution of remembered objects is higher on realistic textures. If looking at the median instead of the mean, testers with realistic textures check a median of 8.0 objects, while testers with low textures stay at 6.5 remembered objects. It would be interesting to further research, if a bigger sample size would narrow the distribution and create a clearer difference between realistic and low texture settings.

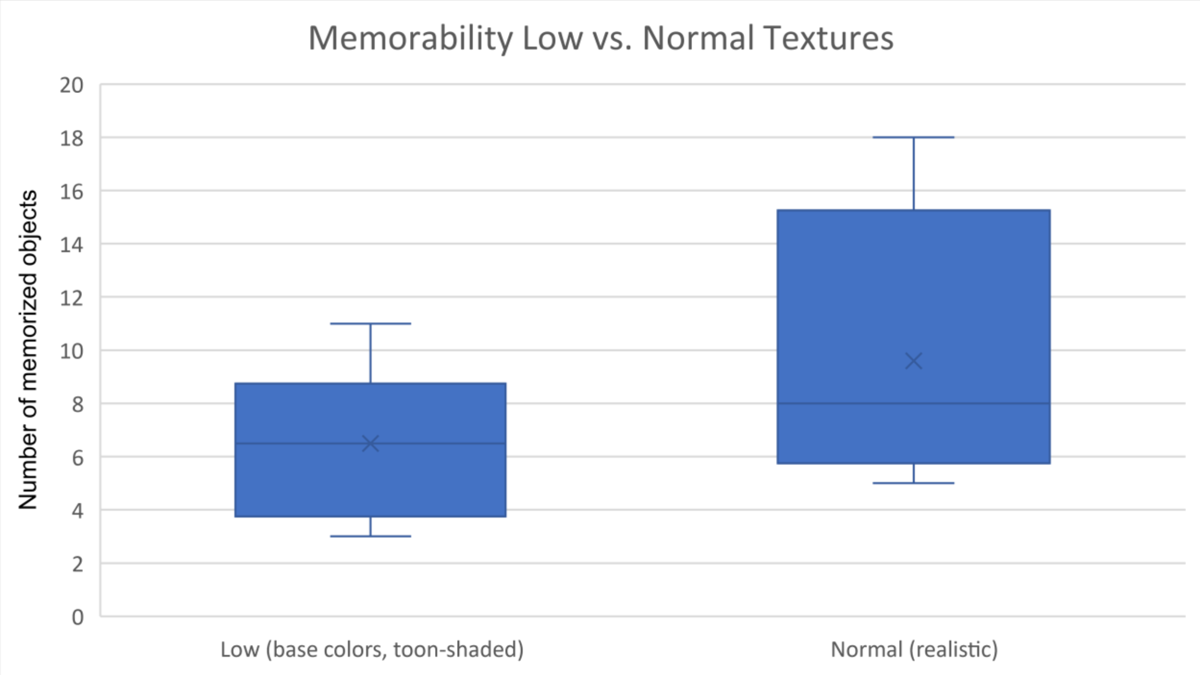

Figure 19: Results number of memorized objects in low vs. normal texture settings

In summary, it can be suggested that texture realism has an important impact on the general memorability of a VR experience. Therefore, as this study was done at the beginning of the project, for the implementation of the final application, it makes more sense to use realistic textures instead of a low texture setting to further support memorability.

6.1.3. Results VR Tour Expectations

As a part of this user test, it was decided to collect data about the target group's expectations of a virtual reality tour through the FHNW campus. This was done with an open question: "What would you expect to see during a virtual tour through the FHNW campus (e.g. special project, interesting places, study course related content, infrastructure, etc)?". In Figure 20, the answers have been collected and visually prepared. It is shown that the most named expectations are to see the mensa, the learning environment, study courses and projects as well as interesting places in general. To further harden this data, it would be useful to add this question to the widely spread questionnaire of the marketing department of the FHNW to collect a bigger sample size.

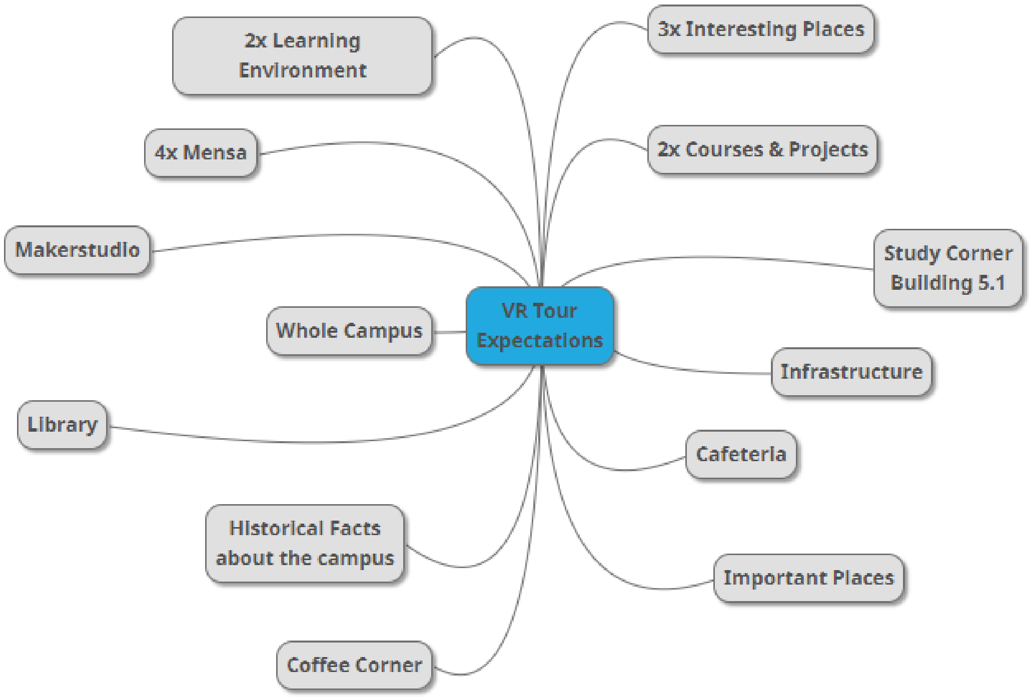

Figure 20: Visualisation of VR Tour expectations

6.2. VR Tour User Test Results

This section covers the results of the user tests conducted to validate the base concept as well as two different versions of the prototype. As described in chapter "5.2. VR Tour User Test", the concept validation used a different user test method and did not test using the User Engagement Scale, therefore this chapter is split into chapters "6.2.1. Results Concept Validation" and "6.2.2. Results User Engagement".

6.2.1. Results Concept Validation

The base concept validation showed three main observations:

- Portals: The portals were not intuitive, as testers would think of mirrors or windows instead of pathways to another location. Due to the portal placement, the other side of the portal (the new location) could not always be seen, which further distracted the tester. Without a hint from the moderator, testers would hardly understand that there are three locations connected by portals. Even after an initial hint of how the portals work, most players had difficulties finding the way to the last location.
- Performance: The general performance, frames per second, needs to be optimised, as most testers complained about an unsmooth experience, which in response leads to motion sickness in untrained testers.
- Environment: The rooms/environments feel empty and lifeless, testers asked for more life in all locations, for example, a beamer projection or textures for the whiteboards in the classroom, food, menu, and price details in the mensa or distant avatars or minigames outside the playing area on the stairs.

