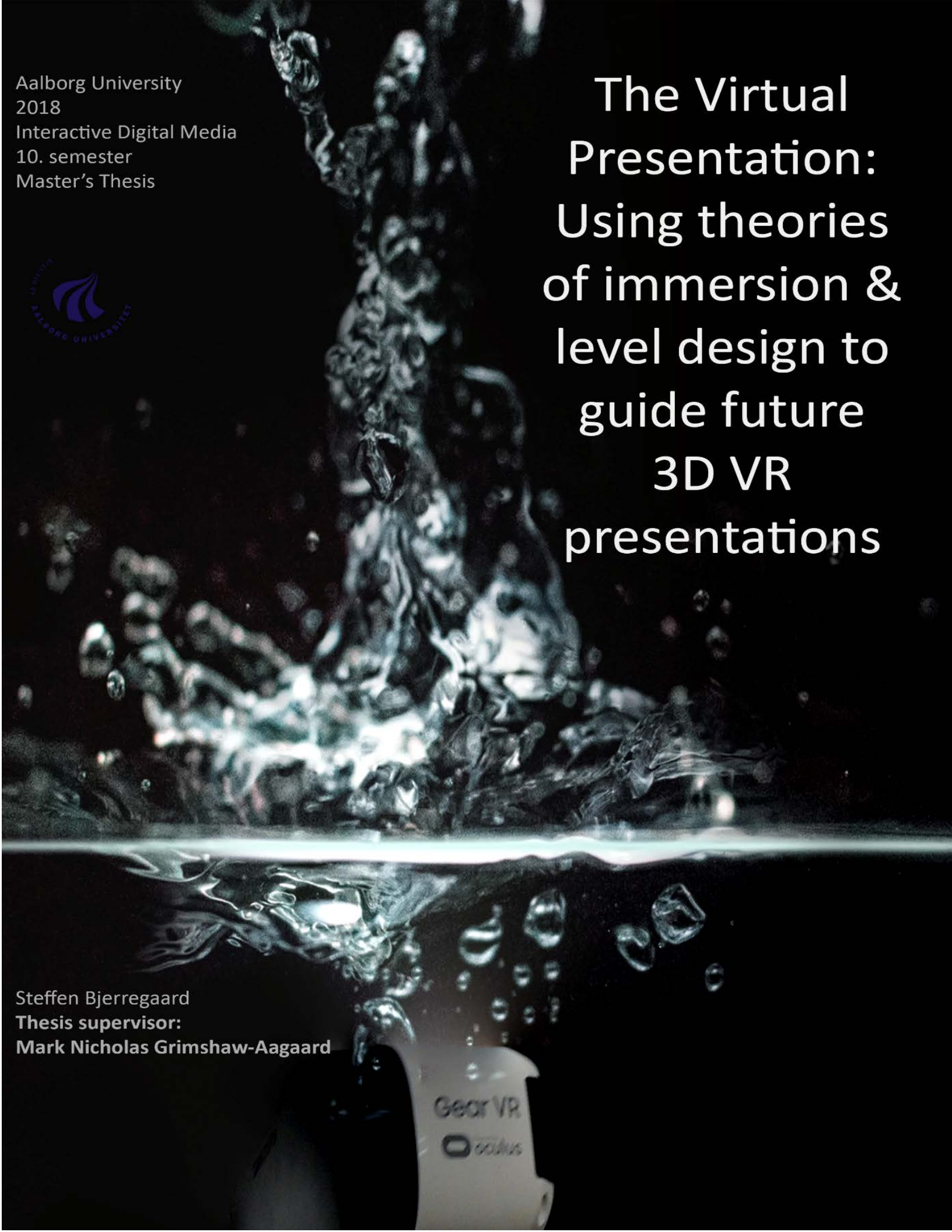
Aalborg University
2018
Interactive Digital Media
10. semester
Master's Thesis

The Virtual Presentation: Using theories of immersion & level design to guide future 3D VR presentations



Steffen Bjerregaard
Thesis supervisor:
Mark Nicholas Grimshaw-Aagaard

AALBORG UNIVERSITY
DENMARK

Title page

Title:

The Virtual Presentation: Using theories of immersion and level design to guide future 3D VR presentations

Semester: 10. semester

Semester theme: Master's Thesis

Project period: Summer exam 2018 – Ordinary

ECTS: 30

Supervisor: Mark Nicholas Grimshaw-Aagaard

Group consists of:

