

Universität Stuttgart

BACHELOR THESIS

VISUALIZING INSURANCE RISKS AND ACCESSIBILITY PROBLEMS WITH VIRTUAL REALITY

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Bachelor Thesis

Visualizing Insurance Risks and Accessibility Problems with Virtual Reality

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Commenced:	February 1, 2023
Completed:	August 1, 2023

Abstract

Since the availability and technology advancement regarding Virtual Reality technologies reached sufficient maturity, utilizing them in the context of education can provide us with novel and rich experiences to acquire knowledge in unprecedented ways. This provides the foundation for the two prototypes being developed in the confines of this thesis. The first prototype will be used in the context of insurance to teach participants about related risks in living-spaces. The second prototype will provide a basis for a accessibility simulation, teaching the user about potential barriers. In addition to the implementation of the first prototype a user study has been conducted.

Contents

1	Introduction	9
2	State of the Art Virtual Reality	11
2.1	Application Domains of VR	12
3	Related Work	15
3.1	Barrierefreiheit	15
3.2	Related Work Thesis	16
3.3	Related Work Barrierefreiheit	17
3.4	Insurance	18
3.5	Related Work Insurance	19
4	Prototype Requirements	21
4.1	Usability	21
4.2	Topic related	21
4.3	The Prototype Factor	22
5	Development Process of the Prototype	23
5.1	Game Engine	23
5.2	3D Modelling Software	23
5.3	Free Assets	24
5.4	VR Interaction	24
5.5	Sound Integration	25
5.6	User Guidance	25
5.7	The Different Scenarios regarding Insurance Risk Simulation	26
5.8	The Barrierefreiheit Scenario	29
5.9	The Educational Hub	29
5.10	Environment	30
5.11	First Draft	30
5.12	Second release	31
6	Documentation of the Prototype and Implementation	33
6.1	Key Concepts Unity	33
6.2	Scripting	37
6.3	In-Game Documentation	41
7	User Study	47
7.1	The Method	47
7.2	Study Documentation	48
7.3	Results	50

8	Conclusion and Outlook	55
8.1	Conclusion	55
8.2	Discussion	55
8.3	Outlook	56
8.4	Future Work	56
	Bibliography	57
A	Used Resources	61
A.1	Turbosquid	61
A.2	Unity Asset Store	61
A.3	Development Environment	62
B	Study Data	63
B.1	Extra/Tips for improvement	63
B.2	Fix Data	64
B.3	Demos	64
B.4	List of Abbreviations/Acronyms	67

1 Introduction

Virtual Reality has been at the forefront of the entertainment and social-network industry a-like, at least according to news cycles with the metaverse¹ being pushed and Apple releasing the flag-ship Virtual Reality (VR) and Augmented Reality (AR) device, the Apple Vision Pro², soon. However aside from these two domains, VR has also been used in medicine [LYS+17], tourism [TKND22] and education [CTT] with promising results. In education VR could be used to teach ideas in a novel and exciting way, being able to transfer the participant to the point of view of someone else. This could be utilized to teach people about what it feels like to live with certain conditions in an empathy inducing way [SAT21]. In conjunction with a VR experience, people could experience living-spaces from the viewpoint of a wheelchair confined person and learn about different barriers and how to provide solutions to move around them. A tool like this could also specifically help constructors of living-spaces and companions of a physically disabled person help understand their struggles in an intuitive way, or be used by wheelchair confined people themselves to review potential living spaces without physical presence. Insurances are relevant in the lives of most citizens, being able to help customers recover from potentially live-long debt, being educated about them should be in public interest. However despite this, being educated about them may seem daunting, since many different scenarios and kinds of insurances exist, with the real dangers where insurance might save customers only being communicated implicitly, potentially without eliciting much emotional investment from the customer. With VR potentially being able to re-create real-life scenarios in an immersive and safe environment it could be used to transport a potential customer into a scenario where a possible accident, which could be covered by insurance is being portrayed. In addition to increasing there perceived importance of insurance it could also lead to a satisfying customer experience. However since many people may interact with a VR device for the first time, ensuring basic usability concepts in both applications is crucial for positive results. In this thesis, a prototype educating the user about basic accessibility concepts and a prototype containing one or multiple insurance risk scenarios is going to be implemented. Additionally a user study evaluating usability attributes of the insurance risk related prototype is going to be conducted to provide feedback for a future more realized version. The implementation of the prototype is based on two foundations. First, researching and exploring the concepts of accessibility, insurance and the use of VR in different domains is going to provide the reasoning behind the development. Secondly researching different concepts about virtual experiences, such as immersion and usability is used to gain knowledge of how to achieve a product providing the prototypes functionality. In addition to the research, this thesis includes the documentation of the prototypes implementation, including reasoning behind some of the decisions leading to the final application.

¹<https://about.meta.com/what-is-the-metaverse/>

²<https://www.apple.com/apple-vision-pro/>

2 State of the Art Virtual Reality

Often when reading papers in the topic of VR in different domains, the application and potential in future use is a main topic. Rarely is VR already fully integrated into a process and stands on its own. While this often holds true, VR is growing rapidly and the availability and flexibility of these Systems has, as of 2022 reached a level where it could be used for meaningful integration into the domain of medicine, for Execute Function rehabilitation [BBP+22], indicating that for other domains, such as education this could also be the case. Because products can more easily be adapted for entertainment purposes, since there is less at stake when using them in this context, integrating them into something as crucial as education, a lot more research and infrastructure building for these fields has to be done. [Ata19]

Cybersickness can arise during VR usage. Symptoms are nausea, headache or stomach issues. They stem from a mismatch between input and expected output or latency issues [SNL20]. This can result in a very unpleasant experience for the user, which is to be avoided in every domain. But especially marketing, where a negative experience could lead to an immediate loss of interest in any product.

One potential quality of VR systems is immersion [BM07], as the user is fully encased by artificial visual stimuli, the experience can break the wall between perceived reality and simulation better than a simple computer screen. Social interaction usually decreases the immersion but can result in a more satisfying experience, however if the goal is immersion this should be avoided even if it could lead to greater satisfaction [HMPJ19]. In context of this Bachelor Thesis, increasing immersion to create an authentic experience is one of the main goals.

A digital twin is a live replica of a physical environment, meaning they influence each other in real-time, if changes to the physical version are made, they are translated to the twin. If the digital realm is manipulated, it will result in changes in the physical copy. [Bat18] The goal of the prototype regarding accessibility and even future related work is not to create a digital twin, since this would require an unneeded amount of resources for a goal that is not to create a real time interaction between digital and physical world but only a digital copy to mimic a physical place at a certain time-frame. Of course this digital copy can be updated which would be certainly integral if accessibility parameters of the physical original would have been changed. In this instance the digital Version could also precede the construction of the real building, helping with the design to make it more accessible. Because of this, the goal is not create a digital twin but a digital copy or even a digital version with difference to the current physical version. However due to limitations of the assets, a pre-made apartment with (no known) physical source material is chosen. However integrating digital copies in future work could help with determining accessibility parameters or increase the immersion of the insurance risk simulation.

2.1 Application Domains of VR

To get a better understanding of the Role of VR in the present, looking at different domains where VR is used more closely, could give a more nuanced picture.

Medicine

In Medicine VR has been playing a role since at least a decade as of 2017 [LYS+17], as it can help in several different areas ranging from training to treatment. For training VR can create a 3 Dimensional (3D) training environment where practitioners can interact with every part of the human body. Especially for learning about surgery, where practising on a real patient is not possible, VR provides a accessible method of practise. Another promising field is pain management, where patients with acute pain -ranging from burn wounds to trauma induced pain- reported relieve, in addition to this, VR has little impact on the Hospital Environment since only a Headset and a System to run the Application is required. VR can also be used for exposure Therapy, including people with social fear. It can also help children on the Autism spectrum to better learn emotional skills.

Tourism

Another avenue which has found increasing use of VR is tourism. VR tourism or VR travel is characterised by the (digital) tourist diving into digital replicas of existing tourist destinations. This domain has seen increased usage, especially during the pandemic. VR travel provides a secure, ecological and immediate alternative to travelling in real life. A 2021 paper [TKND22] found some users of VR travel to report a desire to continue using VR as a means of digital travel even after the pandemic. Another paper from 2019 [YK19] proclaims that once the Virtual environments reach a satisfying level of perceived authenticity, the questions will not be how to travel, but how to meet. Because travelling is also a largely social experience, as long as this aspect has not reached a desired level of perceived authenticity, VR travel may not be a satisfying substitute for real travel but an additional experience for avid travellers or people who can not travel physically.

Education

VR provides 3D spatial environments, means of intuitive interactions and the potential to provide perceived authentic stimulation of visual, auditory and to some extend even tactile senses. All of these are a great basis to provide educational experiences [CTT]. Google started a program in 2014 to help teachers teach with VR cardboard headsets [SAT21], alongside the paper lists many other ways VR is being integrated in some classrooms, showing a great general interest in integrating VR into school programs. Additionally Museums try to incorporate VR/AR techniques to draw in the attention of younger audiences [SAT21], for example the Dreams of Dali is a free to download VR application in which the user can experience the works of the painter Salvador Dali in a novel way. Also virtual museums with the integration of social interaction are also concepts to be actualized in the future. A decentralized way of education, e learning, which is the process of distributors

selling educational content online for anyone to consume, could also utilize VR. VR could even communicate concepts and ideas in a new way that incites empathy or the perspective of another person. [SAT21].

3 Related Work

3.1 Barrierefreiheit

In German, the word Barrierefreiheit encompasses everything that takes away barriers for disabled people of all kinds or makes it possible for them to also take part in activities with similar success as non disabled people, during this thesis, this term is going to be used interchangeably with the term accessibility. This could include an audio-version of books in a library for blind people, or books in braille. Buildings with ramps for people in wheelchairs are another example. But also lowering vitrines in museums to a level where small people or people in a wheelchair can view it comfortably. Since encompassing all kinds of Barrierefreiheit aspects would be too big for the scope of this thesis, the prototype is going to focus on reviewing accessibility of buildings in consideration for people confined to a wheelchair, however since there has been some VR applications developed for people with different kinds of disabilities like blindness [PADK14], looking into them may be beneficial to get a broader view of the role VR has and could have for disabled people. In 2018 there have been 884000 barrier reduced apartments in Germany¹, meaning they don't fulfill every requirement to be labeled completely as accessible but provide the bare necessities. Also there is demand for 386000 additional barrier reduced apartments. Some important attributes of accessible living-spaces, according to **DIN! (DIN!) 18040-2**² (A german guideline to provide accessible living-spaces), some of which will be topic in the Barrierefreiheit related prototype, are as follows:

- Accessibility of apartment complex entry
- No stairs inside the apartment
- Door into bathroom are broad enough
- Floor level shower
- Kitchen usable inside Wheelchair

However apart from these formal aspects, factors like the amount of time a person confined to a wheelchair needs to get to their apartment and other important areas of the living complex could also crystallize through the use of VR.

¹<https://nullbarriere.de/bedarf-barrierefreie-wohnung.htm>

²<https://nullbarriere.de/din18040-2.htm>

3.2 Related Work Thesis

This section is going to provide the aforementioned foundation to help deciding different aspects regarding the prototype while also providing a glimpse into scientific literature regarding thesis relevant topics.

A 2017 study focuses on the affect of flow, involvement and presence during VR usage have in information recall, in the context of learning about physical disability [CFQ17]. It cites that some studies conclude immersion does increase learning effectiveness while others claim this not always to be true. In the study walking difficulties caused by Multiple Sclerosis are simulated. To achieve that a video game like experience is generated by VR. In the study the AT&T center along with its annual fundraising walk to raise money for people with disability was reconstructed. They chose to use auditory information for the educational part of the experience. During the experiment participants were put into real wheelchairs and then hooked up to a wheel rotation translator. Each simulation took up to 55 minutes.

The effect of immersion had a great impact on information recall, indicated by the VR group scoring higher in a questionnaire that was to be completed after the experience than the control group who used a more traditional way of digesting the information. Since many of the goals of this study align with ours, some guidelines and principles could be adopted. Additionally, the findings of it suggest that a VR experience in combination with disability could greatly benefit both architects and wheelchair users in pursuit of creating accessible living-spaces.