A detailed list of all observations can be found in the appendix in chapter “Observation Concept Validation”.

6.2.2. Results User Engagement

This chapter covers and compares the user test results of the two tested prototype versions as described in chapter “5.2.2. Prototype Version Default Lighting and “5.2.3. Prototype Final Version”.

With only seven and five testers per session, all statistical analyses of this user study cannot be considered meaningful and only show a broad overview or insight into what could be determined in a bigger user study with a bigger sample size. The scoring method of the User Engagement Scale – Short Form can be found in chapter “Scoring The User Engagement – Short Form” in the appendix.

During the two user tests, only the results of the UES-SF were documented. The observations and feedback during the sessions remained undocumented. As of this chapter, the two prototype versions will be compared. The main difference between version A, “Default Lighting” (also referred to as “Version 2023/02/07”) and version B, “Final Version” (also referred to as “Version 2023/03/09”) is the revised portal version and the optimised lighting.

Version A featured seven test persons, six on the same date. In this version, an average user engagement score of 3.87 was reached, as shown in Figure 21.
Version B featured five test persons, included significant improvements compared to version A and reached an average user engagement score of 4.22, as shown in Figure 22.
Given that a score of 2.5 means a neutral position, a score of 3.75 is considered good and a score of 5 is considered perfect.

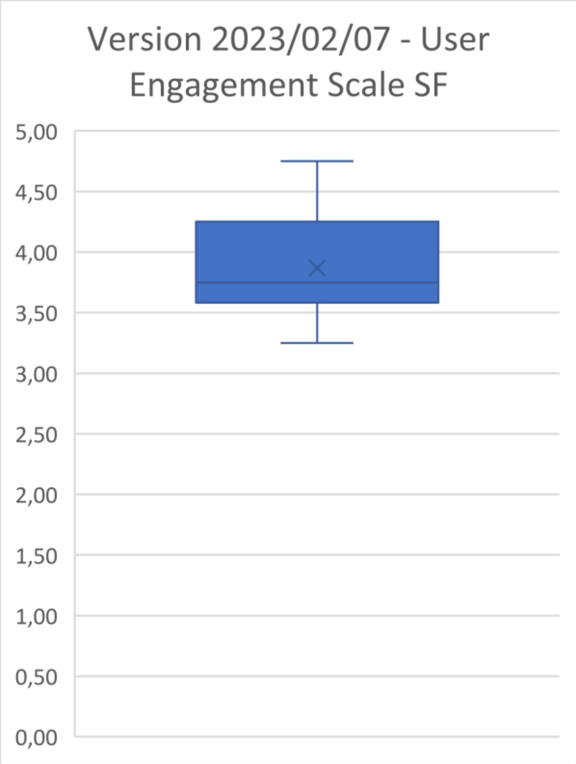

Figure 21: Results of UES-SF of prototype version 2023/02/07

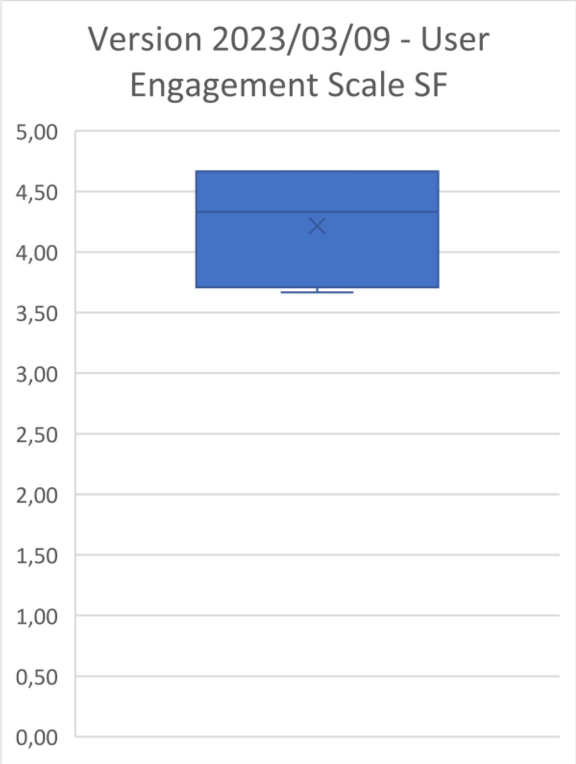

Figure 22: Results of UES-SF of prototype version 2023/03/09

As described before, the User Engagement Scale offers insight into four dimensions of engagement, focused attention (FA), perceived usability (PU), aesthetical appeal (AE) and endurability, novelty and involvement (RW) (O'Brien et al., 2018). As shown in Figure 23, all dimensions show a slightly higher score in the final prototype version.

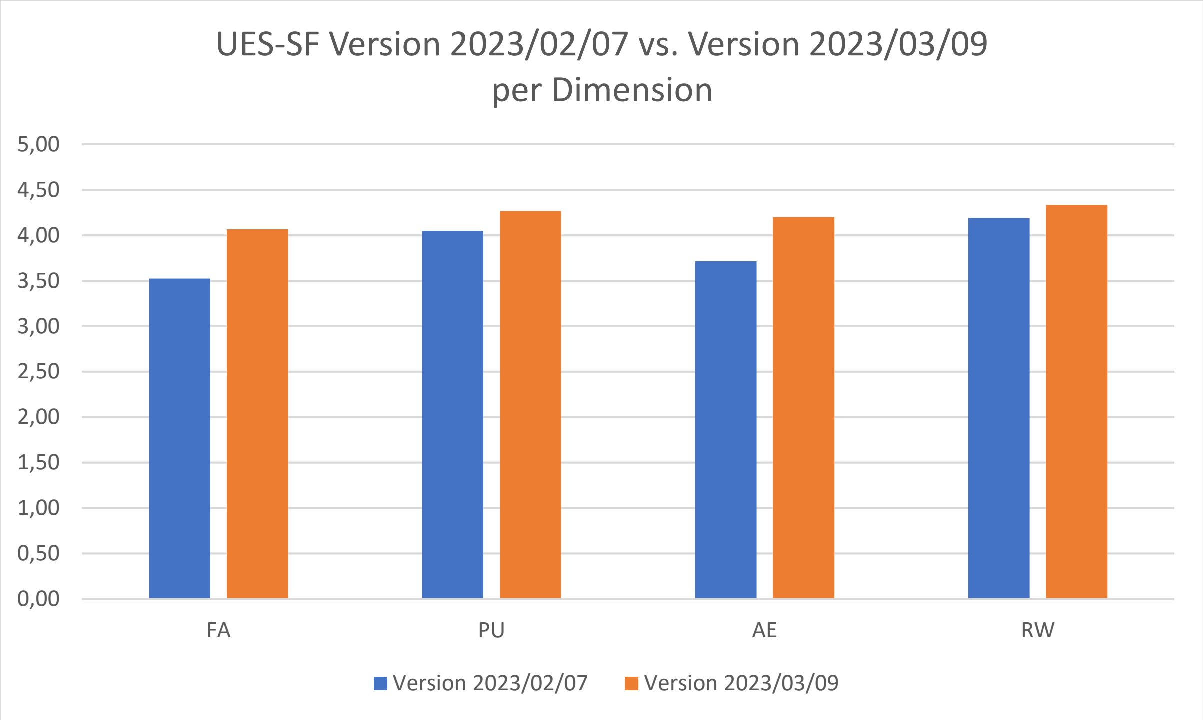

Figure 23: Results UES-SF Version 2023/02/07 vs. Version 2023/03/09 per Dimension

In summary, there can be seen a slight improvement in the user engagement score after significant improvement of the application.