Steffen Bjerregaard

Count of pages: 72

Number of keystrokes: 102.829

Count of standard pages: 42.8

Count of appendixes: 2

Abstract

I dette speciale undersøges brugen af immersion i 3D præsentationer til virtual reality teknologi. I de sidste år har virtual reality teknologi braget frem på scenen igen, med den skælsættende præsentation af Oculus Rift headsettet i 2012 har branchen eksploderet, og andre store teknologi giganter har forsøgt sig med teknologien, såsom HTC, Sony, Samsung og Sony. Med denne genfundne fascination med virtual reality, har virksomheder ligeledes fået øjnene op for teknologien. Flere og flere virksomheder anvender i dag virtual reality teknologi til at præsentere nye projekter eller kommunikere med offentligheden. Følgende med disse virksomheders interesse, har flere og flere firmaer af udviklere af virtual reality teknologi opstået. Mange af disse virtual reality projekter har en ting til fælles, de taler ofte om fænomenet immersion. Hvad er immersion? Dette er et spørgsmål akademikere har forsøgt at besvare i årevis. Anskues litteraturen omkring immersion vises der sig ligeledes mange forskellige definitioner af dette fænomen. I dette speciale gennemgås de centrale definitioner af immersion samt definitionerne af fænomenet presence. For at anskue immersion i 3D VR præsentationer, er det nødvendigt at kunne klargøre hvilken definition af immersion disse anskues ud fra. I dette speciale blev definition systematic immersion valgt til at tilgå 3D VR præsentationer. Grundlaget for valgt af denne definition, var baseret på at systematic immersion anser immersion som et objektivt fænomen, der kan forbedres igennem brugen af mere avanceret teknologi. Da dette speciale har til formål at skabe en guideline for udviklerne af VR software, var valget af systematic immersion som definition af immersion oplagt, da denne definition giver objektive målinger af niveauet af immersion. Derudover blev teori omhandlende level design af computerspil ligeledes undersøgt. 3D VR præsentationer har meget til fælles med computerspil, idet at de begge finder sted i virtuelle 3D omgivelser og brugeren kan interagere med den virtuelle verden. Ligeledes anvender spilbranchen ofte begrebet immersion til at sælge deres spil. Det blev derfor foreslået at disse design teorier kunne hjælpe 3D VR præsentationer og gøre disse mere immersive. I specialet blev teori omhandlende VR, immersion og level design gennemgået. Derudover blev et spørgeskema anvendt til at adspørge VR udviklere om deres forhold til disse begreber, for at danne et overblik over deres enighed eller uenighed med teoretikernes konklusioner om immersion, VR og level design. Resultaterne af dette spørgeskema var en generel enighed med teoretikerne, dog var VR udviklerne overvejende mere kontekst orienterede end teoretikerne i, hvordan immersion fremhæves for brugerne i forskellige sammenhæng.

Dette mundede ud i en guideline der menes at kunne anvendes af udviklere til at fremhæve brugernes niveau af immersion i 3D VR præsentationer, disse guidelines er dog ikke testet i praksis. Primært var

disse guidelines at jo flere sanselige modaliteter teknologien kunne efterligne, jo mere immersive blev VR præsentationen.

Contents

1. Introduction

Virtual Reality (VR) has in recent years resurfaced in pop culture, with the dawn of the Oculus Rift six years ago, the technology has exploded. Since that groundbreaking reveal of the Oculus Rift, many other companies have gone head first into the technology, from HTC, Sony to Google. VR is by no means a new technology, or a new idea, the idea of creating believable virtual realities has been around for decades going all the way back to early flight simulators at the start of the 20th century. VR has usually come into pop culture in waves, looking back at the 90s many companies attempted to sell the technology to consumers for entertainment purposes, the technology to facilitate a believable VR experience however, either didn't exist or was out of reach for the average consumer and smaller business. This new wave of VR technology however, seem to have caught on, not just in the realm of the entertainment industry, but businesses looking to VR for solutions to everything from prototype demonstrations to employee training. With this surge of interest from the business sector, companies developing VR products for business use, has likewise seen a surge. A quick web search, reveals that even here in Denmark several new companies have entered the scene, creating VR experiences for businesses, and they boast impressive client lists as well, from large international businesses like Maersk to smaller businesses like Nordlux. This wave of VR technology seems different than previous waves, as most sectors are actively embracing the technology.

This boom in the VR industry however, is also accompanied by difficulties, because the current technology is so new, there is very few guidelines, very few handbooks and there is a very different understanding of what makes a good VR experience. It is therefore a prime opportunity to explore how to enhance these VR experiences. Specifically, this thesis will focus on how to enhance VR presentations set in 3D virtual environments, as this seems to be one of the prime uses of VR technology in businesses today. So how can these be improved? Well, 3D VR presentations share a lot of similarities with another software industry, video games. Although video games and business presentations in VR have major differences, they also share major similarities; their use of high fidelity 3D graphics, virtual environments the user can navigate through and interact with and lastly, both industries make heavy use of the term, immersion. Because of these similarities this thesis explores how VR developers can use theories of immersion, presence and level design to enhance the VR experience. The thesis will also make clear distinctions on what separates the two mediums, as one is for entertainment purposes and the other is for communication in a business setting. The first and most important aspect of this will be to create an

overview of the different definitions of immersion and presence that are used today. This is important as a first step, as this will provide the thesis with a specific lens on how to improve immersion. The next step is likewise to take a brief look at how VR technology got to where it is today, as well as the current state of 3D VR presentations. Lastly, after going through what academics and designers have to say on the subject, a questionnaire based on these theories is answered by VR developers, to get a feel for what the practitioners think about the topic, as the practitioners might have some insights into what is needed in businesses today. All these elements will then culminate into a guideline for developers, on how to improve 3D VR presentations, using these theories. Lastly, all of these aspects and the shortcomings of this thesis are discussed and concluded upon.