For an older study from 2002 [PMML02] a game-like desktop application where students from school controlled a wheelchair confined person with the goal of finding 24 barriers inside of a virtual school was created. It claims that the programmed game was the first of its kind with the intend of simulating the experience of a person with disability. The study concluded that children that played the game were more aware of barriers inside and outside of schools. However the control group didn't attend any other form of education instead which the study claims is fit for future work.

In a 2018 study [SHD+18], non-isomorphic and isomorphic shopping methods were compared in a virtual apartment where the user was tasked to buy items that could be found in the apartment in their to be assumed location, e.g. soap by the sink. Non isomorphic methods were preferred which consisted of a shopping sphere to put in the items and a pointing beam to select items versus a hand-like grabbing mechanic and a conventional shopping basket. This indicates that users can adapt quickly to new methods in an VR environment and prefer their usability versus the familiarity of the isomorphic methods. For least amount of motion sickness the basket/beam combination was recommended. Users reported that they would use this method of shopping again in the future and reported high levels of immersion and user satisfaction.

Helping potential users of a building with VR is also explored in a 2017 paper [DS17]. To cater to specific needs of customers and help them realize the look and utility of a yet to be build apartment, a digital copy of the apartment is created in order for the customer to experience it through VR. This aims to increase the quality of feedback for changes in the current design. The hereby measured qualities were apartment functionality assessment and apartment space/dimensionality assessment. Even though the amount of subjects is 38, still the subjects using the VR Environment reported a significant higher mean value in both qualities. This suggests that using VR could yield positive results in the functionality assessment for Barrierefreiheit and apartments or even help cognitively learn different insurance related dangers to living spaces.

How VR is implemented in the training and construction of buildings is being explored in [WWW+18]. Here several different ways in which VR is being integrated into the aforementioned areas are abstracted from other articles, ranging from VR desktop applications, to mobile applications in more recent developments and even Augmented Reality(AR). Based on these findings they conclude that these methods have "tremendous potential to increase students' participation, interaction and motivation."

In [BAA19] a 3D software for the purpose of modelling architecture with VR tools and its effects are being researched. Here Unity is also the software of choice. The application allows users to immerse-fully design and build architecture while also being educated about the individual steps in constructing. With a sample size of 22, participants agreed to strongly agreed to the statement that the experience was educational, enjoyable and could be integrated with other teaching courses. (Mean of a 5 point Likert Scale) Both of these studies underline VR as a helpful tool in designing, rating and educating people about architecture.

Educating about potential risks through VR is done in a 2019 study [ID19] in the context of mining roof fall hazards. Here a 3D render based on a real mine has to be explored in VR by domain related people. Potential hazards have to be detected and then the correct safety measure is to be applied. During the simulation the participants walking is mirrored in VR and the hand gestures are translated to in-game movement through a wand controller. The promising results this application has for roof fall hazards could be translated as hazard identification in the context of Barrierefreiheit where architects have to identify constructions that could negatively impact a wheelchair confined person.

3.3 Related Work Barrierefreiheit

Wheelmap is a crowd-sourced tool in which users can rate locations by their accessibility [MDD17]. It is used in conjunction with Open Street Map³ and can help wheelchair users or people with other physical restrictions choose a location based in the rating, which ranges from green for wheelchair accessible places, yellow for partially wheelchair accessible places and red for not wheelchair accessible. This tool is a great example in how modern technology can help wheelchair people in their day to day life.

Apart from accessible apartments, public transit is an infrastructure important for the social inclusion of wheelchair users, however it still instills anxiety in some [VHSB16]. A 2021 Paper rates all (official) 212 global rail systems in 59 countries, then categorises them by country, continent and UN geographical region [FLF+21]. This translates to 30% of all countries having a public rail system, where these systems are most prevalent in economically prosperous countries. The paper used 7 different levels indicating the accessibility. Of all of these the most prevalent was fully accessible, roughly making up 40% of all rail systems. Accessibility is considered in a lot of rail systems, however there is still room for improvement even in developed regions like Europe, North America and East Asia.

³<https://www.openstreetmap.org/>

As of 2021 it estimates that 1,85% of the global population requires a wheelchair. Additionally wheelchair confined people have difficulties partaking in public life due to missing infrastructure. The paper cites that only in the 20th century the awareness of people with disabilities improved. [FLF+21].

In developed countries like South Korea a major interest in the design of apartments, more specifically kitchens, is the increase of senior residents. Their loss of motor functions and often dependence on a disability friendly environment increases the requirements for affected people. This is also the case for younger wheelchair confined people. The 2016 study [KL16] evaluates different kitchens for their wheelchair accessibility and works out solutions on how to increase the parameter. It concludes that kitchens are often difficult for the disabled people. To provide clear floor space, a working triangle and everything to be in range the sink and refrigerator often had to be moved. In addition smaller kitchens often need extra counter-tops and the heights of these in addition to sink size also needed adjustment. The studies findings suggest the difficulty and lack of general work for all solutions for accessibility in kitchens, however with the available space an accessible kitchen can be arranged. The study included 5 parameters for evaluating accessibility which could be relevant for the prototypes assessment of the kitchens.

3.4 Insurance

Before designing and developing a prototype for insurance customers, limiting potential domains of types of insurances could help to decide the focus of the prototype and which insurance companies to ask for advice and input. Because the prototype is going to be used in Germany for the focus of this research, restricting it to German Law is the first step. *Industrierversicherungen* by Carlheinz Mikosch⁴ is a lecture designed to help Customers of insurance companies help navigate through laws and types of insurances. Unmovable objects is a category that seems fit for the purpose for the apartment domain, however, since people are also at risk in apartments some subcategories from Insurance of people is also relevant. For objects located in a persistent place the following types are listed:

- (I) Fire insurance
- (II) Insurance from theft
- (III) Tab-water insurance
- (IV) Insurance for storm related damages
- (V) General danger insurance
- (VI) Insurance for tech related items (with subcategories)

For a simulation all of these could be used for a satisfactory user experience, but the most interesting categories for a VR Simulation might be I, III and IV since here a visceral experience could underline typical scenarios in which these insurance types might save the customer from financial risks.

For person related insurance types the following are listed:

⁴ISBN: 978-3-322-90891-9

- Life insurance
- Compensation insurance
- Health insurance
- Term life insurance
- Endowment insurance

Compensation insurance is split up into private and public Compensation insurance. The importance of one of these could also be communicated in the prototype. Tab water damages and fire damages are one of the most ubiquitous regarding a household and therefore having them covered in Germany is often done by the Hausratsversicherung or the Gebäudeversicherung, which are Insurances that get automatically booked when renting or buying a flat. Tab water insurance covers everything where tab water is ejected in places where it is not foreseen or used and its corresponding damages. The difference is that the Gebäudeversicherung covers only the direct damages where the Hausratsversicherung also covers the restoration of the installation. These kinds of damages occur more often in older housings which have not been restored to new technology, therefore some insurance companies do not cover houses or apartments up to a certain year of construction. For the insurance related prototype, fire and tab-water damages, covered partly by Hausratsversicherung and Gebäudeversicherung is going to be picked out as the theme overarching the implementation.

3.5 Related Work Insurance

A paper from 2013 [KBW13] evaluates health insurance literacy, which is the ability to use knowledge about health insurance for decisions regarding the domain, in the United States. It concludes that many consumers do not have the knowledge on how to make optimal health insurance related decisions. This could indicate a need for insurance related education. Another study, aiming to evaluate knowledge about long-term care insurance in Canada supports this claim [BDF+17]. In 2002 the effects of educational materials about certain health insurance programs translated to knowledge about the Medicare and Medicare + Choice program. Positive effects were measured, while modest, showed greater results than the traditional informational sources about the program. [MGH+02]. This could suggest the potential in alternative educational methods related to insurance.

4 Prototype Requirements

4.1 Usability

One of the most integral attributes that a Software must provide is usability, even more so in the context of customer persuasion [MD96]. Because previous VR usage cannot be guaranteed with all users, as only 17% of Germans report regular VR usage as of 2021¹, giving instructions to inexperienced users could increase usability factors for them. This could be achieved by a small briefing held by instructors or in-game instructions. Usability factors are going to be a focus for the prototype implementation. According to the ISO 9241 [KZL22] usability can be split up into five subcategories:

- Learn-ability: how easy it is to accomplish basic tasks the first time the device is being used.
- Efficiency: How quickly tasks can be achieved once it is learned by the user
- Memorability: How easy is it to reestablish proficiency the next time the device is being used
- Errors: how difficult is it to produce errors and how easy can they be recovered
- Satisfaction: How pleasurable is the usage of the device

Although these provide a strong framework to examine usability some of these are not as important in the context of the prototype. Memorability and efficiency most notably won't be as important in a small scale simulation setting as most users won't return to the experience and the functionality is only means for the simulation to take place, not to accomplish a specific task. Since the actions will be very limited, for the sake of learn-ability, error reduction and scope of the prototype, memorability and efficiency will also loose in importance. When conducting studies to assess and increase usability of a product, often a qualitative study with fewer users can be used to assess the needs and incorporate findings in early development. [KZL22] The researchers from Poland conducted a paper that aims to generate autonomous analysis of VR usability. The additional requirements are that the user experience is not disturbed by the methods used during application. During the study the System Usability Scale² has been implemented to assess the usability score of the software.

4.2 Topic related

Before looking at quality measures like usability, the topic related requirements need to be addressed, what needs to be implemented on an abstract conceptual rather than technical level is going to be evaluated here.

¹<https://de.statista.com/infografik/14533/aktivitaeten-in-der-virtual-reality/>

²<https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html>

4.2.1 Risk Simulation

The first part of the prototype is the insurance related risk simulation. Here the user should be experiencing some type of accident that will underline first how easily the mentioned accident can happen, and secondly how important it is to have that part covered by insurance. However this needs to be communicated implicitly by the experience and the user should make that connection on his own, functioning as the reward of the experience. This incident should happen in an apartment as opposed to a house, to reduce the scope of the experience and have the user flow more directed, since less rooms are there to discover, which turned out to be an important decision since even the few rooms in the apartment were sometimes enough to overwhelm participant during the study.

4.2.2 Barrierefreiheit Tool

The Barrierefreiheit related prototype will be based on the functionality and environments created for the insurance related prototype. Its scope will be very limited and serve to propose a software with the intend of educating the user about wheelchair confined people facing barriers in living-spaces. To achieve this, potential barriers in the apartment found also in the insurance prototype, will be visually highlighted. The experience will also include a knowledge-hub where different guidelines, din18040-2³ used in Germany to help provide accessibility in living-spaces for wheelchair users and generally physical disabled people alike, will be displayed.

4.3 The Prototype Factor

Since the here to be implemented experiences are prototypes of a potential more realized version, making out the core functionality that has to be implemented and features or qualities that could improve the experience but are not as necessary for a first user evaluation and therefore can be omitted, is part of the process.

³<https://nullbarriere.de/din18040-2.htm>

5 Development Process of the Prototype

The development process for insurance related simulation is split into two version of the prototype, a first draft to get feedback for the full implementation of the prototype, and the finalized version that will be used during the study. For the Barrierefreiheit related Prototype just the implementation without feedback was used to create a foundation for possible future work.

5.1 Game Engine

First, to create a working 3D simulation a medium through which this is accomplished needs to be chosen. Since the prototype requires a controllable character in a 3D Environment a modern game engine can save a lot of time and provide the necessary tools to realize the product. Through recommendation and shifting through multiple articles¹²³, Unity⁴ seems to be the main contender. Its inclusion of easily to implement VR integration and interaction cements this decision. The other main contender Unreal Engine⁵ does not have as strong of a VR support, in addition with several the developer having previous Unity experience, Unity was being decided on. Unity uses the programming language C#⁶ for its scripting and supports several tools to design 3D objects and generate landscapes with ease, however the features of these tools are limited compared to a common 3D modelling software, which could be required in some instances.

5.2 3D Modelling Software

Blender⁷ is a free licensed 3D modelling and editing software that provides many features to design and export 3D objects. In additions its popularity leads to an abundance of material about the different ways to achieve a desired outcome. Due to these factors Blender was chosen initially in case 3D objects needed to be designed and imported into the prototypes. However since Unity offers some free assets in its asset store⁸ that fulfill the prototypes needs for 3D objects in addition to free 3D FBX files from websites like Turbosquid⁹, the use of a 3D modelling software has been abandoned relatively early into the project.