7. Discussion

This section elaborates on the meaning, importance and relevance of the achievements and results of this thesis as well as possible future work needed to further improve the application.

7.1. Technical Achievements

In this bachelor thesis, a prototype for an immersive, engaging, and memorable VR experience named “VR Tour” could be realized as expected. Based on user feedback, personal experience and input from the marketing and communications department of the FHNW, the most fitting locations to feature the FHNW campus, its benefits and offers as well as its study courses have been identified. Using Blender, a free 3D graphics suite, these three locations have been modelled and textured as close to reality as possible. The realized application offers space to feature projects realized by other students and research institutes of the FHNW and allows the promotion of food options, prices and diversity as well as leisure and sports activities of the FHNW. In the current state of the application, most of these spaces are filled with placeholders, which allows future development as described in section “7.3. Possible Future Extensions”.

In advance to the development of the VR Tour, a separate Unity project was created in order to examine the impact of texture realism on user engagement and general memorability. The results of this “Research Test Scene” as described in the following chapter “7.2. User Study” have been used as a base for the development of VR Tour.

7.2. User Study

In this section, both the results of the Research Test Scene as described in chapter “6.1. Engagement and Memorability Test Results” as well as the VR Tour application as described in chapter “6.2. VR Tour User Test Results” are discussed.

7.2.1. Discussion Research Test Scene User Study

The user study done to get insight into the impact of texture realism on user engagement and memorability showed, that higher texture realism slightly improves user engagement and strongly improves memorability. This suggests that user engagement and general memorability of the experience correlate with texture realism. This result gives insight and can be used as a broad indicator, that it may be worth the time investment to create high-quality textures for the final application. However, there are a number of aspects of that user study that have to be discussed and that may have a big impact on the validation of the results. These aspects are discussed in the following chapters.

Level of Realism

To examine the impact of texture realism, two different texture settings were used as described in chapter “4.1. Development of the Research Test Scene”. The issue here is that the two settings that were used both look good in their own style. Therefore, especially for testers with no previous VR experience, both settings could look good and be engaging. To create a user study that can provide detailed information about the impact of texture realism on user engagement and memorability, more different texture settings should be used, for example, a completely untextured setting, a low, mid and high-quality setting as well as a photorealistic setting. This way, the study could verify or disprove the hypothesis of a direct correlation between texture realism and user engagement and memorability in VR applications. Using the current study settings, it is very well possible that a slightly higher level of texture realism is beneficial, but photorealism may be too much detail and therefore have a negative effect.

Sample size

With a sample size of 20 testers for user engagement and 16 testers for memorability, the results of this user study can only be used as a broad indicator that suggests a general direction and cannot be used for statistical analysis. Using a small sample size, there is a possibility that the produced results are artificial and do not represent the real world. To validate the first impression created by this user study, a bigger sample size would have to be used. With a bigger sample size, it is expected to show less distribution of the data and therefore a clearer difference between the two test settings.

Test Method Memorability

For this user study, an own method of testing general memorability of a VR experience was created. This alone brings a big discussion with it. The created test method is not generalized nor further validated and is mainly based on literature. It is possible, that the method of measuring memorability based on the number of recalled objects that were consciously or unconsciously present during the VR experience is not valid or does not mean that a stronger memory was created just because a tester could memorize more. Furthermore, it is possible that the method of recalling objects by a list of object names is not optimal. Based on literature, most memory research is done on image memorability, it is possible, that testers would have been able to recall more information if they were provided with an image of the object instead of the name of the object. Again, this method would have to be validated by itself.

Additionally, as described in the previous chapter, with a small sample size it is well possible that testers with naturally good memory capabilities were not distributed evenly between the two test settings.

Response Time Memorability

Lastly, the results of the memorability study have to be treated carefully, as some testers did not submit their answers at the requested time. The planned response time was seven days (the memorability questionnaire was handed out after seven days), the median response time for both groups is 7.5 days, while the average response time for the low setting is 12 days and for the realistic setting 8.4 days. The highest response time needed by a tester was 23 days. There is a good chance that the memorability of the experience is lower after 23 days than after seven days, which in turn falsifies the results generated by this study. To create stable and valid results, the response time of the questionnaire would have to be fixed, for example by having the testers fill out the questionnaire in person or ignoring all data that was submitted after the planned seven days.

7.2.2. Discussion VR Tour User Study

The results produced by the concept validation were implemented and validated by the user tests conducted on a mid-project prototype version and the final prototype version as described in chapter “6.2.2. Results User Engagement”. The results suggest that both versions feature good user engagement and that the final version improved in comparison to the previous version. With a user engagement score of 4.22 on a scale of 1 to 5, where 3 equals neutral, the final application shows good user engagement but leaves room for improvement as described in the next chapter. While these results can be used as a general indicator of user engagement, the main aspect that could falsify or impact these results is the sample size. With a sample size of only seven and five testers per prototype version, the results cannot be used for statistical analysis and cannot be considered significant or meaningful, unless used for a general indication. To validate the results of these user tests, a bigger sample size would be needed.

7.3. Possible Future Extensions

The prototype of a VR tour developed in this project has already been received positively by users. To achieve the full potential of the application, further iterations are recommended.
Since the application is meant to represent the school over a time of multiple years, it is also recommended to keep the application up to date by replacing or adding new student project results to the virtual world.

For the application to be considered complete, the features described below must be implemented.

The most important feature is populating the world with the information that should be transferred to the users. This means textures for blackboards, whiteboards, beamer, and models of student projects need to be added to the classroom. The mensa needs to feature information about food, prices, and diversity. The stairs should be outfitted with information about possible sports and leisure activities.

The feature that will take the most effort is the upgrade of all of the surroundings. The classroom needs to be positioned and adapted to be at the side of building 5 that faces the stairs, with the windows providing a view of the stairs.
The mensa needs to be expanded to include the eating space and other areas that are visible from the play area. It also needs the addition of food and furniture items to achieve the looks of a mensa that is ready to receive students for lunch. The stairs area needs to have all the surroundings modelled to a degree where buildings are recognizable and where it does not feel like the school floats in the sky.
Suggested methods to achieve this is to either have professionals create a photogrammetric model of the surroundings, or to commission professionals to model the area.