2. Problem formulation

When I started this thesis, I was researching the current state of presentations using VR head-mounted displays (HMDs). This was in part due to an internship I had applied to earlier that year. Specifically, this internship was about using VR to show off prototypes of their future projects for internal use for presentations to potential stakeholders, as well as for public outreach programs. This internship required me to center my thesis around a subject relating to the internship. Unfortunately, this internship fell through, however, I did discover one thing as I was researching VR presentations, most larger companies are using VR technology for various purposes, from training new employees to pitching new products to potential investors. Many of these VR presentations were set in fully rendered 3D environments, much like video games. After this I started looking into what research had been done on this particular subject, however, not much research had been done on this particular topic, there were a lot of research on VR in and of itself, but not VR for use in presentations nor how these were developed to provide an immersive experience. It was then I hypothesized that due to the many similarities between VR presentations in 3D environments and video games, that theories of immersion and level design could potentially benefit future development. So, as these discoveries were made the problem formulation and research questions evolved into this:

In what way is it possible to improve 3D VR presentations by using theories of immersion and level design?

Research questions:

- What definitions of immersion and presence are most relevant for developing 3D VR presentations?
- What elements of level design should developers focus on, to improve 3D VR presentations?
- What is the current state of VR development and its' implementation into businesses?
- How much of a difference exists between the academics understanding of immersion and level design, and the developers?

3. Science studies

The lenses with which this thesis has been viewed is a mixture of hermeneutics and phenomenology, in this chapter both of these studies of science will be explained. These studies of science function mostly as a perspective in which the problem of the thesis has been examined.

3.2. Hermeneutics

This chapter is based on the book *Truth & Method* (2004) by Hans-Georg Gadamer as well as *Understanding Hermeneutics* (2006) by Lawrence Kennedy Schmidt.

When reading a text, watching a movie or playing a video game, we all have different experiences of them and interpret these in different ways, someone might have a completely different take away from it than the other. The same happens in scientific research, for instance, when a researcher conducts interviews and subsequently analyzes these, the researcher has to interpret the responses. This is where hermeneutics comes into play, hermeneutics describes how researchers can recognize their own prejudices, and thereby become as objective as possible when interpreting data. The stories by H.C. Andersen are good examples of how people interpret them differently, through the years there has been much debate as to whether or not H.C. Andersen was a homosexual, these assertions were in part due to interpretations people made of his works. This debate has been ongoing for years, and the answer varies greatly from person to person, as witnessed in an article from The Telegraph (Orange, 2011) where they wanted to use Andersen's sexuality in what they called "Gay week", however, some people took great offense to this as they say no one knew about H.C. Andersen's sexuality. This is a good example of how different people come to varying interpretations of literature and the meaning behind them. These interpretations stem from our own personal prejudices, these prejudices affect how we view any type of communication and can greatly affect how we interpret any work of fiction or non-fiction. However, hermeneutics is not about removing those prejudice as they will always be present, but to understand our own prejudices, to understand our own view of the world, so that the data we analyze can stand on its own, with minimal influence from our prejudices (Gadamer, 2004, pp. 271-272).

Another central aspect of hermeneutics is Gadamer's hermeneutic circle (Kennedy Schmidt, 2006, pp. 4), Kennedy Schmidt describes it as such; "*… the parts can only be understood from an understanding of the whole, but that the whole can only be understood from an understanding of the parts.*" (Kennedy Schmidt, 2006, pp. 4). Kennedy Schmidt writes that this clearly presents a problem, since entry seems impossible when one cannot understand either without first understanding the other. However, he writes that one might first get a general impression of the whole, and then dig deeper into each part until it is fully understood.

The reason hermeneutics is included in this thesis, is because one of the core elements is understanding the different theories regarding immersion, presence, VR and level design, as well as understanding the responses to the questionnaire. This involved understanding my own prejudices in regard to these topics. As I've previously worked on these subjects, both in academia and in practice, I do carry biases and opinions on them, however, before beginning to read through them, I went through and identified these biases before proceeding, so as to minimalize their influence on the results of this thesis.

3.2. Phenomenology

This chapter is based on *Kvalitative Metoder – En Grundbog* (Brinkmann & Tanggaard, 2010) and *Edmund Husserl: Phenomenology of Embodiment* (Behnke, E., A., n.d.).

This thesis examines immersion, a sensation that arises when one engages with works of fiction, this phenomenon of immersion is what's being explored. To examine immersion, we must first see what it means to be immersed, to feel as if the fictional world surrounds you. Because of this, the study of science called phenomenology is also part of the perspective of this thesis. Phenomenology centers around the study of phenomena, that is to say that it explores phenomena that we experience in every day life and examines them separately from their common context (Brinkmann & Tanggaard, 2010, pp. 185-186). Phenomenology was first described by Edmund Husserl, who wanted to explore humans from a more sensory based perspective, in contrast to the objective, natural sciences that existed at the time (Brinkmann & Tanggard, 2010, pp. 186-187) (Behnke, E., A, n.d.). In phenomenology our senses are viewed as intentional, which means, that whatever we do, it's always directed at something i.e. that it's

intentional. Instead of viewing these as separate processes, phenomenology dissolves this separation between humans and the world around them (Brinkmann & Tanggaard, 2010, pp. 187).