¹<https://www.g2.com/categories/vr-game-engine>

²<https://www.slant.co/topics/2202/ best-game-engines-for-virtual-reality-development>

³<https://servreality.com/blog/the-best-game-engines-for-virtual-reality-applications/>

⁴<https://unity.com/de>

⁵<https://www.unrealengine.com/de>

⁶<https://learn.microsoft.com/de-de/dotnet/csharp/>

⁷<https://www.blender.org/>

⁸<https://assetstore.unity.com/>

⁹<https://www.turbosquid.com/>

5.3 Free Assets

Both simulations will take place inside of buildings, however since the insurance simulation prototype is the first to be developed, looking for usable assets in this context is an early priority to assess the needs of a previously mentioned 3D Modelling Software and the graphic style in which the prototypes digital environment will be enveloped. Very early on an apartment came into consideration as the place of interaction for the insurance related prototype since this could offer a more confined space compared to an entire house, thus providing the user with a shorter more cohesive experience and making it easier for the developer to control the course of actions a typical user might take. The Apartment Kit by Brick Project Studios¹⁰ provides several different prefabs (in Unity this means a fully assembled object with possible components ready to integrate into any Scene) for apartments, ranging from a single story apartment to a an entire apartment complex with several, uniquely designed Apartments. Furthermore the asset provides all of these prefabs with high quality and realistic textures and form, including single objects with multiple individual parts, allowing for easier scripting. This asset is the base for the insurance prototype since it provides a scene with high immersion and satisfaction.

5.3.1 3D Objects - FBX

Apart from using assets from the Unity Store, it is also possible to import 3D objects from various online sources and in various file types, one of them being .FBX which stands for Filmbox and originates from the 3D software Autodesk¹¹. The website Turbosquid¹², which provides 3D-objects in different file formats, was chosen in cases where the Unity Asset store did not provide a specific object that could be utilized in the prototypes. The 3D model of the pan used in a scenario was downloaded under free license from this website, a full list of all the objects can be found in the appendix.

5.4 VR Interaction

In addition to a place and context where the simulation takes place, another key factor to increase immersion and teach the user about insurance risks through an satisfactory experience is the interaction between him and his environment. The key interactions take place during the scenarios in which the user experiences accidents like a skillet going up in flames, however small interactions like the closing and opening the door through which the user enters the apartment can also play a role in making him accustomed to his environment and teaching basic VR interaction. An easy and universal way of achieving this is the Unity XR Interaction Toolkit¹³ which provides cross platform interactions which can be used by several controllers like the Vive or Oculus. In addition some key interactions like the grab mechanic have a script through which this interaction can easily be integrated into the simulation. The first VR interaction that was implemented into the

¹⁰<https://assetstore.unity.com/packages/3d/environments/apartment-kit-124055>

¹¹<https://www.autodesk.de/>

¹²<https://www.turbosquid.com/>

¹³<https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@2.4/manual/index.html>

prototype is the opening of the door which is possible with the XR Grab Interactable¹⁴ script. Additionally to things that need interaction based on the scenarios, there were also some interactions being implemented that have no further function other than to increase the immersion, for example throw-able objects like a wine bottle, located in the living room of the apartment.

5.4.1 Movement

In most Virtual Reality applications two types of movement are possible. One is the ordinary controller based input, like the use of a bumper sticker to move the character inside the application around. However VR also introduces a second option, which is to translate real world movement through sensors into in-game movement [Gil16]. The second option, while increasing immersion, is very limited due to real-life constrictions like cable length and room size. In addition to physical movement, through which the character is moved across the scene, camera (which controls what a user sees in the application) movement shares the same properties and is also required. However in this case the headset movement which is then translated to camera rotation is sufficient to fully experience a 3D-world. Additional controller input related camera movement acts as a convenience and could increase the accessibility of the software.

5.5 Sound Integration

The absence of sounds decreases immersion of the user a lot [GLN] therefore integrating sound is significant in ensuring an immersive experience for both experiences. The main focus is to create sounds with the key interact able objects such as the drill and the pan in case of the insurance related simulations. Also sounds that are result of the users actions. For the cooking accident, sound effects for the fire going off, the cooking process itself and the water tap were added. Since environmental sounds such as a forest backdrop were not rated as important for impassiveness [GLN] however could still be used as a tool for conveying the scenario more convincingly. Regarding the sound of walking, players also found sounds that were repeating too often sometimes annoying [Col13], for the integrated sound to add to the experience, it should not irritate the player. This is especially tricky for dynamic actions like opening a door where determining the start and the end of the action could lead to a sound repeating in an irritating way.

5.6 User Guidance

To ensure the intended output of the VR experience, some measures need to be taken into account to guide the user into the right direction. This includes teaching him how to interact with the environment, specifically the tools needed to trigger and complete the events and indicating what these tools and events are, these measures to increase learn-ability could increase end-user satisfaction [CC04]. For the first draft highlighting certain tools with a glowing outline before first interacting with them leads to a quick and immediate learning experience. Once the user interacted

¹⁴<https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@2.0/manual/xr-grab-interactable.html>

with a usable tool and it stops glowing it suggests that the tool is interact-able but by stopping it will also indicate a successful interaction. If an object will start glowing after a specific event, it could also suggest to the user that in order to progress in the scenario he now needs to interact with the newly glowing object. This sacrifices the enjoyment of finding the scenarios and interactions on the users own but will also diminish frustration if they otherwise would not succeed. Because of the circumstances and the low expected skill-level of the user this approach might lead to more satisfying results than leaving them to their own devices.

5.7 The Different Scenarios regarding Insurance Risk Simulation

5.7.1 Drilling into a Water Pipeline

Since tap water damages are one of the most prevalent risks in a home setting, the choice to include a scenario involving it was based upon this. Additionally water damages are often immediate and of visceral nature. To provide a guideline for the development of the prototype, the following User Story, a piece of functionality in a software described from the users perspective [Gan13], was created:

- I approach a room, which includes a wall where a hole or more need be drilled in, which is indicated by highlights.
- Inside of the room is an also highlighted drill, which i can grab. This interaction was learned beforehand, or is indicated by a floating graphic
- Once i have grabbed the drill, a tool-tip will reveal which button i have to press to activate it.
- If i drill into one of the highlighted screws for x amount of time it will give me positive feedback and an indication for doing the right action during the act will be shown.
- One of the holes represents the place where a pipe leads through the wall, which will trigger an event including water coming out of the wall and a water level slowly rising until a certain point.
- During this event the pipe inside of the wall will have a glowing outline to teach me why the water is spilling outside of the wall.

Implementation First Draft

For this draft, not every part of the user story needed to be fulfilled since the demo would be played by the developer. For this draft, the following list of features needed to be implemented:

- A powered screwdriver to screw the screws into the apartment contained painting, changing states when activated
- Screws that will interact with the running screwdriver and be highlighted until drilled a sufficient amount
- One screw that will trigger the "disaster event"when drilled a sufficient amount

- A particle System, indicating water leaking out of the wall.
- A rising water level that will start when the disaster event is triggered, indicating the dangers water leakage.

Since no sufficient powered screwdriver model was found, a drill has been used in its place. Additionally to that the drill is not affected by gravity, increasing its usability but decreasing immersion. However as previously mentioned in the paper usability is more important for user satisfaction than immersion which is the reason for this decision. Another perceived error in this version might be the water not flowing out of the apartment even with open doors. This is due to the water mechanism being just a water block prefab, continuously increasing its Y-value (the height axis in Unity) to a certain threshold when triggered. How this error was to be fixed in the final version was yet to be discussed.

Prototype Implementation

The scenario implemented in the first draft turned out to be very similar to the version used for the prototype with only minor changes added due to the fact that an inexperienced user was to play it. With additional bug fixes and polishing an experience with the following user-story as reference was to be implemented:

- I will see instructive images upon entering the simulation.
- Upon exploring the surroundings i see the apartment, entering it through the door.
- Approaching the bedroom i will see a painting with 4 highlighted screws attached to it.
- I may try to interact with the screws by hand but fail in drilling them in, encouraging further exploration.
- The drill, highlighted in yellow, will then be picked up and emit a sound upon pressing the activation button
- With the newly acquired drill i may now screw in the screws.
- Upon finishing the upper right screw, water will start flooding out of it.
- I may now roam around the house in panic searching for a tool to stop the accident.
- After a predetermined duration i will be transported to the knowledge-hub.

5.7.2 The cooking accident

Another active insurance damage a person can create inside their home includes fire, which can, for example, emerge during cooking. For this scenario the user will cook something which will then start burning, following this the user is asked to get rid off the flames with tap water, resulting in a more severe accident. User Story:

- I approach the kitchen, the stove is turned on indicated by a gas flame. Above the flame a skillet with some food items is located.

5 Development Process of the Prototype

- The skillet's handle is highlighted, indicating a possible grab interaction.
- Once I grab the handle, a graphic will indicate the food needs to be cooked above the flame.
- Once I have cooked the food for a certain amount of time, the skillet will go up in flames and smoke will emerge from it. The fire alarm will go off urging me to act.
- If this happens, the faucet will be highlighted, indicating that I should try to get rid of the flames by putting it under running water.
- If the pan gets into direct water contact, it will go off in bigger flames and smoke.

Implementation first Draft

Congruently to the drilling into a water pipeline scenario, the first draft of the cooking accident will also omit some features that are going to be implemented for the final version of the prototype. The list with to be implemented features of the first draft is as follows:

- An interact-able skillet containing a food item.
- A stove with an active flame, it will trigger the first stage of the disaster.
- Two particle systems, each representing a different stage of the disaster, a smaller and a bigger flame.
- A particle system on the faucet and an interact-able faucet that will trigger the second stage of the disaster
- Highlighting outlines that will be applied through different stages of the scenario, indicating possible key interactions.

To avoid unwanted interactions with the food, the skillet and its environment, the food will be attached to the skillet and not have physics on its own, since its only purpose is to serve immersion and not actually interact with its environment.

Implementation Prototype

In addition to adding user guidance, polishing and bug fixing, an event containing a phone ringing was to be implemented, resulting in the following user-story:

- I will see instructive images upon entering the simulation.
- Upon exploring my surroundings I see the apartment, entering it through the door.
- I approach the kitchen, the stove is turned on indicated by a gas flame. Above the flame a skillet with some food items is located.
- The skillet's handle is highlighted, indicating a possible grab interaction.
- Once I grab the handle, a graphic will indicate the food needs to be cooked above the flame.
- Once I have cooked the food for a certain amount of time, the phone will ring and disrupt the user's action.

- Upon taking up the phone, a signal indicating a failed call appears, i will return to my disrupted cooking session.
- Re-entering the kitchen i will find the skillet in flames, the faucet will be highlighted, indicating that i should try to get rid of the flames by putting it under running water.
- If the pan gets into direct water contact, It will go off in bigger flames and smoke.
- After a predetermined duration i will be transported to the knowledge-hub.

To aid the problem of the open entry door, revealing the block of water, upon entering either scenario the door will be automatically closed and lose its ability to be interacted with. However due to no sufficient screw-driver model or bit to be found, in addition to time constraints, the mismatch between expected real-life counterpart and actual in-game model of the drill still remained.

5.8 The Barrierefreiheit Scenario

For the scenario regarding accessibility for wheelchair confined people the apartment environment also seemed fit, since increasing awareness of what is required for an occupation to be accessible and the need for them could help to increase architects and investors willingness to build and buy apartments with the required features in mind. This time the experience will be mostly non interactive with focus on education through visuals. The user is set to explore the apartment through the lens of a wheelchair confined person. This will be achieved through highlighting parts that could decrease the accessibility of the building. Since the apartment is not set to be either particularly accessible or inaccessible it will be a more randomized representation of an apartment. After that the user will also be teleported into the knowledge hub, this time containing information about accessibility. For a guideline the user story is as follows:

- I find myself outside of an apartment, with brief instructions on how to navigate through the scene.
- When entering the apartment a tooltip explaining the purpose of the simulation will be shown.
- Now i can explore the different rooms of the apartment, with some containing highlighted furniture indicating their lack of accessibility.
- If i enter a small room with an exit indication, i will be teleported into the educational hub.