Further, it is recommended to also update objects like balloons, fences, portals, and food items to fit the style of the new surrounding models, as well as adding items to plausibilise the launching of fruit and spawning of balloons.

Once these issues are addressed, there is the possibility to extend the app with more minigames, a user guide and a livelier world. Minigames could for example be basketball, baseball, or a puzzle. As a guide, the mars rover of the FHNW Rover Team would be quite a good match.

When planning any changes to the application, it is crucial that the performance impact is considered. A loss in performance and thus in framerate can easily lead to effects like motion sickness that will strongly reduce the user engagement and usability of the application.

8. Conclusion

In this section, a more personal reflection of this project, its challenges and its project management are given, as well as a short comparison to the original project description, ending with a few final words about this thesis.

8.1. Challenges

In view of the development of the Research Test Scene to examine the impact of texture realism on user engagement and memorability, one major challenge was to find a suitable memorability test method. In literature, most studies regarding memorability are done on specific features or objects, such as what images will be memorized better or how can route learning benefit from realism. Very little literature could be found that talk about memorability in VR, and none could be found about how the general memorability of a VR experience could be tested. Therefore, creating a custom test method was the only suitable option, but enables room for errors.

In view of the development of the final application, apart from the huge amount of time the 3D model creation consumed, the biggest challenge represented the performance issues due to using portals. Portals render the next location, and especially in the mensa, the middle location containing two portals, the performance was problematic. To solve this issue, both the portal placement as well as the connection between the locations needed to be revised and optimised.

8.2. Project Management

As planned, for this project agile management was used. Due to biweekly meetings and close communication with supervisors and customer and frequent testing with the target audience, ideas could be quickly validated and requests or changes could be easily responded to. Especially at the beginning of the project, a long phase was used to gather different ideas and approaches on how to fulfil the customer's needs, and an equally long phase was used to narrow down these ideas with the customer and the supervisor team. Due to new ideas or delayed work packages, the overall time plan had to be adapted several times.
Overall, the agile project management methods used in this project worked well for all involved parties.

8.3. Comparison to Original Project Description

The overarching vision of creating an engaging and memorable XR experience to leave an impression of the FHNW campus and arouse interest in the FHNW School of Engineering's study courses for our target group could be reached. The only major difference to the original project description is the use of 360° images. It was decided early in this project, that 360° images will not be used, as it can only be used as an addition to add a faraway background of a location. In this project, the locations were only implemented in close proximity to the player, further implementation of the environment were not possible due to time limitation.

8.4. Final Words

The goal of this project was to create an engaging and memorable VR experience for prospective students to leave an impression of the FHNW campus, arouse interest in the FHNW School of Engineering's study courses and therefore attract new students. This includes the goal of understanding how high user engagement and memorability can be influenced, achieved, measured and tested. In specifics, it was a research goal of this thesis, to understand the impact of texture realism on user engagement and memorability in a VR experience.

This project reached all of its goals. While the user tests conducted to reach and validate the achievement of certain goals are discussable mainly regarding sample size, the produced results still provide a general indication. Based on user tests, texture realism seems to have a direct influence on user engagement and the memorability of the experience. This suggests that at least high-quality textures should be used. Based on user tests, the developed application shows a high level of user engagement, and as it implemented the learnings of the texture realism research, it most certainly also shows good memorability.

On a personal note, this project was of great interest and personal benefit to both authors. We both had nearly unlimited ideas on basic concepts, locations, minigames and objects to fill the virtual world with. Given enough time, this project shows a lot of potentials and might hopefully be continued and further improved. We both were able to learn new skills and harden already acquired skills, not only in programming and working with unity, but also in 3D modelling and user interaction on events.

In the end, this project still allows room for future work and improvements, but overall, it reached its goals and can be considered a success.

9. Acknowledgements

A special thanks goes to our customer Jadwiga Gabrys for making this project possible and giving us the chance to bring up and implement many of our own ideas. It was always pleasant to work with you, you have given us many liberties in implementation decisions and working with you on events was always a great time.

We would also like to thank Cédric Merz and Cloe Hüsser, who supported us throughout the entire project as supervisors with valuable information, ideas, and a lot of feedback. It was a pleasure to work with you and we hope for further successful collaboration.

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11. Glossary

Term or Acronym	Description
VR	Virtual Reality
AR	Augmented Reality
XR	Extended Reality, including AR, VR and other modes like mixed reality
VR Tour	The main application created in this project, also referred to as “final application”, “prototype” or “final prototype”
Research Test Scene	The separate Unity project created to conduct the texture realism user study, also referred to as “Test Scene”, “Research Scene” or “Research Application”
Toon Shading	A rendering method that achieves a cartoon style look with dark outlines, also referred to as “cel shading”
UES, UES-LF, UES-SF	User Engagement Scale, User Engagement Scale – Long Form, User Engagement Scale – Short Form; a generalized set of questions to determine an engagement score of a digital application

Declaration of honesty

«We the undersigned declare that all material presented in this bachelor project report is our own work and written independently only using the indicated sources. The passages taken verbatim or in content from the listed sources are marked as a quotation or paraphrase. We declare that all statements and information contained herein are true, correct, and accurate to the best of our knowledge and belief. This paper or part of it has not been published to date. It has thus not been made available to other interested parties or examination boards. »

Windisch, the 24th of March, 2023

Thierry Odermatt ……………………………

Andreas Leu ……………………………

Appendix

Scoring the User Engagement Scale - Long Form

As described in section “5.1.5 Questionnaire Part Two – Memorability”, all questions have unique identifiers, e.g. FA-1 for dimension “Focused Attention”, question one. The answer sheet must be scored as followed:

1.) Reverse code the following items: PU-1, PU-2, PU-3, PU-4, PU-5, PU-6, PU-8, and RW-3.
2.) Scale scores are calculated for each participant by summing scores for the items in each of the four subscales and dividing by the number of items:
    a. Sum FA-1, FA2, ... FA7 and divide by seven.
    b. Sum PU-1, PU-2, ... PU-8 and divide by eight.
    c. Sum AE-1, AE-2, AE-3, AE-4, and AE-5 and divide by five.
    d. Sum RW-1, RW-2, ... RW-10 and divide by ten.
3.) If participants have completed the UES more than once as part of the same experiment, calculate separate scores for each iteration. This will enable the researcher to compare engagement within participants and between tasks/iterations.
4.) An overall engagement score can be calculated by adding the average of each subscale as per #2. (O’Brien et al., 2018)

Scoring the User Engagement Scale - Short Form

The User Engagement Scale - Short Form features 12 questions in four engagement dimensions. All questions have unique identifiers, e.g. FA-S.1 for dimension "Focused Attention", question one. The answer sheet must be scored as followed:

1.) Reverse code the following items: PU-S1, PU-S2, PU-S3.
2.) If participants have completed the UES more than once as part of the same experiment, calculate separate scores for each iteration. This will enable the researcher to compare engagement within participants and between tasks/iterations.
3.) Scores for each of the four subscales can be calculated by adding the values of responses for the three items contained in each subscale and dividing by three. For example, "Aesthetic Appeal" would be calculated by adding AE-S1, AE-S2, and AE-S3 and dividing by three.
4.) An overall engagement score can be calculated by adding all of the items together and dividing by twelve. (O'Brien et al., 2018)

Texture Realism User Study – Questionnaire Part 1/2

Thank you for participating in our user test of the bachelor project "Campus Brugg XR interactive gamified extended reality app for the application of engineering courses at FHNW". With your participation, you help to further develop and optimize our application and enable us to better meet the needs of our customers and end users.
The feedback you give us during the workshop is very valuable to us, especially if it is constructive and critical. Please feel free to share your thoughts with us, whether positive or negative.