Another central aspect of phenomenology is what Husserl called *lifeworld* (Brinkmann & Tanggaard, 2010, pp. 187) (Behnke, E., A., n.d.). Husserl came up with this term, lifeworld, to describe the world which we experience every day. Husserl said that we must use this lifeworld as the basis in which we conduct science, because science does not create new knowledge according to phenomenology, it instead describes what we already know and brings it to light. Another essential aspect of Husserl's phenomenology is phenomenological reduction. This reduction is not the same as scientific reduction (Brinkmann & Tanggaard, 2010, pp. 188), but instead it's a suspension of ones' existing knowledge of a phenomenon in order to view the phenomenon with as little bias as possible. *Essence* is what Husserl viewed as the goal of phenomenology (Brinkmann & Tanggaard, 2010, pp. 189) (Behnke, E., A., n.d.). Essence is the central aspect of a phenomenon, it's the constant variable that you find when studying a phenomenon. In phenomenology you examine a phenomenon from a variety of different perspectives and in doing so, you begin to see the constant variables that are always present, i.e. the essence of the phenomenon.

Immersion is one such phenomenon. To be able to examine how 3D VR presentations could be improved using theories of immersion, it's important to first understand exactly *what* immersion is. In this thesis this was achieved by reviewing many different sources on immersion (and presence), in order to boil this down to one specific definition.

4. Engaged Scholarship

The intent of this thesis is not only to further the academic understanding of immersion and VR, but also to provide additional tools to the VR developers, so that future 3D VR presentations could maximize their immersive potential. To do this, this thesis has used the book *Engaged Scholarship – A Guide for Organizational and Social Research* (2007) by Andrew H. Van de Ven, in order to try and bridge the gap between the academic and practical world. In this book, Van de Ven lays out methods for creating academic studies, that not only benefit the world of academia, but can also be read and used by people whom work with the subject matters in practice. Van de Ven sees a problem in academia today, that academic works are in a vicious circle where they rarely leave the field of academia and are often only used by other academics. Van de Ven writes that it's not only the fault of academics, but that practitioners are also criticized for not incorporating new research that could improve their work. This gulf between the researchers and practitioners could stem from several different factors according to Van de Ven, from communication to limited cooperation between researchers and practitioners (Van de Ven, 2007, pp. 3-5).

When looking at the communication aspect of this problem, Van de Ven writes that communication between researchers and practitioners could be due to a "*Knowledge transfer problem*" (Van de Ven, 2007, pp. 3). This knowledge transfer problem could be due to problems in translating scientific knowledge into practice, that the scientific research is not written in such as a way that it is easily translatable into practical use.

Another factor Van de Ven suggests could play into this problem, could be that scientific and practical knowledge are two entirely separate forms of knowledge. While scientific knowledge focuses on incremental steps from many different sources that can be pooled into larger generalizations as well as new theories. Practical knowledge however, is very specific and highly contextual to the problems at hand (Van de Ven, 2007, pp. 3-4). Let's use a clogged drain to demonstrate how these two different types of knowledge comes into play; a researcher might have a general knowledge of how a drain functions as well as *why* it might be clogged, a practitioner however might have specific knowledge of *what* is clogging it and *how* to unclog it without damaging the drainage systems. This is a very crude example, but it nonetheless demonstrates how these different modes of knowledge comes into play.

The third factor that Van de Ven points out, is a knowledge production problem. Van de Ven argues that this problem is the result of researchers not grounding their research in the real world, by this he means that much of modern research is based on statistical knowledge gathered through secondary parties without spending much time in the field. This way of researching can result in studies that are neither useful for academia or practitioners (Van de Ven, 2007, pp. 5-6). By researching in this manner, the researcher doesn't get to see the world from the perspective of practitioners, and their work runs the risk of not being usable in practice.

In an attempt to solve this problem, Van de Ven created a model which he called the *Engaged Scholarship Diamond Model* (Van de Ven, 2007, pp. 10)