5.9 The Educational Hub

The educational hub will be the final location of either of the prototypes. Inside some information regarding the respective topic of the prototype can be read by the user to learn some insights. After the educational hub is left, the simulation ends.

5.10 Environment

Apart from the apartment, the place where the main part of the simulation takes place, an environment in which the apartment is placed can function to increase immersion and user satisfaction. From a pure realism standpoint it would be most suited for the environment to be a town, a place in which apartments are found in abundance. However implementing a functional and immersive town/city environment comes with a lot of challenges, especially for the time-frame and focus of the thesis. Assuming a free asset for a city would be integrated into the simulation, an empty city without inhabitants would most likely not feel very immersive, requiring an integration of people occupying the streets. This would break the scope of this thesis. A quick look into the Unity Asset Store revealed that NPC (Non Player Character) or human models exist royalty free in some capacity, however they need animations and routes to walk along, since standing still human models would also decrease immersion. Another factor is optimization since the rendering of said animations could result in cybersickness if not implemented correctly. For these reasons a more remote location, like a place in nature would probably be the best choice to optimize immersion for a manageable time cost and skills required.

For these reasons, a low poly Environment with hills, a lake and some trees is chosen, this setting was used for the first draft and both prototypes.

5.11 First Draft

To gain an additional perspective from people more closely related to the domain of insurance, a first draft of the prototype has been shown to a few Fraunhofer associated people working in the field of insurance, some of them in the field of housing insurance. This was done in the pursuit of getting feedback that could potentially be integrated into the process of prototype implementation. To demonstrate the functionality of the first draft a live demo and prerecorded footage in case of failure was prepared. The prerecorded footage also serves as documentation and a link will be attached to the appendix. Since this version of the prototype was demonstrated by the developer, someone who already knew what to expect from the interaction between the world and the controlled player, some precautions that would later be implemented to guide the user experience were not required. This caused the first draft to contain the two chosen scenarios earlier mentioned without any user orchestration around them. Moreover this first draft did not contain the tutorial that teaches the user how to interact with objects and how to move. However, since the user does not know what to expect from the simulation, the feedback on how a user would interact with the simulation would not be received until the study containing the final version of the prototype would be executed.

5.11.1 First Draft Demo

For the demo of the first draft, several people working in the insurance field associated with the Fraunhofer IAO were asked to attend an online meeting and give their feedback for the first draft. In addition they gave their feedback on how the prototype could be integrated into the process of customer counselling. The meeting began with everyone introducing themselves and talking about their experience with VR. Some of them had little to no experience while few of them reported exposure to VR especially in their private lives. Then our intent with the prototype was explained,

in this time-frame the intent was to use the prototype while people were waiting for the counselling. One attendee reported that the waiting times were too low for a VR experience, often being only a few minutes. It was also suggested to use the simulation during counselling to specifically show ways in which different insurance packages can save the customer from debt. To aid the lack of time during waiting times, someone proposed to ask customers after the session to use the VR headset for an experience. After the intent and the scenarios were briefly explained a live demo was successfully started. However it came to a sudden halt and the recorded demo was used instead. After both scenarios were shown, we asked the attendees for feedback. Generally the most common feedback was to give the user a way to aid the situation after the accident had taken place and a place inside the simulation for further education. The lack of sound was a main concern, however, this feature was already planned for the second release. Additionally a more direct way of leading the user to the different scenes was wished for by some. Suggestions that are more fit for a future release, outside of the scope of this thesis were made, like ordering the scenarios by insurance types and teaching about said types. Also more elaborate resolutions like firefighters to extinguish the fires could lead to more captivating and immersive experiences. In conclusion the most common suggestions were something that was planned for future development in addition with some ideas that are either unfit for the product or out of scope, but could be implemented in the future. Most attendees were eager to use the finished product or showing it to their company to colleagues.

5.12 Second release

After the demo was shown and the feedback received, it was time to compare the feedback from the demo and our own plans for the more realized version of the prototype. In addition to the insurance related simulation, the Barrierefreiheits simulation was the next thing to start implementing.

5.12.1 Insurance Risk Simulation

Gathering feedback from the demo and comparing it to the previously created user-stories, three main tasks, apart from polishing the product, emerged.

The Epilogue/Ending

After the user has gone through one of the scenarios, how the experience ends is a crucial factor in how the user will remember the experience, additionally it should be clear when the experience has ended. As already mentioned in the live demo feedback, it was wished to have the experience end in some type of educational hub where the user is being shown some stats and knowledge about the insurance factors surrounding his experience. However for the specific endings of the scenarios itself competing ideas emerged. The main decision to be made was whether or not the user should solve the issue before the scenario ended. This added interaction could increase user satisfaction and provide the player with a sense of accomplishment. In contrast, the scope of the simulations is not to provide an easy on the hand fix for the problems caused but to undermine their severity and need for outer force, e.g. the insurance, to help the fictional character deal with the aftermath of the caused accident. Therefore the decision to leave the apartment in bad condition without a satisfying conclusion is afferent to the wanted learning experience the simulation should provide.

Sound Integration

Adding sound to the experience was also a given feedback. As already mentioned earlier sound increases immersion if done correctly and can also be used to guide the player, like the phone ringing indicates that the player should interact with the phone object. Therefore its not a question if sound should be integrated, but the choice of sound-clips for the interactions and objects. Apart from the main interactions where one would assume sound, subtle additions like sounds from the feet while walking or objects like the pan colliding with its environment could increase immersion and the quality of the experience but are not necessary and could, if implemented in a satisfaction reducing manner, do more harm than good.

Use Guide

Since incorporating usability concepts into the prototype, adding instructive measures into the application in order to accustom the participants to potentially previously unused technology could be crucial to achieve end-user satisfaction and provide a usable software. Since there are different controllers for VR with different inputs being mapped to actions in the simulation, either knowing which controllers are going to be used in the study, or having different guides show up depending on which device is being connected to the execution environment is a requirement for an efficient use guide. Another option is a graphic or text based manual outside the game, which would also have to be present during the experience and be read by everyone, including people who are eager to start the simulation and maybe not be inclined to carefully read a manual. However adding in-game guidance to the Software could add independence since the application could be used without or less amounts of outside instructions. Even if the subject can put the headset on, which should be intuitive by the look of the VR headset, they could have the needs for some form of guidance inside the application, if they are not familiar with VR controls. This could be achieved through text hints at the bottom of the screen, alternatively signs with graphics depicted on them could be found at the beginning of the scene. Another way of communicating VR interactions is to replace the hands with the correct controller model in game and adding handheld tool-tips with short descriptors and highlighting the corresponding buttons. This however requires 3D importable replicas of the controller and could be a deciding factor against this version of a guide. For the application version, used for the the prototype evaluation, a combination of in-game instructions and instructions given by the developer was used. The in-game instructions included graphics indicating the usage of the controllers and text appearing to guide the user through the scenarios. In case the user was did not know how to continue outside instruction was given, this is however not ideal for a scenario where an instructor might not be present.

6 Documentation of the Prototype and Implementation

This chapter serves to provide different kinds of documentation of the two prototypes.

6.1 Key Concepts Unity

To better understand how Unity provides functionality used to implement both of the prototypes, some of the used concepts and components provided are going to be described by their functionality and their role in the projects.

6.1.1 Game Object

Game Objects¹ are the base entity of all scenes. Scenes² are parent objects that can contain multiple game objects. An important feature of Game Objects is their active state. These can be accessed through scripting and makes it possible to activate or deactivate objects based on the scenes needs, which is also useful for resource management. Game Objects can also contain child Game Objects creating a hierarchy. The child-object will, per default, keep its relative distance to the parent object and will inherit its parents active state.

6.1.2 Component

In Unity, the Component³ is the base class for everything attached to a Game-Object. A Component can be anything from the stock-components provided by unity, to scripts and third party Components included in packages. A single Game-Object can contain multiple different Components which usually can than be customized to fit the developers needs. Additionally some components require other Components to be present, e.g. for XR-Grab Interactable to work a Rigidbody components needs to be attached to the game object.

¹<https://docs.unity3d.com/ScriptReference/GameObject.html>

²<https://docs.unity3d.com/Manual/CreatingScenes.html>

³<https://docs.unity3d.com/ScriptReference/Component.html>

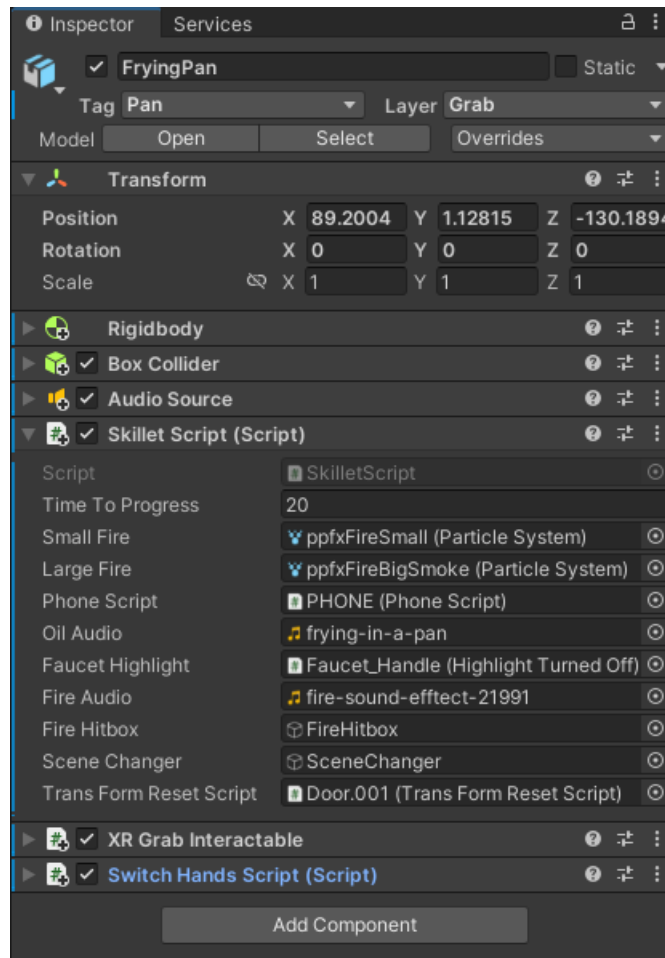


Figure 6.1: Components attached to the skillet object

6.1.3 Rigidbody

The Rigidbody⁴ controls an objects position and rotation through physics. If the object additionally has a Collider Component attached to it, it will collide with other colliders according to Unity's physics engine. To make collisions and physics of the objects seem realistic, Unity's documentation recommends to scale the objects in the game close to real-life scale. In Unity one unit translates to one meter in the real world. The Rigidbody also contains customizable fields, such as the Boolean gravity to turn on and off gravity and various fields to customize and objects damping velocity. The Rigidbody Component was added during to almost all interact-able Game Objects, however objects that did only move in a very limited fashion, like the faucet, did not require this component.

⁴<https://docs.unity3d.com/ScriptReference/Rigidbody.html>

6.1.4 Colliders

Unity provides many different Colliders⁵, to add hit-boxes and trigger-zones to objects. A hit-box determines where a Game Object interacts with its surroundings, often abstracting an objects form topology to provide less resource intensive and more predictable behaviour. They can also be used to check whether or not a specific object enters or stays within a determined area, then the collider acts as a trigger. Often the Box Collider⁶ was used as its simple topology resulted in especially resourceful and predictable interactions. The Mesh Collider⁷ uses an objects mesh to calculate the collision box, however implementation often lead to poor performances and was used sparingly.

6.1.5 XR-Interactor

The XR Interaction Toolkit⁸ package, which was used to implement different VR interactions for the prototype, contains, among others, different scripts for different interaction types. It distinguishes between Interactors and Interactables. Interactors are by intention added to the player object, as it servers as the actor or initiator of the VR controlled interactions. Here different VR controller inputs can be mapped to different in-game interactions. The most used Interactable was the XR-Grab-Interactable which will make the game object follow the VR-controllers position if grabbed and can also trigger different methods based on player input.