Demographics

1. **Date:** ________________
2. **First Name:** ________________ **Last Name:** ________________
3. **Sex**: O f O m O other
4. **Age**: ________________
5. **E-Mail**: ____
   (We will send you the second part of this survey in a week to complete the user test. Your mail will not be used for other purposes or shared with third parties.)
6. Prior experience with VR:
   (virtual reality)

O Layman (0 hours)
O Newcomer (1-10 hours)
O Enthusiast (11-100 hours)
O Expert (100+ hours)

Expectations

What would you expect to see during a virtual tour through the FHNW campus, eg. special project, interesting places, study course related content, infrastructure, etc?

____
____
____
____
____

User Engagement Scale

Please rate the following questions from 1 (strongly disagree) to 5 (strongly agree).

	Question	Value (1-5)
FA.1	I lost myself in this experience.	______
FA.2	I was so involved in this experience that I lost track of time.	______
FA.3	I blocked out things around me when I was using Application X.	______
FA.4	When I was using Application X, I lost track of the world around me.	______
FA.5	The time I spent using Application X just slipped away.	______
FA.6	I was absorbed in this experience.	______
FA.7	During this experience I let myself go.	______
PU.1	I felt frustrated while using this Application.	______
PU.2	I found this Application confusing to use.	______
PU.3	I felt annoyed while using this Application.	______
PU.4	I felt discouraged while using this Application.	______
PU.5	Using this Application was taxing.	______
PU.6	This experience was demanding.	______
PU.7	I felt in control while using this Application.	______
PU.8	I could not do some of the things I needed to do while using this Application.	______
AE.1	This Application was attractive.	______
AE.2	This Application was aesthestically appealing.	______
AE.3	I liked the graphics and images of this Application.	______
AE.4	This Application appealed to be visual senses.	______
AE.5	The screen layout of this Application was visually pleasing.	______
RW.1	Using this Application was worthwhile.	______
RW.2	I consider my experience a success.	______
RW.3	This experience did not work out the way I had planned.	______
RW.4	My experience was rewarding.	______
RW.5	I would recommend this Application to my family and friends.	______
RW.6	I continued to use this Application out of curiosity.	______
RW.7	The content of this Application incited my curiosity.	______
RW.8	I was really drawn into this experience.	______
RW.9	I felt involved in this experience.	______
RW.10	This experience was fun.	

D

Texture Realism User Study – Questionnaire Part 2/2

Thank you for participating in our user test of the bachelor project "Campus Brugg XR interactive gamified extended reality app for the application of engineering courses at FHNW". With your participation, you help to further develop and optimize our application and enable us to better meet the needs of our customers and end users.
The feedback you give us is very valuable to us, especially if it is constructive and critical. Please feel free to share your thoughts with us, whether positive or negative.

Demographics

1. **Date:** ________________
2. **First Name:** ________________ **Last Name:** ________________

Memorability

Please tick all the below objects that you can remember to be in the application you tested last week. Make sure to only tick the one you are sure about.

- o Alarm Clock
- o Antique Ceramic Vase
- o Katana
- o Whiteboard
- o Computer Monitor
- o Baseball
- o Book piles
- o Brass Pan
- o Mobile Phone
- o Brass Pot (with lid)
- o Brass Vase
- o Brass Vase (with handle)
- o Hole Punch
- o Camera
- o Carved Wooden Elephant
- o Cash Register
- o Cassette Player
- o Wall Clock
- o Wooden Chair
- o Decorative Decahedron
- o Decorative Home-Text
- o Stapler
- o Sailing Ship
- o Cup
- o Picture of a Sunset
- o Teapot
- o Marble Horse Statue
- o Light Switch
- o Mantel Clock
- o Marble Bust
- o Pocketknife
- o Ceiling Lamp
- o Plant
- o Power Outlet
- o Red Apple
- o Green Apple
- o Rug
- o TV
- o Ukulele
- o Vintage Pocket Watch
- o Couch
- o Cushions
- o Blanket
- o Carved Wooden Bowl
- o Hammer

E

Others

Do you have any other thoughts about the tested application?

____

____

____

____

____

VR Tour User Test Questionnaire

Thank you for participating in our user test.
With your participation, you help to develop and optimize our application and enable us to better meet the needs of our end users.

The feedback you give is very valuable to us, especially if it is constructive and critical. Please feel free to share your thoughts with us, whether positive or negative.

User Engagement Scale - SF

Please rate the following questions from 1 (strongly disagree) to 5 (strongly agree).

	Question	Value (1-5)
FA-S.1	I lost myself in this experience.	____________
FA-S.2	The time I spent using this application just slipped away.	____________
FA-S.3	I was absorbed in this experience.	____________
PU-S.1	I felt frustrated while using this application.	____________
PU-S.2	I found this application confusing to use.	____________
PU-S.3	Using this application was taxing.	____________
AE-S.1	This application was attractive.	____________
AE-S.2	This application was aesthetically appealing.	____________
AE-S.3	This application appealed to my senses.	____________
RW-S.1	Using this application was worthwhile.	____________
RW-S.2	My experience was rewarding.	____________
RW-S.3	I felt interested in this experience.	____________

Observation Concept Validation

The following observations and feedback were gathered from about 15 testers during the FHNW event of the 18.01.23. Tested was a first prototype of the final concept, to validate the chosen approach and gather feedback on interactions, movement, and environment.

The testers fit in the target group of the end product and have no to little previous VR experience.

General:

- Generally positive, exited reactions
- Destruction and slicing creates positive reactions, physics in general
- Most testers could identify the classroom and the stairs, the mensa could only be identified by students that have already seen the mensa
- The performance of the application needs to be optimised, especially in the mensa, general movement is stuttering/low fps which creates motion sickness

Movement/Portals:

- Portals were not intuitive, most testers did view it as a window or mirror, but did not realize it as a portal to walk through.
- If the portal is not directly visible (behind the portals wall), testers did not realize that there is a portal nor searched for one.