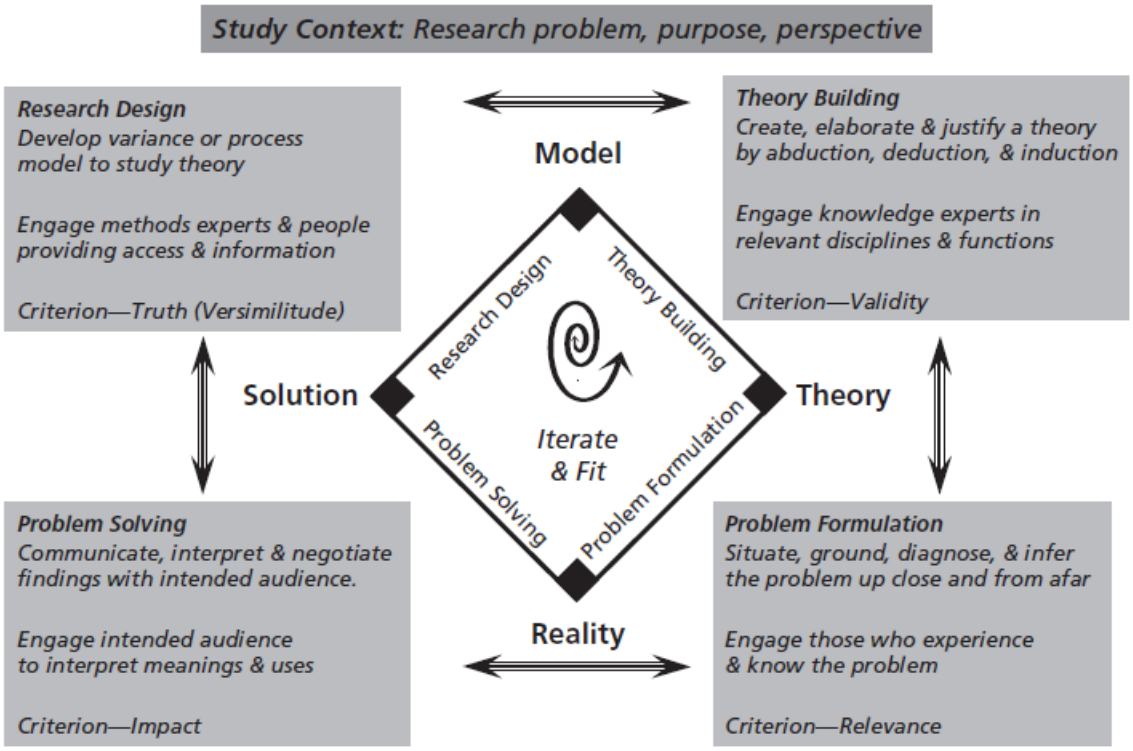


Figure 1 - Engaged Scholarship Diamond model (Van de Ven, 2007, pp. 10)

With this model, Van de Ven aimed to improve scientific studies by grounding them in reality and thus making them more relevant both for scientific and practical use in the future. With this model researchers can start from any point. *Problem formulation* is basically where the researcher identifies a problem that needs investigation. This can be discovered both through interaction with stakeholders as

well as through literature reviews (Van de Ven, 2007, pp. 10). *Theory building* is where the researcher builds upon his or her pool of knowledge by collaborating with other experts in relevant fields. This is also where the researcher justifies the theories (Van de Ven, 2007, pp. 10-11). *Research design* is where the researcher confers with experts about the study's research methods as well as the potential participants in the study (Van de Ven, 2007, pp. 10-11). *Problem solving* is where the researcher attempts to solve the formulated problem, this is where the collected data from literature and the real world is analyzed and interpreted, and is condensed into a possible solution (Van de Ven, 2007, pp. 10-11).

4.1. Engaged Scholarship and this thesis

Engaged Scholarship is the foundation of this thesis' structure and methodology. The goal of this thesis is to further both the pool of knowledge in regard to immersion and VR, as well as provide additional tools for VR practitioners. The way this thesis has been structured in regard to the diamond model, has been problem formulation, research design, theory building and problem solving. Problem formulation came first, as both VR and immersion are of great interest to me, as a result I looked for areas where a problem existed in both research and in practice. As a result, an issue was found with VR presentations, in that businesses increasingly uses VR presentations for both outreach and internal use, and looking at the research aspect, based of literature reviews, there was not a vast body of knowledge on this specific topic, so it was deemed a beneficial subject matter to investigate further. Secondly, was the research design of this thesis. I chose to structure the research design after the problem had been formulated, it seemed necessary to figure out how I should go about researching this subject before I started building the theory, because this decision would influence how and when the data was collected. Throughout designing the research methodology, I conferred with my thesis supervisor, to make sure that the thesis had a solid methodical foundation. Thirdly was theory building, after the research design had been completed, I started building the theory based on further literature reviews. This is also where the connection to practitioners was made, to establish this bridge between academia and practice, a questionnaire was created. This questionnaire was based on the pool of knowledge generated from the literature reviews, this questionnaire was then posted on several VR development forums, as well as sent out to several VR development businesses in Denmark. The intention with this questionnaire was to get the practitioners' views on the conclusions of researchers, to see whether they were in agreement

or not. Lastly, a solution to this problem was discussed and concluded, this solution was communicated using both relevant literature as well as visualized using an editor tool, this was to maximize the usefulness of the thesis for both researchers and practitioners.

Although this structure was mostly followed, research design and theory building did collide during the writing of this thesis, as the research design was being structured, I was also going through literature review and slowly building the theoretical foundation as well.

5. Immersion & Presence

In this chapter, the phenomena of immersion and presence are examined through relevant scientific literature, with the primary focus on immersion. The chapter is divided into several sub-chapters, first examining the basic principles of the terms on their own, then examining immersion through the eyes of video game designers, how sound affects immersion and lastly, examining and choosing a definition of immersion and presence that is most relevant to the aim of this thesis. All these perspectives on immersion and presence will be seen through the lenses of hermeneutics and phenomenology, through which all these texts will be interpreted in order to get to the essence of them.

5.1. Presence

Before we delve into the primary focus of this thesis, it would beneficial to first examine a term that often accompanies the term immersion. This term, presence, is often seen alongside immersion, often used interchangeably, much to the chagrin of scholars in relevant fields. So, what is presence? Presence is a psychological phenomenon where the user feels physically present in a completely different location to where they are, this phenomenon was popularized by Marvin Minsky in 1980, which he called *telepresence* (Minsky, 1980). In Minsky's essay, simply titled *Telepresence* (1980), he proposed that by using remote robotics, for space exploration as an example, with the right technology, the operator could be made to feel as if he or she were present in this remote location. In this essay Minsky explored how telepresence could be a useful tool for dangerous environments like space, ocean exploration or mining (Minsky, 1980). Minsky wrote that the biggest challenge is making telepresence technology that makes the operator feel like they're actually there, our intricate sensory inputs, like touch and pressure, must be replicated through technology in order to achieve this.