6.1.6 XR Origin

The XR Origin⁹ object, provided also by the XR-Interaction Toolkit, is a template for customizable player objects. It is a multi layered object with XR Origin as the parent and different functionalities being added lower in the hierarchy. The Main Camera¹⁰ object will follow the VR-headsets movement and act as the eyes of the player. The left and right hand controller will follow the VR hand controller movement if implemented. All of the players functionality can be changed and added here conveniently.

6.1.7 Text Mesh Pro

The Text Mesh Pro¹¹ (TMP) component is included in the package of the same name. It implements a customizable 2-D text-box with importable fonts and the ability to change the texts properties. It was often used for the simulation, including temporary text to help guide the user and for the informational hub sequences. The hints were displayed for several seconds if the player entered different trigger colliders.

⁵<https://docs.unity3d.com/ScriptReference/Collider.html>

⁶<https://docs.unity3d.com/2019.3/Documentation/Manual/class-BoxCollider.html>

⁷<https://docs.unity3d.com/2019.3/Documentation/Manual/class-MeshCollider.html>

⁸<https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@2.3/manual/index.html>

⁹<https://docs.unity3d.com/2022.1/Documentation/Manual/xr-origin.html>

¹⁰<https://docs.unity3d.com/ScriptReference/Camera-main.html>

¹¹<https://docs.unity3d.com/Manual/com.unity.textmeshpro.html>

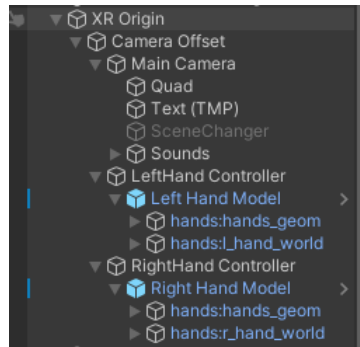


Figure 6.2: XR-Origin Hierarchy

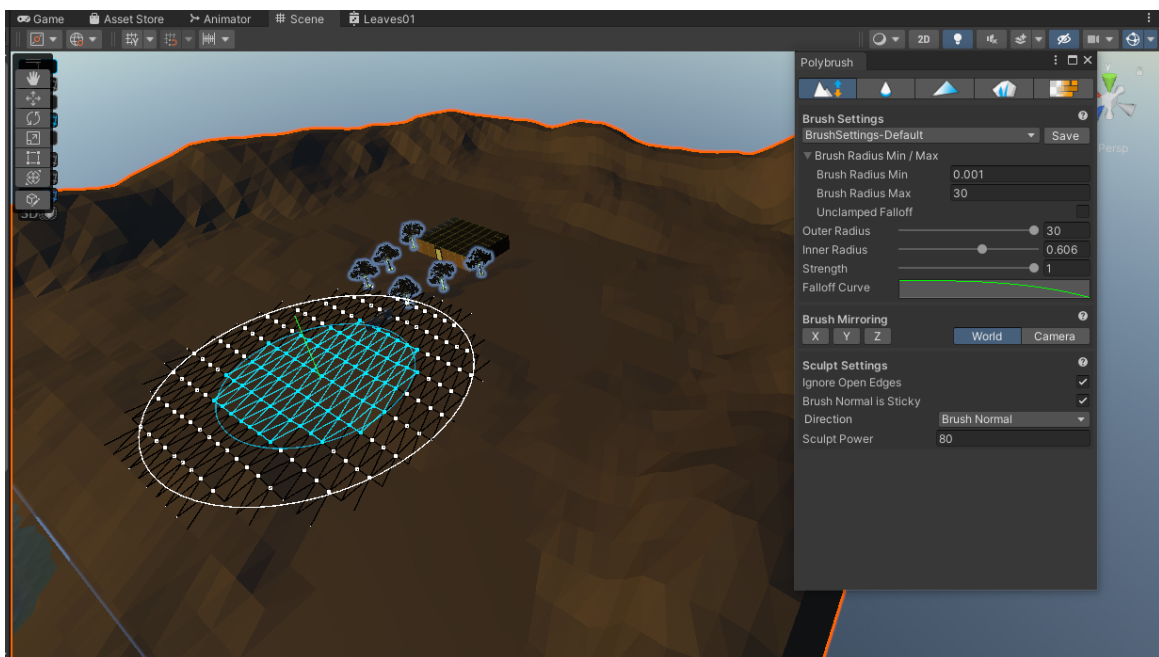


Figure 6.3: Polybrush, with a brush scaled to a radius of 30m

6.1.8 Polybrush

The package Polybrush¹² implements the ability to manipulate an objects topology in an easy to use and intuitive fashion. The Polybrush window adds a customizable brush with the ability to pull or push mesh down in the applied area. It also adds the feature of placing down prefabs on a mesh in a custom but randomized way. Polybrush was used to create the surroundings of the apartments.

¹²<https://unity.com/features/polybrush>

6.2 Scripting

Unity uses C #¹³ as its programming language and provides many packages which include different scripts, providing solutions for required interactions and behaviours. Alongside the provided scripts, for example by the Unity XR Interaction Toolkit, many, mostly smaller scripts, had to be developed for the project. Because of the linear nature of the scenarios, a main concern was to implement the dependencies between the different objects, ensuring the correct order of the events and the intended ending leading into the knowledge hub. To achieve this, many scripts had references to other objects, like the door closing automatically after a scenario is started.

```
public class TransformResetScript : MonoBehaviour
{

    Vector3 originalPosition;
    Quaternion originalRotation;
    Transform transform;
    XRGrabInteractable grabInteractable;
    // Start is called before the first frame update
    void Start()
    {
        originalPosition = GetComponent<Transform>().position;
        originalRotation = GetComponent<Transform>().rotation;
        transform = GetComponent<Transform>();
        grabInteractable = GetComponent<XRGrabInteractable>();
    }

    public void resetPosition()
    {

        transform.position = originalPosition;
        transform.rotation = originalRotation;
    }
}
```

Listing 6.1: Door reset script

This led to one main script per scenario containing the orchestrational part of the code, referencing many different objects and scripts, while the many smaller scripts were mostly referenced either by the main scripts or by player interaction. All of the scripts written by the developer can be found in the digital release of the thesis.

6.2.1 Drilling Scenario related Script

The main script that initiated and progressed the drilling scenario, containing the water spill accident, is the Drill Interaction script attached to a screw.

¹³<https://dotnet.microsoft.com/en-us/languages/csharp>

6 Documentation of the Prototype and Implementation

```
bool drillingDone = false;
bool risingDone;
public GameObject sceneChanger;
Animator screwAnimation;
public bool waterRiseEnabled = false;
public ParticleSystem waterSpill;
public GameObject waterBlock;
public GameObject footStepChanger;
Transform screw;
public float riseHeight = 1.0f;
public float riseSpeed = 1f;
bool waterSpillStarted = false;
bool displayWater = false;
AudioSource audioSource;
HighlightObject highlightObject;
public TransformResetScript transformResetScript;
Vector3 waterToBe;
Vector3 screwToBe;
void Start()
{
    audioSource = GetComponent<AudioSource>();
    highlightObject = GetComponent<HighlightObject>();
    screwAnimation = GetComponent<Animator>();
    screw = GetComponent<Transform>();
    waterSpill.Stop();
    waterBlock.SetActive(false);
    waterToBe = new Vector3(waterBlock.transform.position.x, waterBlock.transform.position
.y + riseHeight, waterBlock.transform.position.z);
    screwToBe = new Vector3(screw.position.x - 0.122f, screw.position.y, screw.position.z)
;

}

// Update is called once per frame
void Update()
{
    if(checkProgress() && !waterSpillStarted)
    {

        waterSpill.Play();
        waterSpillStarted= true;

    }
    if(drillingDone&& !risingDone)
    {
        if(!displayWater) { enableWater(); }
        if (Vector3.Distance(waterToBe, waterBlock.transform.position) > 0.1 &&
waterRiseEnabled)
        {
            waterBlock.transform.position = Vector3.MoveTowards(waterBlock.transform.
position, waterToBe, Time.deltaTime * riseSpeed/100);
```

```

    }
    else
    {
        waterSpill.Stop();
        risingDone = true;
        sceneChanger.gameObject.SetActive(true);
        audioSource.Stop();
    }
}
}

```

Listing 6.2: Drill Interaction Script excerpt

In 6.2 the fields contained in the Drill Interaction script are displayed, revealing the referential nature. While some variables have the purpose of customizing the event, like the speed and height of the rising water, there are also game object references, mainly to set them active at different stages of the scenario.

The update function, in Unity, is called in each frame of a scripts lifetime. In this instance its main purpose is to check if certain conditions are in the right state to call a method containing the events of the next part in the scenario. The *checkProgress* method will check if the screw is already screwed in. If that is the case the water starts flooding out of it, initiating the rise of the *waterBlock* object. If the water is done rising the *sceneChanger* object will be set as active, teleporting the player into the educational hub.

6.2.2 Cooking Scenario related Script

The scripts which are responsible for the main functionality of the cooking scenario, while very similar to the drilling scenario differ in the fact that the main script, attached to the skillet receives and sends information to the script attached to the phone, creating a bi-directional relation between them.

```

void Update()
{
    if(progress >=timeToProgress && !cookingDone)
    {

        // cookingDone = true;
        phoneScript.eventStarted = true;

    }
    if (phoneScript.phonePicked && !cookingDone) {
        cookingDone= true;
        turnOnSmallFire();
    }
}

private void OnTriggerStay(Collider other)
{
    if (other.gameObject.CompareTag("Cooking"))

```

```
    {
        startCooking();

        progress += Time.deltaTime;

    }else if (other.gameObject.CompareTag("Water")&& cookingDone)
    {
        turnOnBigFire();
    }
}
```

Listing 6.3: Skillet Script excerpt

This code, contained in the *SkilletScript*, is responsible for integral logic of the cooking scenario. The *OnTriggerStay* method is called when another object stays within the hit-box of object containing the method. Here it checks if the colliding object is the pan and will increase the cooking progress accordingly. The update method will check mentioned progress and reference the *PhoneScript* to start the phone intermission event when a certain progress is reached. The second if-statement contained in the update function will check whether or not the player has picked up the phone.

```
void Update()
{
    if(eventStarted && !eventInvoked)
    {
        StartRinging();
    }
}
public void GrabPhone()
{
    gameObject.tag = "Untagged";
    if(eventStarted)
    {
        audioData.clip = busyTone;
        audioData.Play();
        phonePicked= true;
        StartCoroutine(delay(20));
    }
}
public void StartRinging() {
    print("Cooking Done");
    audioData.clip = ringingTone;
    audioData.Play();
    eventInvoked =true;
}
```

Listing 6.4: Phone Script excerpt

This snippet is contained within the *PhoneScript*, called by the *SkilletScript*. The boolean *eventStarted* is manipulated in the *SkilletScript*'s update function and will invoke the phones ringing when set to *true*.

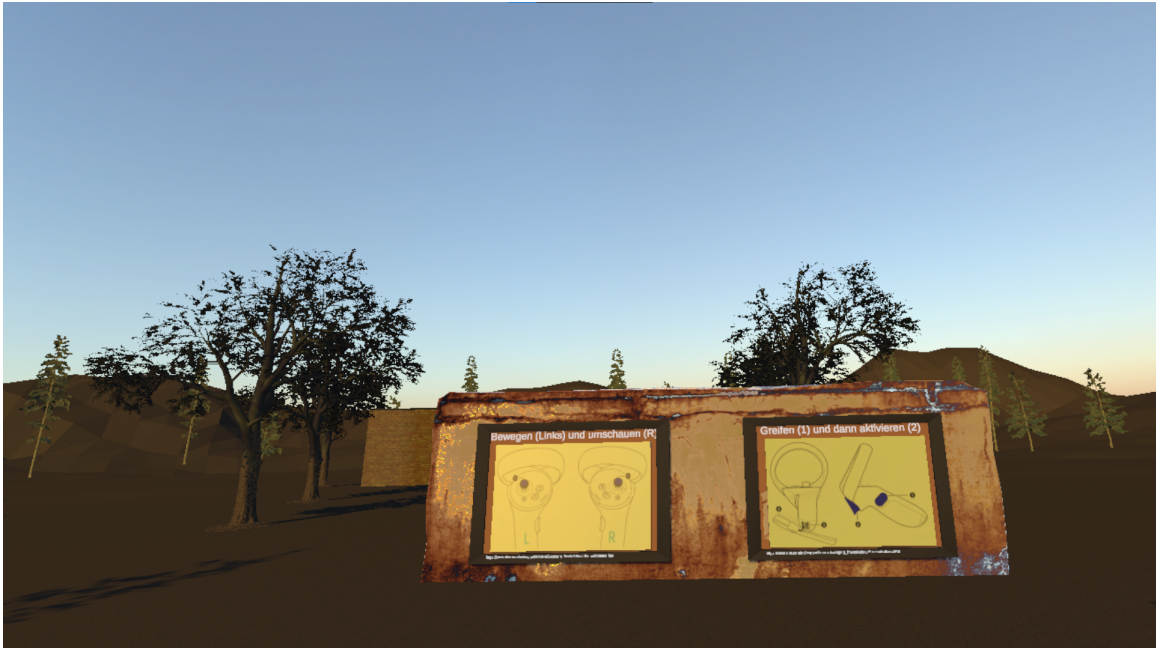


Figure 6.4: Outside the apartment

6.3 In-Game Documentation

In this section, many of the key scenes are captured in image format. Some rooms or locations are not included here if they do not serve a major role in the application, however these will be visited in the demo, linked in the appendix.