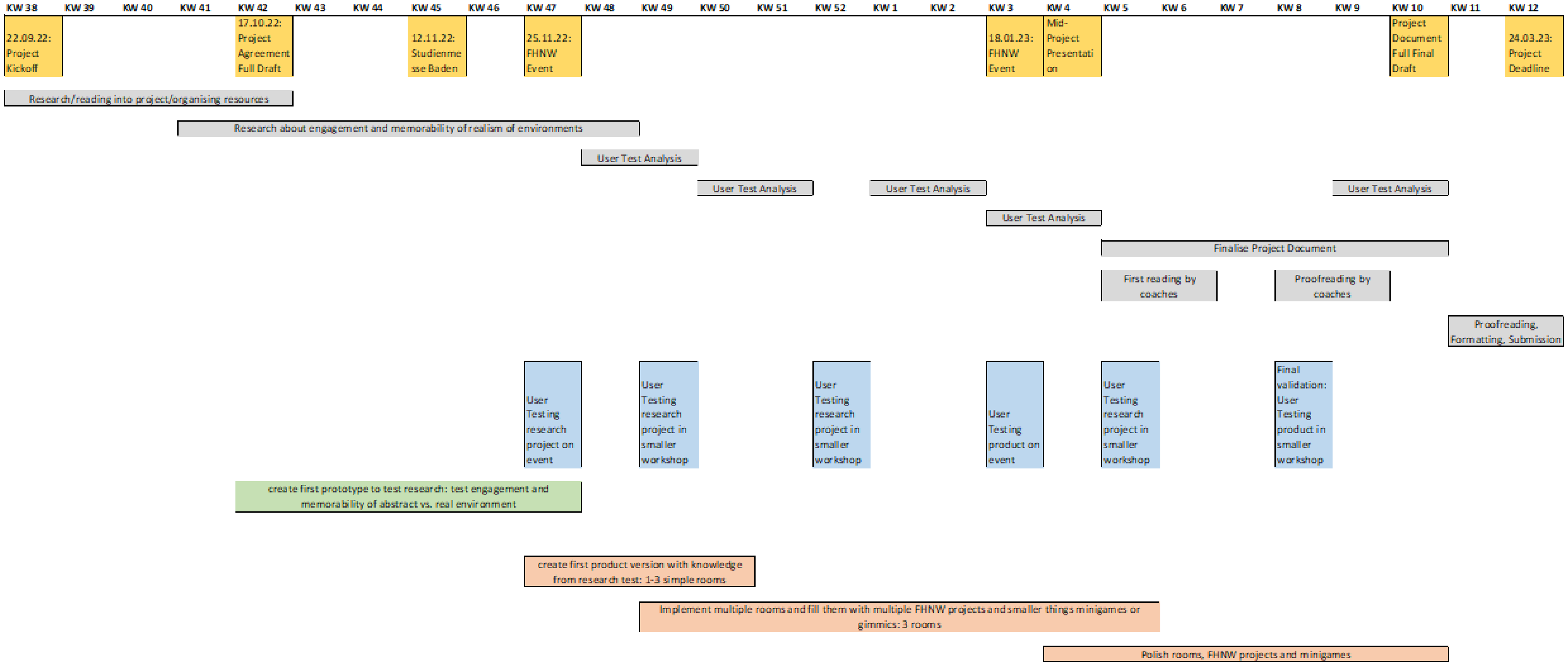
Rooms/Environment:

- The size/height of some rooms are not perfectly real scale
- In general, the rooms/environments need to be more vivid, more filled, for example:
    - Classroom: add a projection of the beamer (can be static, but would promote the technical infrastructure of the FHNW)
    - Classroom: add simple textures to the whiteboards, like writing/sketches/notes
    - Classroom: add power outlets to promote the technical infrastructure
    - Classroom: add paper/pencils/laptops etc. to show, how one can learn in classrooms
    - Mensa: add further details like menu/prices, add more environment like avatars sitting together at the tables eating
    - For all rooms: maybe add avatars to bring in more life (performance?), out of players bounds
    - Stairs: maybe add avatars playing volleyball, add avatars sitting together etc.

Conclusions:

- Portals have to either be marked so that players will understand better, that it is a pathway to an other room, and/or have to be styled differently
- Portals may need to be places differently, so that players can more easily see the portal and therefor understand faster that there are different rooms
- This guidance could also be solved with a guiding object, such as a small robot guiding the way to the next portal (as mentioned in previous meetings, the mars rover could be used for that)
- The rooms/environments need to be more vivid and filled
- The player needs to get any kind of hint (application intern or extern by the moderator) that the rooms/environments are FHNW campus based and that they represent what is possible there
- General performance needs to be optimised to create a smoother experience

Project Plan



Design UX | CG IP

22HS_IIT06: Campus Brugg XR: interaktive, gamifizierte Extended Reality App, um Technikstudiengänge der FHNW zu promoten

			Priorität 1	Priorität 2
Betreuer:	Arzu Cöltekin Cédric Merz	**Arbeitsumfang:**	P5 oder P6	---
		Teamgrösse:	1er oder 2er Team	---
Sprachen:	Deutsch oder Englisch			
Studiengang:	Informatik			

Ausgangslage

Die FHNW ist jährlich an zahlreichen Marketingevents präsent, an welchen das Studienangebot der Hochschule für Technik beworben wird. Um potenziellen Studierenden in innovativer und spielerischer Art und Weise einen kompakten Einblick in die Angebote und Räumlichkeiten des FHNW Campus Brugg-Windisch zu geben und Standortvorteile aufzuzeigen, soll eine interaktive XR App entwickelt werden.

Ziel der Arbeit

Das Ziel der Arbeit ist die Entwicklung und Umsetzung von einem Gamekonzept für eine interaktive XR Anwendung, welche für zukünftige Studierende (Teenager, junge Erwachsene) attraktiv ist. 360° Aufnahmen des Campus sollen eine zentrale Rolle in der App haben, um der erwähnten Zielgruppe einen anschaulichen Einblick in das Leben, die Angebote und die Räumlichkeiten auf dem Campus zu bieten. Das Endprodukt der Arbeit ist ein interaktiver, validierter Prototyp einer solchen XR Anwendung, welche sich durch eine gute User Experience und hohe Usability auszeichnet.

Problemstellung

Folgende und ähnliche Fragen sollen durch die Arbeit beantwortet werden:

- Was für Gamekonzepte eignen sich für die gegebene Zielgruppe und Anwendungsdomäne?
- Wie können 360° Videos in die Anwendung integriert werden?
- Was für Interaktions- und Navigationskonzepte und welche visuelle Sprache eignen sich für eine solche Anwendung?

Technologien/Fachliche Schwerpunkte/Referenzen

- XR Game Entwicklung
- Spatial Interface- und Interaction Design
- User Experience und Usability

Bemerkung

Professionelle 360° Aufnahmen vom FHNW Campus Brugg Windisch sind vorhanden, siehe https://www.fhnw.ch/de/studium/technik, "Virtueller Rundgang durch den FHNW Campus Brugg-Windisch". Coachingmeetings werden teilweise in Englisch durchgeführt. Es steht den Studierenden frei die Thesis/Abschlussbericht in Deutsch oder Englisch zu schreiben.