In the 90's during the dawn of the internet and 3D technology, the concept of presence was further explored, to create virtual spaces that tricked the user into feeling present. This was particularly notable when companies started developing technology for the 21st century. For example, one such project was under development by Sun Microsystems called *Starfire*, with this project Sun aimed to explore how the user would use technology in the 21st century, with both interactable 3D user interfaces and video conferencing technology that made the user feel present. This project was featured in an episode of The

Computer Chronicles in 1996 (Archive.org, 2004), where they demonstrated how future technology would make the user feel present, by using wireless control devices, VR goggles and interactive desks. This method of making the user feel present, is very close to the vision that Minsky had about telepresence. Of course, these predictions weren't exactly what we've ended up with in the 21st century, but the idea of making the user feel present is still very much relevant in today's technology. Today, virtual reality is the major driver in the pursuit of presence, where developers try to make hardware and virtual environments that make the user feel present, but how does virtual environments promote this feeling of presence? In an article titled *A sense of self: The role of presence in virtual environments* (McCreery, et. al., 2013) they wrote that virtual environments today are realistic 3D spaces that the user navigates through and that users "*... are not only required to navigate a three-dimensional space and interact with artificial intelligence in order to solve problems, but also exist within the confines of player developed social systems.*" (McCreery, et. al., 2013, pp. 1636). This sentiment also supports the results of a study titled *Factors That Influence Presence in Educational Virtual Environments* (Mikropoulos & Strouboulis, 2004) where they tested the effects of presence in young teenagers in an educational virtual environment of an ancient Greek house. The results of this study was that, a higher level of interactivity correlated with an increased feeling of presence in the virtual environment, and that the more the participants associated with the virtual bodies, the higher their sense of presence (Mikriopoulos & Strouboulis, 2004, pp. 586-589). These studies indicate that the essence in crafting a virtual environment that promotes the feeling of presence, it should be crafted with a high degree of interactivity.

5.2. Immersion

Immersion is one of the single biggest buzzwords in media marketing. From role-playing video games to Hollywood blockbusters, the word is used extensively and promises the consumer that the entertainment product will suck them into a fictional world. But what exactly is immersion? The literal definition of immersion in the Oxford dictionary is "*The action of immersing someone or something in a liquid.*" ("Immersion", n.d., para 1), the secondary definition of the word is "*Deep mental involvement in something.*" ("Immersion", n.d., para 2). The secondary definition is presumably the definition that the entertainment industry promises to its customers, that their products are so well made that they will

instill a deep mental involvement in the user. This definition though, barely scratches the surface of what immersion is.

So, what is immersion? That is a question scholars have asked for decades, if not centuries. The concept of being absorbed into a fictional world is a wholly difficult question to answer, because it's a very subjective experience that varies from person to person, but the experience is nonetheless one most of us can relate to. In his book *Experiencing Narrative Worlds: On the Psychological Activities of Reading* (1993), Richard Gerrig explored the experience of immersion, of being transported into a fictional world, whether through a book, TV show or a movie. In this book Gerrig wrote about users being transported into the fictional worlds, the feeling of being "lost" in an entertainment product, even in poorly crafted products. Gerrig argues that it's more difficult to *not* be transported into these fictional worlds, as users often fill in the gaps to a given product, regardless of whether it's a soap opera or a book (Gerrig, 1993, pp. 3-7). When reading a book, it's often visualized within our mind's eye, for instance, before the first *The Lord of the Rings* (2001) movie came out, people probably had very different imaginings of what The Shire looked like. In movies, this immersion is built upon by the viewer forming empathic bonds with the characters, where they feel invested in these characters lives' and internal relationships. Gerrig wrote that narrative worlds often give us the impression of uncertainty, by that he meant that although we know a character in a novel or a movie is going to die, when we are transported into these narrative worlds, we get a sense of uncertainty, a feeling of being capable of changing the fate of the story in some way (Gerrig, 1993, pp. 14).

As mentioned at the beginning of this chapter, no other entertainment industry uses the term immersion as heavily as the video game industry, it's one of the most common selling points of video games. Video games certainly are different when compared to other entertainment media like literature, movies and music. Video games offer a mixed-bag of what the other forms offer, motion pictures in the form of cutscenes[1], text, sound and music, but above all, the biggest difference between video games and other forms of entertainment, is interactivity. It stands to reason to suspect that this new level of involvement changes how immersion is achieved as compared to other forms of media. The effects of immersion was the subject matter of Laura Ermi and Frans Mäyrä's paper *Fundamental Components of the Gameplay Experience: Analysing Immersion* (2007). In this paper Ermi and Mäyrä

[1]Cutscenes are short motion clips in video games, often used to convey the main story in a video game

explored how users experience immersion as well as the different *types* of immersion users can experience. The first part of gameplay immersion that's listed is *sensory immersion* (Ermi & Mäyrä, 2007, pp. 101), this relates to the audiovisual aspect of games, i.e. the sounds and graphics that are often empowered by better screens and speakers. The next type of immersion is *challenge-based immersion* (Ermi & Mäyrä, 2007, pp. 101), this type of immersion is related to the challenges the user can overcome in a video game, where they feel a sense of immersion by "*…a satisfying balance of challenges and abilities.*" (Ermi & Mäyrä, 2007, pp. 101). The next type of immersion they call *imaginative immersion* (Ermi & Mäyrä, 2007, pp. 101-102), often associated with role-playing games, where the user uses his or her own imagination in the game, like imagining the backstory of the main character the user is controlling. They created a model of these different types of immersion and how they related to the structure of the game, and the users' experience of this;