6.3.1 Insurance related Prototype

The images contained here were taken in the application version used for the study.

This is entry scene which the player will face after the application is started, its purpose is to teach the player the controller interactions. With the apartment peaking it might also give the player an idea where to go next.

The first room upon entering the apartment is the living room, it is connected to all the other rooms contained in the apartment and serves as a first impression of the apartment and should entice the player to explore and interact with their surroundings.

This image contains the player holding the drill after the flooding started following the screw insertion. The water levels rise to a certain height until the player is teleported into the knowledge hub. The scenario is located within the bedroom.

The kitchen contains the cooking-scenario, the image is captured after the player answered the telephone which triggers the skillet going up in flames. The highlighted faucet lever suggests the next interaction.



Figure 6.5: Living room

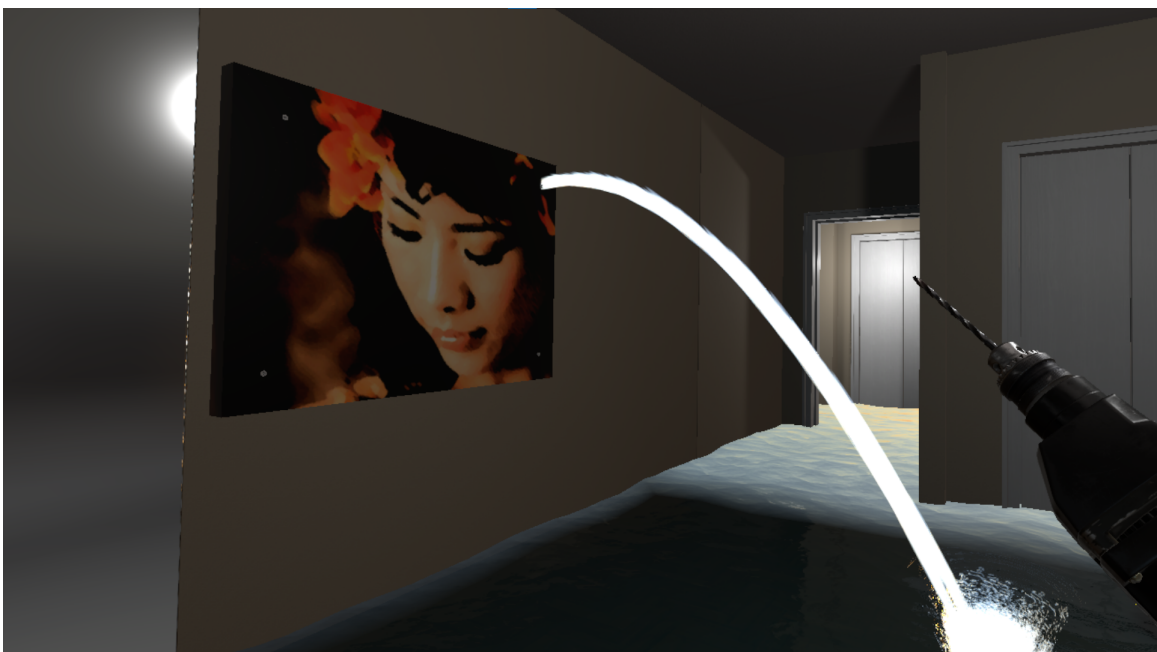


Figure 6.6: The Drill Scenario



Figure 6.7: Skillet Scenario

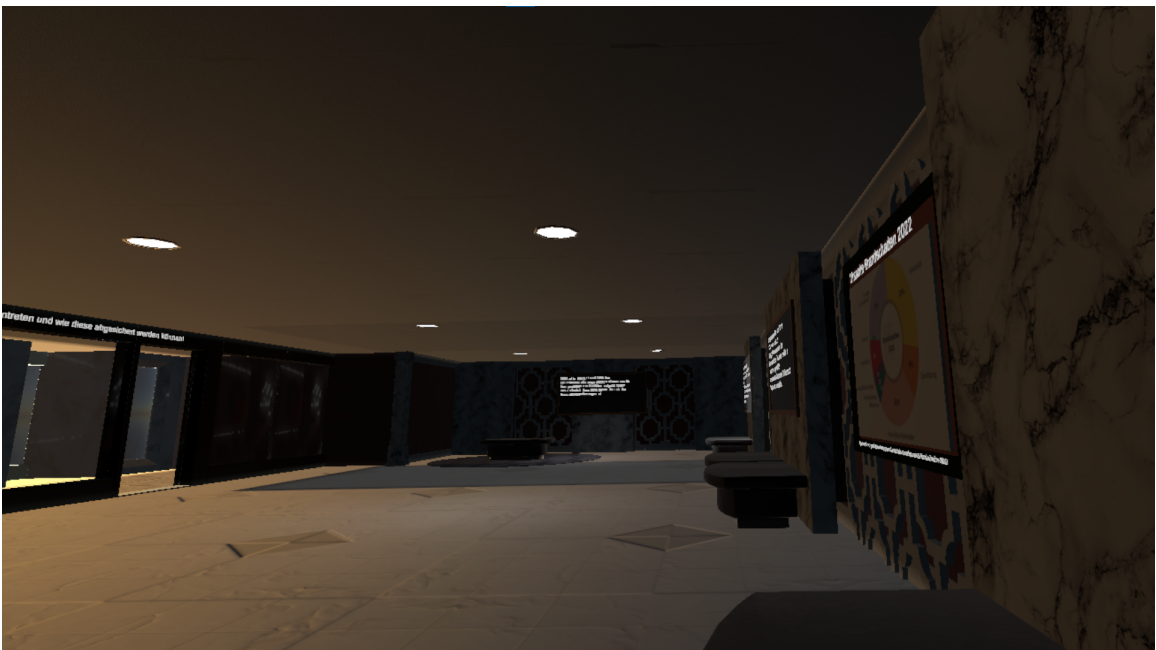


Figure 6.8: The insurance related Informational Hub



Figure 6.9: Barrierefreiheit bath

After either of the scenarios the player will find themselves in the knowledge hub which serves to teach them about relevant insurance information. If the player leaves the room the simulation will end.

6.3.2 Barrierefreiheit-related Prototype

The images contained are screen-captures from the Barrierefreiheit-prototype.

Left to the living room the hallway and bathroom can be seen, the areas highlighted in blue may be barriers for wheelchair confined people.

Kitchens often contain barriers for wheelchair confined people due to the height of the countertop. The L-shape of the layout however may be beneficial to cooking in a wheelchair.



Figure 6.10: Barrierefreiheit kitchen

7 User Study

7.1 The Method

The study serves as a user evaluation of the insurance related prototype. To raise this data a study containing potential insurance clients participating in the insurance risk simulation prototype will be executed. After this experience a questionnaire will be completed by the participant. However since the sample size will not be of representative size, the scientific validity of the study will be limited.

7.1.1 The Questionnaire

The questionnaire will include the 10 questions provided by System usability scale¹. The reasoning behind this decision is to get a scientific proven method to evaluate different usability attributes in the prototype, since the scale is designed specifically for user interaction with a system the questions can be used without any change. The questions are as follows:

- I think that I would like to use this system frequently.
- I found the system unnecessarily complex.
- I thought the system was easy to use.
- I think that I would need the support of a technical person to be able to use this system.
- I found the various functions in this system were well integrated.
- I thought there was too much inconsistency in this system.
- I would imagine that most people would learn to use this system very quickly.
- I found the system very cumbersome to use.
- I felt very confident using the system.
- I needed to learn a lot of things before I could get going with this system.

However since these questions are all purpose, some additional more specific questions about the prototype are added. Like the system usability scale these questions will be scored by a 5 point Likert-scale containing the values strongly agree, agree, neutral, disagree and strongly disagree. The questions include (here translated to English):

- I experienced symptoms of dizziness, headache or nausea.

¹<https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html>

- The experience increased my perceived importance of certain insurance types.
- In the context of insurance counselling, i could see the simulation as beneficial.
- The simulation felt authentic.

Combined the two sets of questions provide a scientific measurement for usability and more specific insight for the prototype evaluation. In addition to that the participant is asked to put in their age and gender. In order to get further feedback for possible improvements, a section asking for the participants ideas for improvement and miscellaneous feedback was added.

7.1.2 Apparatus

The data for the study was gathered inside a Fraunhofer faculty which also provided a Vive Focus 3² headset and a notebook, the ThinkPad T14³ with an external GPU, containing a Nvidia 4070T for the hardware requirements. The participants used the Vive headset for the simulation one by one.

7.2 Study Documentation

Many of the here described locations are documented in the prototype documentation section, in addition to that the links to the different demos can be found in the appendix.

This section is dedicated to document the verbal and behavioural feedback received from the participants during and after attending the study. Many people had little or no experience with VR, however general experience with video-games seemed to greatly improve accustoming to a VR environment and intuitively knowing how to progress. Before the experience started for each participant they were asked to adjust the VR- headset to their needs until they had a sharp image before them, after that the controllers put into the respective hand.

The first thing almost everyone saw were the introductory images displayed on a wall 6.4, with one person initially facing in the wrong direction. People less accustomed to gaming had trouble interpreting the graphics to controller interactions and needed verbal cues from the instructor/developer. Because the wall was construing the view to the apartment, giving people the cue to look around was often needed to lead them to the right direction. The interaction with the door was often met with trial and error from the participants side, ending often in pushing the door inward to open it. This interaction was then met with either enthusiasm upon entering the apartment or confusion as to why a certain approach worked better than a previously tried attempt. Often the controls for activating and grabbing were mixed up during this first interaction, this learning experience lead to switch ups happening more sparsely later on in the individual experiences. Some, upon entering the apartment immediately asked for further guidance while other looked around the living room 6.5 or trying to interact with every possible prob located either in the living room or the adjacent bath room. When entering either the bedroom 6.6, containing the drill scenario, or the kitchen 6.7, containing the cooking scenario, the appearing text in combination with the

²<https://www.vive.com/de/product/vive-focus3/overview/>

³<https://www.lenovo.com/de/de/p/laptops/thinkpad/thinkpadt/thinkpad-t14-g1/22tpt14t4n1?org>

highlighted props was in almost all cases enough to initiate the wanted interaction with the objects. Due to different player height than at the setup used to develop the application, it was often difficult to reach the screws required in the drill scenario. The realization of the low character height was often met with laughter and could be reason for some difficulties in some of the interactions in both scenarios. In two cases the person had to stop the initiated drill scenario and was guided by the instructor to the kitchen so that completing a scenario was possible without major complications or disrupting the experience entirely. During the drill scenario some participants were hung up on the drill, containing a bit used for drilling holes into matter rather than to dig in screws. This resulted in some searching for the right bit or comical remarks in other cases. Often observed behaviour was impatience or confusion in dedicated times where waiting progressed the scenario, like the act of cooking the steak or the flooding of the house in the drill scenario. Some participants even managed to start the cooking scenario while the flooding was happening which once resulted in an unintended consequence of the phone ringing during the knowledge hub part of the simulation. While some participants seemed to enjoy the exploratory nature of the simulations others asked for guidance. Many participants tried to interact with lots of different props in the scene, some without integrated interaction. The key objects, like the drill and the pan were almost always seen as interact-able which could be due to their yellow outline. The objects were often interacted with, with a sense of instinctiveness which could indicate a high level of immersion, which was then partly broken when the interaction was not possible or increased when possible.