Fachhochschule
Nordwestschweiz

Windisch, 30.11.22

22HS_IIT06_ Campus Brugg XR_ interaktive, gamifizierte Extended Reality App, um Technikstudiengänge der FHNW zu promoten

Supervisor: Arzu Cöltekin
Cédric Merz

Client: Jadwiga Gabrys, Marketing and Communication FHNW

Project duration: 19.09.2022 until 24.03.2023

Task

1. Familiarization

1.1 Expectations for the project process

Dates
Fix appointments early, i.e. reviews with the customer and about every 2-3 weeks a meeting appointment with your supervisors. Clarify any absences right at the start of the project.

Meetings
Meetings are generally intended to discuss the status of the project, clarify questions, discuss ideas and plan the next steps.
Send a list of agenda items and all other necessary documents to the supervisors. At the beginning of each project meeting, explain the status of the project, the progress and problems as well as the planned steps.
Meetings are recorded in the meeting minutes, which are made accessible to the supervisors and will serve as reference for decisions made.

1.2 Specifications for the agreement

As a first task in your work you have to complete this agreement (cf. point 3). A first version should be produced by 2-4 weeks (BB 4-6 weeks) after kick-off. For projects that require technical analysis, it may be useful to carry out a first implementation iteration before the sub-mission of the project agreement. Please complete the following items:

Initial situation
Formulate the project and the initial situation in your own words.

Project vision
Describe which goals and results are to be achieved with the project. The vision serves to derive quality criteria.

Project specific issues
In addition to the general questions, formulate 2-3 project-specific questions. These serve as a basis for a scientifically structured research and the derivation of suitable solutions.

Examples of questions and solutions:

- <u>Which approaches do you use to reach the defined target group?</u>
  Solution approach: Development of concepts for user-centered approaches and implementation of the user interface of the application, e.g. in the form of storyboards with a continuous user story or GUI prototypes.
- <u>With which technical concept do you achieve the desired solution?</u>
  Solution approach: Technology evaluation, development of technical solution concept (PoC), definition of subsystem decomposition, architectural style and technologies.
- <u>Which interaction concepts, interface designs and visual languages are suitable for your approach?</u>
  Solution approach: Development of interaction concepts and graphically carefully designed, clearly structured imagery for interface design, which meet the requirements of an innovative user experience.
- <u>With which technical implementation do you meet the requirements for functionality, usability, reliability, efficiency and maintainability?</u>
  Solution approach: Implementation of an executable application for a previously evaluated setup and defined usage scenario based on suitable technologies and frameworks
- <u>Correctness, usability and reliability are central to the successful introduction of the software. How can you ensure and test them?</u>
  Solution approach: In-depth testing of correctness, usability and reliability, documentation of test results, demonstration of the fulfillment of the requirements by means of live test.

Methodology
Describe how the goals are achieved. Which methodologies do you use for this (e.g. Scrum, Agile, scientific approach, etc.).

Planning
Create an initial project schedule. Define work packages and their deliverables.

Risk Assessment
Identify and evaluate risks within the project and develop strategies for dealing with them.

2. Documentation

2.1 Written documentation (Thesis Rapport)

Document in writing and electronically your approach, the theoretical background, the application of methods and concepts, the implementations and test results. Also check the planned with the actual schedule, the achievement of goals and reflect on experiences.
Be sure to strictly separate personal comments from facts. **The main part of the documentation is completely fact-based**. This means that no sentences of the kind "Then we had the problem x and tried to solve it with y" are allowed to occur. But if such a problem x really exists and not only you did not get to the edge with it, then you should write: "Tests z have clearly shown that a problem x exists. Possible approaches to solve problem x are a, b and c. We chose variant c for reasons e and f." Only in an extra section can you formulate your personal impressions, experiences, problems and the like.
It is also important that a good documentation must still be read after many years and that it gives the reader a well-rounded picture, even if he was not directly involved in the work. Please also attach great importance to linguistic quality.
The target audience of this documentation are the supervisors, the experts, the client and future students who want to continue working in this area.
The documentation is created during the course of the project. For the second coaching meeting, a table of contents of the report should be prepared so that it can be discussed with the supervisors.
The parts for research and analysis are to be presented after the first third of the project.

On the web portal of the FHNW you create a project presentation (web summary). For bachelor theses in the spring semester, you will also create a poster for the exhibition. Both artifacts must be discussed with the supervisors prior to publication.

The following information must be mentioned on all publications:
- Logo FHNW
- Semester project IP5 or Bachelor thesis (IP6)
- Project name
- Spring- or Autumn Semester 202x, Degree Programme Computer Science (Profiling iCompetence), University of Applied Sciences and Arts Northwestern Switzerland
- Submitted by: Name of Students
- Submitted to: Name of Supervisor
- Client: Company / Institution
- Date

Further information on writing reports can also be found on the Information Literacy Platform

2.2 Presentations

Presentations take place in consultation with the supervisors and the client. The expert will also be present when defending your bachelor's thesis.

On the one hand, presentations provide an overview of the entire project and the results achieved and deepen one or two important interesting questions. Also part of the presentation is a concise demonstration of how to use your software. With the audience, you can expect a technically experienced professional audience. Schedule 30' for the presentation and demonstration and reserve 30' for questions and discussion.

2.3 Publication of the project results

If the work or parts of the work are published, all names of the project participants (students, supervisors, clients) as well as the name of the institution (FHNW) must be mentioned. Before each publication, supervisors and clients must be asked for their consent in advance.

2.4 Protocols

Protocols are an important part of the documentation. Professionally managed protocols contain the following points:
- Date, Space, Time, Participants, Excused
- Agenda
- Project status (possibly with screenshots, sketches, etc.; Status according to planning)
- Content (fact-based, thematically structured and comprehensible in terms of content; Decisions are recorded)
- Open questions
- Next steps; Appointments & tasks (who, what & until when)

2.5 Document repository

Set up access to your document storage for the maintainers. If there are no compelling reasons against it, use the Gitlab infrastructure of the FHNW[1].
Also, use this document cabinet to store additional documentation, such as how to run your code. Make sure that an adequate commit history is visible to the caregivers.

2.6 Submission

[1] https://gitlab.fhnw.ch/

The project submission includes (unless otherwise defined with the project manager) the following artifacts:

- Written documentation (Thesis Rapport)
- Project agreement (on the shelf as an appendix in the thesis)
- Codebase (documented & with readme to explain the setup),, hosted on GitLab of the FHNW (https://gitlab.fhnw.ch/iit-projektschiene/[semester]/[project]) and as a ZIP archive
- Link to the project appearance on the FHNW web portal
- other artifacts, if available (screencast recommended, ...)

3. Project-specific agreement

3.1 Starting situation

The FHNW School of Engineering is present at numerous marketing events every year to promote its study programs. This is done to give potential students a compact insight into the offers and premises of the FHNW Brugg-Windisch campus, and to demonstrate the advantages of the location. To provide potential students with a fun and innovative experience, an interactive XR app is to be developed.

The main use-case is on events to promote the FHNW School of Engineering’s study courses by an engaging and memorable experience. Prospective students will get to know the FHNW, its campus in Brugg-Windisch and see special places and projects within roughly five minutes of playtime.

3.2 Project vision

Our overarching vision for this project is to develop an engaging and memorable XR experience for prospective students to leave an impression of the FHNW campus, arouse interest in the FHNW School of Engineering’s study courses and therefore attract new students.