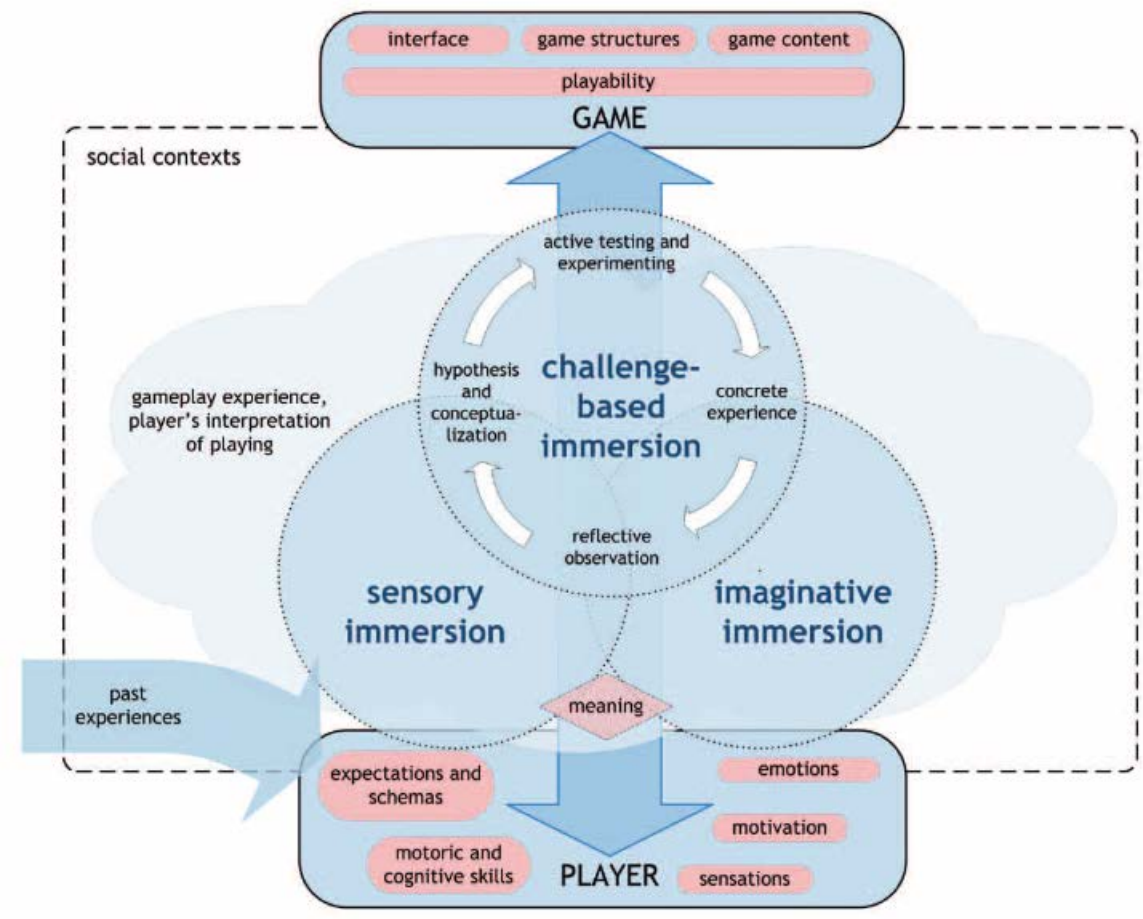


Figure 2 - SCI-Model (Ermi & Mäyrä, 2007, pp. 103)

They tested these types of immersion and their model with users, which showed a distinct difference between the gameplay experiences, especially that participants reported differently to each game depending on their gender.

In a paper by Emily Brown and Paul Cairns titled *A Grounded Theory of Game Immersion* (2004), they tried to distinguish the different levels of immersion that users experience in video games, as well as the prerequisites in order to achieve these different levels of immersion. The first level they call *engagement* (Brown & Cairns, 2004, pp. 1298-1299), this is the time, energy and concentration the user sets aside to play the video game. The next level is called *engrossment* (Brown & Cairns, 2004, pp. 1299), this level pertains to the user's emotional investment in the game, where the user forms an emotional attachment to the game. Brown and Cairns writes that at this level the user becomes so immersed in the game that they become less aware of their surroundings and themselves. The highest level of immersion they call *total immersion* (Brown & Cairns, 2004, pp. 1299), at this level the user becomes so immersed in the game that the game becomes the sole center of attention for the user. Brown and Cairn also describe this level as presence.

5.3. Video games, immersion and presence

When researching immersion and presence in virtual environments, it is often associated with video games either directly or indirectly. Video games are after all one of the most prolific examples of virtual environments today, and as mentioned, immersion is a buzzword often used by video game publishers to sell their games. Video game designers often use the term very loosely, without much explanation of *what* they mean by the term immersion. From a hermeneutical standpoint, one could say that video game designers have a prejudice when it comes to immersion. An example of the lax use of this term can found in *The Art of Game Design: A Book of Lenses* by Jesse Schell (2015); "*We often say that the guest is "immersed" in the world. This kind of immersion increases projection, boosting the overall interest of the guest significantly*" (Schell, 2015, pp. 290). While there's nothing inherently wrong with this statement, it nonetheless demonstrates the relaxed way in which video game designers use the term. With that being said, video games, designers and gamers are some of the most prolific users of the term, so there must be something that makes video games stand out when talking about immersion. To explore this further, and to explore how the techniques in video game design might be used in 3D VR presentations, the above book as well as *Level Up! The Guide to Great Video Game Design* (2014) by