A glaring factor that resulted in a lot of displeasure, especially during one early study cycles was performance induced cybersickness, which could have been result of the notebook, which ran the application, overheating. The application, which normally ran smoothly with hardly noticeable latency created visual artifacts such as black rectangles appearing when rotating. This could not be examined on the notebook, which showed the application for the reviewers information but could only be retrieved through verbal feedback of the participant after the experience. After this incident, which resulted in severe cybersickness symptoms, a check whether or not the application was running smoothly was added. Closing the application immediately after each cycle fixed this issue and only low to no symptoms, at least verbally, were reported after this addition.

7.2.1 Role of the Instructor

Since a lot of people had little to no experience in VR or some even video games in general, some guidance was required to achieve a smooth and satisfying experience. However, since this required spontaneous intervention by the developer, deciding whether or not to help was sometimes difficult, since, on the hand the learning curve for an interactive VR-interaction seemed steep in some cases, at least initially, on the other hand the simulation should be able to stand on its own without instruction. Moreover finding out interactions on the participants own merit often lead to feedback indicating satisfaction. Often waiting a few moments before intervening lead to the participant finding out themselves, making an intervention obsolete. Often instructions was repeatedly required with different participants in the same situation, indicating that more user guidance was required.

7.2.2 Interpretation / Feedback for future study

In this section the verbal and behavioural feedback received will be interpreted and changes that might increase user satisfaction and usability will be hypothesised, in addition this subjective analysis will be compared and connected to the questionnaire result evaluation.

Because the wall containing instructive images obstructed the view to the apartment, many participants did not know how to proceed after they learned the controls. While this encourages exploring the surroundings, either placing the apartment into immediately visible vicinity or adding a visual hint indicating its importance or placement earlier might help.

Another important addition that would definitely be integrated for a next evaluation is to have the player model change size relative to the VR device and used for the application and user height, this would help with the volatile character size and make the scenarios easier to complete and increase immersion.

More challenging is the task of bridging the gaps where waiting is required to progress. Adding a progress indicator of some sort would suggest to the player that no action is required, it could also potentially reduce the element of surprise added by the sudden events happening after the waiting is bridged. It could also potentially decrease immersion and add a more gamification elements, which could be positive or negative, depending on the subjects preferences and expectations. However adding visual cues, for example the steak getting cooked, might solve the problems while adding immersion.

Since many participants were eager to interact with every object in the environment, adding more simple interactions, such as grab-interactions, might increase satisfactions gained from these interactions while also increasing immersion. Also adding possible scenarios to the rooms without key interactions, such as the bath room or the guest room might add replay ability and user satisfaction.

While teaching players about the key interaction, the grabbing mechanism, in opening the door to the apartment, it also was met with initial confusion. This could be due to a new environment with novel interactions, but also slightly altering the interaction to be more beginner friendly could reduce the frustration factor while still maintaining its educational role.

Because of the nature of a study, where participants are being watched, some emitted behaviour or verbal cues could be due to the feeling of being judged or under study-induced time pressure. This could be the reason of impatience of the participants and the need for immediate guidance, while a more relaxed setting, like trying a VR-application on their own without active examination by a instructor might lead to different behavioural patterns. Without any user testing this might lead to frustration when a participant gets stuck, as early as the introduction. However with some changes to the application it could lead to a more laid-back exploratory approach.

7.3 Results

The study took place on the 10th July of 2023. A total of n=12 participants experienced the simulation and gave their feedback on the questionnaire.

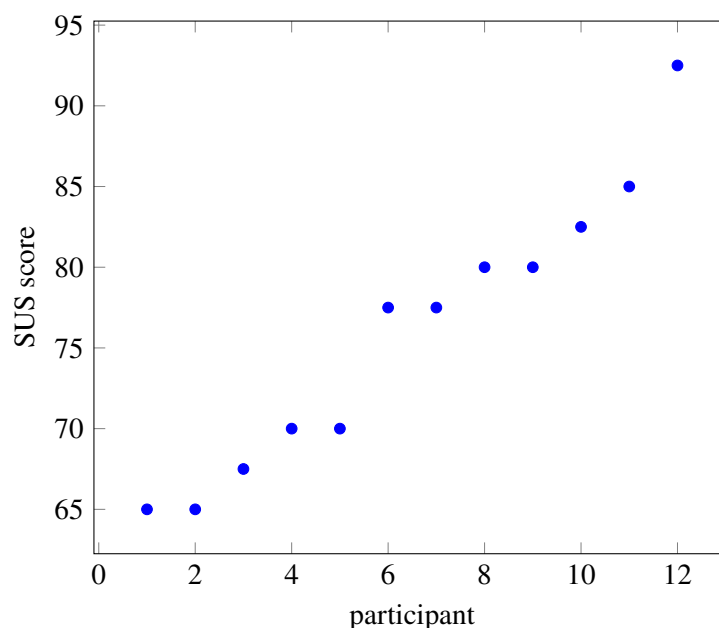


Figure 7.1: SUS score in ascending order

7.3.1 The System Usability Scale (SUS)

To evaluate the usability of the system, the System Usability Scale was chosen. To accommodate for the SUS scale ranging utilizing a Likert-scale ranging from 1 to 5, unlike the hereby used Likert-scale ranging from 0 to 4, every entry for the questions 1 to 10, those relevant for the SUS score, were incremented by 1. Figure 1 depicts the scoring of each participant for the 10 relevant questions, the resulting SUS score and the averages. The SUS score is calculated as follows : $= ((Q1 - 1) + (5 - Q2) + (Q3 - 1) + (5 - Q4) + (Q5 - 1) + (5 - Q6) + (Q7 - 1) + (5 - Q8) + (Q9 - 1) + (5 - Q10)) * 2,5$, with Q_i being the score of the respective question. This categorizes the questions into positively and negatively weighted questions.

With an average of 76 the grade of the system would be B, according to a grading system based on 241 industrial usability tests using the SUS [LS18]. Since $n=12$ is not representative and not all relevant age groups were presented equally this does not translate to a reliable score. However it still suggests that the usability of the system is generally deemed good, with a standard deviation of 8,6.

7.3.2 Result Discussion

With a standard deviation of 1,642 in question 11, regarding symptoms of cybersickness, the results varied a lot depending on the participant. This could be due to poor software performance in some instances during earlier cycles but also differing reactions to the VR-realm. This limits the validity of this measure and would require further testing. Usability scores averaging at 76,0 with a standard deviation of 8,6 indicates that most participants found the system to have good usability and satisfies the proposed need for the prototype to conform to usability standards, due to the small sample size however the validity of this results is not of scientific proportion, however sufficient as a

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	2	1	4	3	3	4	5	1	2	1	65
p2	5	1	5	3	5	1	5	1	5	2	92,5
p3	3	2	4	3	4	2	4	2	5	3	70
p4	3	1	2	3	5	2	5	2	3	4	65
p5	4	1	5	3	4	2	4	1	4	2	80
p6	4	1	4	2	4	1	5	1	3	1	85
p7	3	1	5	2	4	3	4	2	5	2	77.5
p8	3	3	4	2	4	3	4	2	4	2	67.5
p9	4	1	4	2	4	2	3	1	4	1	80
p10	2	2	4	3	4	3	4	2	5	1	70
p11	3	1	5	1	5	3	4	1	4	4	77.5
p12	4	1	4	2	3	1	4	1	4	1	82.5
AVG	2.333	0.333	3.166	1.416	3.083	1.25	3.25	0.416	3	1	76
SD	0.887	0.651	0.834	0.669	0.669	0.965	0.621	0.514	0.953	1.128	8.6

Table 7.1: Likert scoring of each participant, questions 1 to 10, resulting in the respective SUS score

Age	Gender	q11	q12	q13	q14	Fire Scen.	Water Scen.	Unsure	SUS Score	
24	w	4	3	3	3	X			65	
31	w	3	4	4	3	X			92,5	
28	w	0	1	3	2	X			70	
42	w	4	2	3	4	X			65	
23	w	0	3	3	3	X	X		80	
33	m	0	0	2	2			X	85	
32	m	1	0	2	1		X		77,5	
23	m	1	0	2	2		X		67,5	
29	m	1	0	0	2	X			80	
34	m	3	1	3	2		X		70	
29	m	4	4	4	3		X		77,5	
23	m	1	1	2	1		X		82,5	
29,25		1,833	1,583	2,583	2,333				76	AVG
5,69		1,642	1,564	1,083	0,887				8,6	SD

Table 7.2: Questions 11 to 14 including age, gender and scenario, in same order as Table 11.1

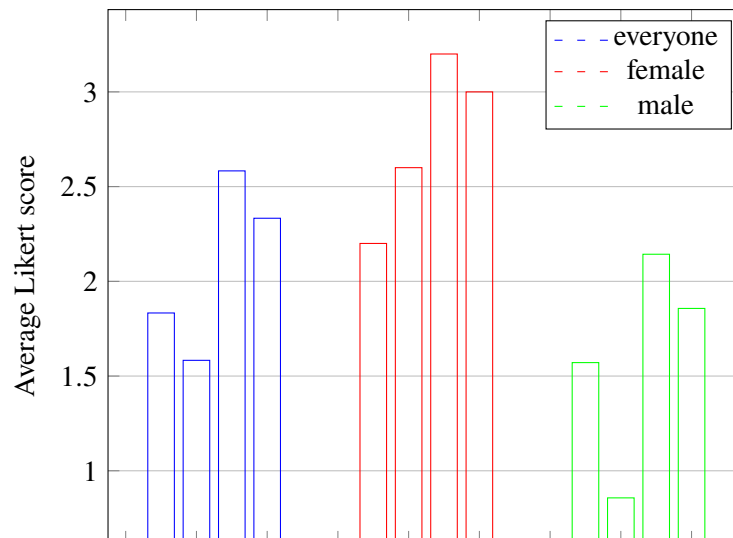


Figure 7.2: Average Likert score of Questions 11 to 14

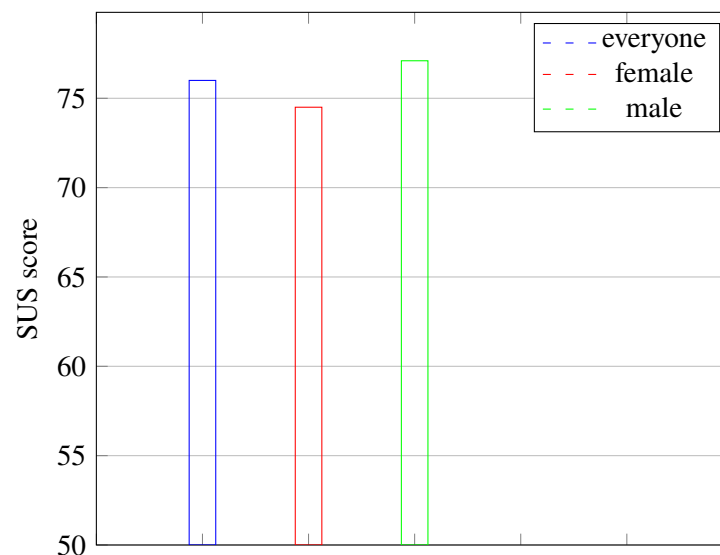


Figure 7.3: Average SUS Score

evaluation of a prototype. The perceived increased importance of certain insurance types averaged at 1,6 with a standard deviation of 1,6 indicates that while most people seemed to report neutral to a lower increase, others were positive about the effects. However if a participant already had a higher perception of importance of certain insurance types, they may report low to no increase, while also not undermining the experiences effects. This variable could be researched by adding a questionnaire before the experience, however this may change the subjects expectations. The simulation being an useful addition in the context of insurance counselling averaged between neutral and partially agreeing. Despite the mixed results, this indicates that some participants are interested in likewise educational VR experiences in the case of insurance related risk. This could indicate a niche market that would justify further development.