The aim of this work is the development and implementation of a game concept for an interactive XR application that is attractive, engaging and memorable for future students (teenagers, young adults) and stands out by a good user experience and a high usability. The developed concept can be used as a marketing and promotion tool for events. In order to offer the aforementioned target group a vivid insight into life, the offers and the premises on campus, 3d models and 360° images of certain locations play a central role in the experience.

3.3 Questions

A. How can a high user engagement be achieved, measured, and tested in an interactive XR experience?

B. How can a high memorability of the experience be achieved, measured, and tested in an interactive XR experience?

C. How can realism such as high-resolution or photorealistic textures of 3d models impact user engagement and memorability in an interactive XR experience.

In addition to the project-specific questions, the following generic questions will be considered in the implementation of their work:

D. Identification of suitable scenarios and user interface prototyping: Which approaches do we use to reach the defined target group of prospective students, age 18-25 with technical background or interests?

E. With which technical concept can we achieve an engaging, memorable, and seamless experience through different locations of the FHNW campus?

F. Which interaction concepts, interface designs and visual languages are suitable to create the best experience?

G. With which technical implementation do we meet the requirements for functionality, usability, reliability, efficiency, and maintainability?

H. How can we ensure and test the correctness, usability, and reliability of our implementation?

3.4 Methodology

This project will be run in an agile manner. Rapid iterations will result in time-sensitive solutions and allow fast error correction and frequent communication and meetings with the customer and supervisors will guarantee the project's direction and progress. To get a quick and continuous overview of the project's state, the planning and impending activities will be developed and organized using a Kanban style board. The user-centered design is ensured through regular testing of the theoretical and practical prototypes with the target group with the aid of this task- or issue-based project overview, as well as the tasks in all other areas such as requirements engineering or scientific activity.
To test and validate our product, we have planned to take part in at least two events which correspond to both the main use-case of the product as well as the target group. Further, all features shall be tested and validated by a small group of testers.
For the technical side, Unity will be used together with a collection of frameworks, tools and packages that come with Unity. As Unity works on C#, the main programming language will be C# for scripting.

3.5 Planning

The most important and largest work packages:

- Design of User Tests
- Implementation of User Test Application
- Conduct of User Tests
- Implementation of Main Application
- Writing of the Project Documentation

Our largest work packages also represent most of the milestones of this project (effort estimated in person-hours):

MS1: Research Project - Environment	
Goals	A first research project is setup and can be user tested to test user engagement and memorability based on the realism of the environment.
Activities	WG1: Research how user engagement and memorability can be measured. WG2: Research how user engagement and memorability can be enhanced by realistic environment. WG3: Setup a Unity project with different grades of realism WG4: Setup User Test WG5: User Test the project at the Studienmesse Baden
Deliverables	First results of the research project
Start	CW 42
End	CW 45
Effort	Approx.. 90-100 h

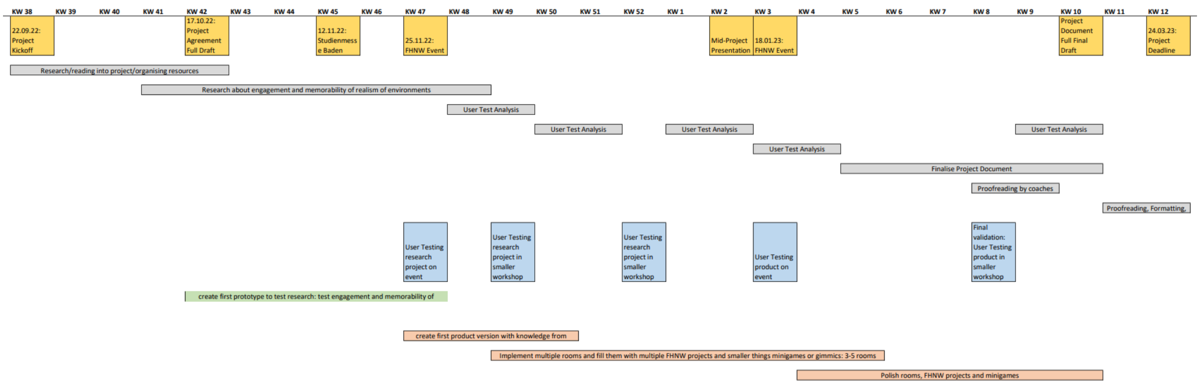
MS3: Product - Concept	
Goals	The main project (product) can be user tested to verify the basic concept.
Activities	WG1: Setup a Unity project with 1-3 simple rooms and a few simple FHNW projects WG2: Setup User Test WG3: User Test the project at the FHNW event (25.11.22)
Deliverables	First prototype of the product, containing simple rooms with a grade of realism based on MS1.

Start	CW 44
End	CW 47
Effort	Approx.. 100-110 h

MS4: Product - MVP	
Goals	The main project (product) contains 3-5 rooms with FHNW projects and smaller world-filling items and can be user tested.
Activities	WG1: Setup a Unity project with 3-5 filled rooms containing FHNW projects and other world-filling items WG2: Setup User Test WG3: User Test the project at the FHNW event (18.01.22)
Deliverables	MVP of the product, containing 3-5 filled rooms with a grade of realism based on MS1 and containing sound based on MS2.
Start	CW 47
End	CW 3
Effort	Approx.. 190-210 h

MS5: Product - Final validation	
Goals	The main project (product) contains 3-5 polished rooms with FHNW projects and smaller world-filling items and can be user tested for final validation.
Activities	WG1: Further fill and polish the game world based on MS4 WG2: Setup User Test WG3: Organize workshop WG4: User Test the project at a workshop for final validation
Deliverables	Pre-final product, containing 3-5 filled and polished rooms with a grade of realism based on MS1 and containing sound based on MS2.
Start	CW 4
End	CW 8
Effort	Approx.. 100-120 h

The detailed plan can be found in a separate file (MS Teams file).



3.6 Risk Assessment

Risk	Measure	Priority	Probability
COVID-19: New regulations regarding a corona outbreak could largely impact on our planning, as no events could be organized, and user tests would need more organizational time	Prepare User-Tests and questionnaire in a way that could be used in a remote/one-on-one session, so that analysis and verification could still be done	Medium	High
Failure to meet milestones due to fault in planning or delay	Regular review and adjustment of the project planning if needed to be able to react quickly	Low	Medium
Consideration of incorrect requirements due to misunderstandings	Regular consultation and updates with the client to quickly clarify any misunderstandings	Low	Low
Loss of data	Data backup for documents via MS Teams and for code via GitHub	Low	Low
Div. problems due to miscommunication	Regular meetings and close, informal communication as well as formal protocols to ensure good communication	High	Low

4. **Final provisions**
The undersigned acknowledge that they have read and understood the text and undertake to comply with the points listed and the general duty of care with their signature.

Windisch, the …30 November 2022..…

Supervisors

Arzu Cöltekin ……………………………

Cédric Merz ……………………………

Students

Thierry Odermatt ……………………………

Andreas Leu ……………………………