As seen in Figure 11.2, females, on average reported up to one point higher in perceived importance (q11), the simulation being a useful addition (q12) and validity of the experience (q13), this could indicate that females prefer the simulation and its perceive its utility as higher, however to confirm this claim, further studies would have to be conducted. However their Average SUS-Score only differed by two on average, with males reporting slightly higher scores.

Since not all usability factors are of the same importance for the application, as discussed in the usability chapter, looking at individual System Usability Scale's questions may expose if the proposed important usability measures specifically were satisfied.

Off the positively weighted questions, question 1, regarding the participants eagerness to use the system again, averaged the lowest. The most factors chosen as most important in the context of a one-time shorter experience are learn-ability and low complexity. Questions regarding these factors are 2,3,4,7,8 and 10. All of which were higher or lower than 3 or 1 in positive and negatively weighted questions respectively. Except for question 4, indicating that the system may need to improve as a standalone experience without outside instruction.

This claim is also supported by some of the inputs regarding the additional info and improvement tips section, located at the bottom of the questionnaire. 2 of the 12 participants wished for better user guidance. The full results of this section can be found in the appendix.

Comparing the results of the verbal cues gained during the study reveals that while of the participants were sometimes lost during the experience, the overall usability factor was higher than anticipated based on these findings. However the often perceived satisfaction and eagerness of the participants did not necessarily translate to high levels of authenticity or perceiving the experience as a positive addition to insurance counselling. Incorporating both the results of the questionnaire and verbal and behavioral cues into the next version of the prototype might yield better results than only considering either findings.

8 Conclusion and Outlook

8.1 Conclusion

As a first study evaluating some attributes of the implemented prototype experience indicates, there is some demand for VR education in the domain of insurance risks, this is also supported by the eagerness of many participants and employees working in the insurance domain. Many participants reported symptoms of cybersickness, which is congruent to the research done. However this warrants increased responsibility for developers and employees using the application to persuade customers for their safety. The study also indicates that the experience is not satisfactory for everyone, which should be respected and place the role of a likewise application, like in the case of e-tourism [YK19] as an add-on to already existing insurance counselling, at least in the current landscape of VR.

8.2 Discussion

Implementing the prototypes as a single developer, often being inexperienced in many of the required fields, lead to choosing an easy time efficient solution rather than the one best suited for the application. Especially regarding the craft of 3D-modelling a lot of the success of the prototype is owed to royalty free 3D-objects being available on various services. Despite this, the development and research process resulted in one prototype that successfully implemented the proclaimed usability factors while also successfully communicating the idea to be educated in a VR application about different insurance related risks and being able to build a base for an accessibility educational tool upon this.

8.2.1 Limitations

Since the purpose of this thesis was to provide two prototypes in the domains of educating either about insurance or accessibility the scope of this thesis is very limited, serving as a foundation for future work, instead of already providing scientific conclusions. If the study would have been of bigger sample size and included more questions it would have only lead to the evaluation of a very limited prototype. In addition to the time, team and skill restraints the resulted software, while being sufficient for its requirements as a prototype, was limited in functionality. One additional development cycle, implementing the verbal and written feedback could already result in a software with increased usability,immersion and user satisfaction. Moreover the user evaluationrefreiheits related prototype only received very little time during development compared to the insurance risk related prototype, and many off the features, included in a software which would be fit to educate about accessibility issues found living-spaces, are still missing.

8.3 Outlook

The VR experiences implemented in the context of this thesis indicate, that while VR is a powerful tool in the domain of education, many people are still inexperienced with the technology and educational tools need to take this into account, especially in the context of a one-time experience, and implement a quick, understandable way to teach users about VR-interaction. However with the right approach and implementations both prototypes could be developed into something that could provide a target audiences with a fun and educational experience. Making sure the introduction is more cohesive with a stronger focus on user guidance could help especially beginners to VR and first-person game-like experiences alike. Reducing potential for cybersickness should also be crucial, making sure the software is running as smoothly as possible was a first step during the user study. Aside from these two factors there are many qualities that could be improved upon in a future version, implementing more and better VR-interaction could lead to more immersion and user satisfaction. Building upon the existing scenarios with user-choices influencing the outcomes or entirely new scenarios could add replay-ability and add authenticity to the experience. Also the environment could be changed for something more authentic like a city or town environment with added civilians or even non-player-character interaction. The most untapped potential may be present in the user evaluationrefreiheit-related prototype, from adding user-interactions to adding pre-existing apartments or buildings to evaluate their accessibility are potential additions. Also having the user maneuver in a virtual wheelchair might increase immersion and even functionality of the prototypes intent. Adding gamification elements to both prototypes could also yield interesting results, regarding their educational effect.

8.4 Future Work

Apart from the aforementioned changes and additions to the implemented prototypes, future works could evaluate the improved upon versions in the context of a user study, potentially with more participants, adding user guidance and introduction to a sufficient amount where as little outside introduction as possible is required to evaluate the experiences on a scientific level. Additionally other applications could be implemented to teach about other parts in accessibility and insurance a-like or even entirely different domains of education.

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All links were last followed on July 17, 2023.

A Used Resources

Here are some of the used resources including Unity version and dependencies, note that in the future a repository with the full projects will be linked.

A.1 Turbosquid

<https://www.turbosquid.com/3d-models/free-damaged-wall-3d-model/747378>
<https://www.turbosquid.com/3d-models/trees-realistic-3d-1218366>
<https://www.turbosquid.com/3d-models/3d-painting-1683109>
<https://www.turbosquid.com/3d-models/black-board-3d-model-1357354>
<https://www.turbosquid.com/3d-models/3d-landline-telephone-1419155>
<https://www.turbosquid.com/3d-models/free-blend-model-low-poly-food/740569>
<https://www.turbosquid.com/3d-models/3d-screw-1194998>
<https://www.turbosquid.com/3d-models/free-obj-model-frying-pan/1022591>
<https://www.turbosquid.com/3d-models/scanned-ash-tree-model-1827855>
<https://www.turbosquid.com/3d-models/grass-ready-terrain-3d-model-1309955>

A.2 Unity Asset Store

<https://assetstore.unity.com/packages/vfx/particles/particle-profx-one-20251>
<https://assetstore.unity.com/packages/3d/props/drill-soviet-226098>
<https://assetstore.unity.com/packages/vfx/particles/particle-pack-127325>
<https://assetstore.unity.com/packages/vfx/particles/particle-collection-skj-2016-free-samples-72399>
<https://assetstore.unity.com/packages/tools/particles-effects/quick-outline-115488>
<https://assetstore.unity.com/packages/3d/vegetation/trees/conifers-botd-142076>
<https://assetstore.unity.com/packages/2d/textures-materials/water/simple-water-shader-urp-191449>
<https://assetstore.unity.com/packages/3d/environments/apartment-kit-124055>

A.3 Development Environment

Unity version: 2021.3.28f1¹

Dependencies:

"com.unity.collab-proxy": "2.0.5", "com.unity.feature.development": "1.0.1", "com.unity.feature.vr": "1.0.0", "com.unity.ide.rider": "3.0.24", "com.unity.ide.visualstudio": "2.0.18", "com.unity.ide.vscode": "1.2.5", "com.unity.learn.iet-framework": "3.1.1", "com.unity.polybrush": "1.1.3", "com.unity.postprocessing": "3.2.2", "com.unity.probuilder": "5.1.0", "com.unity.progrids": "3.0.3-preview.6", "com.unity.render-pipelines.universal": "12.1.12", "com.unity.test-framework": "1.1.33", "com.unity.textmeshpro": "3.0.6", "com.unity.timeline": "1.6.5", "com.unity.ugui": "1.0.0", "com.unity.visualscripting": "1.8.0", "com.unity.xr.interaction.toolkit": "2.4.0", "com.unity.xr.management": "4.3.3", "com.unity.xr.oculus": "3.3.0", "com.unity.modules.ai": "1.0.0", "com.unity.modules.androidjni": "1.0.0", "com.unity.modules.animation": "1.0.0", "com.unity.modules.assetbundle": "1.0.0", "com.unity.modules.audio": "1.0.0", "com.unity.modules.cloth": "1.0.0", "com.unity.modules.director": "1.0.0", "com.unity.modules.imageconversion": "1.0.0", "com.unity.modules.imgui": "1.0.0", "com.unity.modules.jsonserialize": "1.0.0", "com.unity.modules.particlesystem": "1.0.0", "com.unity.modules.physics": "1.0.0", "com.unity.modules.physics2d": "1.0.0", "com.unity.modules.screencapture": "1.0.0", "com.unity.modules.terrain": "1.0.0", "com.unity.modules.terrainphysics": "1.0.0", "com.unity.modules.tilemap": "1.0.0", "com.unity.modules.ui": "1.0.0", "com.unity.modules.uielements": "1.0.0", "com.unity.modules.umbra": "1.0.0", "com.unity.modules.unityanalytics": "1.0.0", "com.unity.modules.unitywebrequest": "1.0.0", "com.unity.modules.unitywebrequestassetbundle": "1.0.0", "com.unity.modules.unitywebrequestaudio": "1.0.0", "com.unity.modules.unitywebrequesttexture": "1.0.0", "com.unity.modules.unitywebrequestwww": "1.0.0", "com.unity.modules.vehicles": "1.0.0", "com.unity.modules.video": "1.0.0", "com.unity.modules.vr": "1.0.0", "com.unity.modules.wind": "1.0.0", "com.unity.modules.xr": "1.0.0"

¹<https://unity.com/releases/editor/whats-new/2021.1.28>

B Study Data

B.1 Extra/Tips for improvement

German raw data

- 1) Perspektive anpassen/ erhöhen
 - 2) Anmerken das Kopf-/Handbewegungen parallel zu controller laufen
 - 3) Die Storyline war sehr genau vorgegeben
 - 4) Bessere großen Relationen von Objekten, bessere Nutzerführung und Erklärung (tutorial) Erwartungsmanagement, was bei der Simulation erlebt wird.
 - 5) Statt wireless Bohrer mit Bohrer (Akkuschrauber mit passendem Bitsatz) Körperhöhe anpassen bei Start des systems
 - 6) Höherer Detailgrad bzw Realismus der Überschwemmung und zerstörung des ausrats, Money/Destruction Counter
- Bessere Integration der Statistiken, mehr Gamification -> nur um trotzdem gegen die Katastrophe zu verlieren
Prio des Telefonbugs erhöhen

English Translation

- 1) Increase/adjust perspective
 - 2) Note that head and hand movement function parallel to controller
 - 3) The story-line was very accurately predetermined
 - 4) Better relations of objects, better Userguidance and explanation (tutorial) Expectation management, what to expect in the simulation
 - 5) Except wireless drill, electric screwdriver with fitting bits Adjust body height on system start
 - 6) Increase detail on flooding and destruction of the apartment. Add Money/Destruction Counter.
- Better integration of statistics, more gamification -> Only to still loose against catastrophe
Increase importance of phone bug (related to phone ringing in info hub when triggering skillet event while flooding event)

B.2 Fix Data

B.3 Demos

Here all 3 pre-recorded demos are linked.

Barrierefreiheit prototype: <https://youtu.be/69FxY8HkipA>

Insurance Risk Simulation Prototype Demo: <https://youtu.be/tAQICV-9UIE>

VR Insurance Risk Simulation First Draft Demo: <https://youtu.be/k7hNmdfmF6A>

List of Figures

6.1	Components attached to the skillet object	34
6.2	XR-Origin Hierarchy	36
6.3	Polybrush, with a brush scaled to a radius of 30m	36
6.4	Outside the apartment	41
6.5	Living room	42
6.6	The Drill Scenario	42
6.7	Skillet Scenario	43
6.8	The insurance related Informational Hub	43
6.9	Barrierefreiheit bath	44
6.10	Barrierefreiheit kitchen	45
7.1	SUS score in ascending order	51
7.2	Average Likert score of Questions 11 to 14	53
7.3	Average SUS Score	53

List of Tables

7.1	Likert scoring of each participant, questions 1 to 10, resulting in the respective SUS score	52
7.2	Questions 11 to 14 including age, gender and scenario, in same order as Table 11.1	52

B.4 List of Abbreviations/Acronyms

VR	Virtual Reality	9
AR	Augmented Reality	9
3D	3 Dimensional	12