Scott Rogers will be examined. In the chapter where the above citation from Schell's book is from, Schell also wrote about how the user projects him or herself into the virtual world, i.e. immersion, he wrote that consistency is a very important aspect to the users feeling of immersion, that the virtual world is consistent and believable, that there aren't elements that feel out of place like for instance, a jet aircraft in a fantasy game. Laurie N. Taylor also echoed these views of consistency in video games in her thesis titled *Video Games: Perspective, Point-of-view, and Immersion* (2002). In this thesis Taylor wrote that a consistent game world is required for user immersion, both in terms of the actual game space as well as consistency in the game rules. (Taylor, 2002, pp. 12-15). Schell also wrote that one major advantage video games have over other forms of entertainment in terms of user projection is that, the user *is* the main character, and that events within the game centers around the user. Schell ended the segment by posing two questions for video game designers they can ask themselves to further user projection in their video games; "*What is there in my game that players can relate to?... What is there in my game that will capture a player's imagination?*" (Schell, 2015, pp. 291). In Scott Rogers' book he also enlightened on some aspects of video game design to further user immersion. One such aspect is the camera view in the game, whether the game is played from a first-person or third-person perspective. Rogers wrote that one of the biggest advantages of using a first-person camera view in video games is that a greater level of immersion is achieved by the user, because they can much more easily project themselves into the virtual world. In this segment, Rogers continued to write about using visual effects like lens flares in the game but ends it by writing that while all of the same effects can be applied to games that doesn't use a first-person camera perspective, the visual effects have more impact when used in a first-person perspective and increases the feeling of both immersion and presence (Rogers, 2014, pp. 137). Interestingly though, Schell argued in his book that a third-person perspective can be equally immersive, however, he argued that the experience is different. He argued that instead of projecting themselves into the virtual world, they instead relate and empathize with the playable character, for instance feeling pain when the main character is hurt, comparable to the empathy felt for characters in a movie as Gerrig described (Gerrig, 1993, pp. 3-7). Schell argued that this type of immersion can be equally, if not more, immersive than its first-person counterpart.

Another aspect Rogers said designers should take into consideration is the heads-up-display (HUD). He wrote that one of the most immersive games he ever played had no HUD, but instead used sound and other non-intrusive visual ques that blended into the games' environment as communcation. Rogers also wrote about game design that can actually break the users sense of immersion, one of these is invisible walls. He wrote that if the user is met with a wall that isn't presented by an object such as a

brick wall, their sense of immersion will be broken, because it conflicts with the expected rules of the game (Rogers, 2014, pp. 216). Another immersion breaker Rogers pointed out, is save systems, this is where the differences between video games and VR presentations come to the surface, a save system is a specific gameplay element in video games, it allows the player to save their current progress. This however won't have much value in a 3D VR presentation, as the time investment and priorities of the user are vastly different.

5.4. Immersion and sound

When reading literature about immersion in video games, one cannot fail to stumble upon the mentioning of sound design. Sound is also a feature that could be successfully incorporated into VR presentations. So, how does sound affect immersion? For starters it's important to look at *how* sound is different in an interactive medium compared to traditional "passive" media, to understand this, the book *Playing with Sound: A Theory of Interacting with Sound and Music in Video Games* (2013) by Karen Collins is used along with other sources. Interactivity fundamentally changes how we use sound, in a video game for instance, Collins uses a good example to differentiate between traditional media and video games; traditional media acts *on* the users' body while interactive media acts *with* the users' body. (Collins, 2013, pp. 22). What this means is that with traditional, passive media like movies, music and books the medium acts on the user, that is to say the user perceives and interprets the sounds and images produced by the media. In an interactive medium however, the user must act with the media in order to progress. In a video game for instance, if the user doesn't interact with it, one of two things will happen, depending on the video game. In a game like *The Legend of Zelda* (Nintendo, 1986) if the user doesn't interact with the video game when it starts, nothing happens, the main character will just stand in one place and no further development will happen until the user interacts with it. In a game like *Pac-Man* (Namco, 1980), if the user doesn't interact with it, the main character will eventually just die as soon as the ghosts reaches him.

Interactive media fundamentally changes how the user perceives and engages with sound. Sound in an interactive medium is very different to traditional media, in traditional media sound is always tied to images (Collins, 2013, pp. 32) whereas in an interactive medium sound is tied to actions. The sound of a truck exploding in a movie for instance is tied to the image of said truck exploding, but in a video game

that sound is tied to an action that either the user or an NPC[2] performed. In the book Collins also wrote about how sound in video games contribute to the feeling of being in the virtual world, by extending the users' self into the space. A big contributor to this phenomenon is self-produced sound, i.e. that the actions the user performs in the video game also produces a sound. By doing this, the user can extend him- or herself into the video game world (Collins, 2013, pp. 43-44). Another major contributor to this extension of self, is sound positioning. With the use of surround sound, the user can use the sounds inside the video game to locate events and instead of turning around in the physical world, they instead turn around their virtual avatar in the direction of the produced sound.

In a paper titled *Game audio – an investigation into the effect of audio on player immersion* (2013) by Nicola Gallacher, the impact of audio on user immersion into video games was studied. This was studied by letting users play through a game with and without audio, the results of the study showed an increase of immersion of the users when playing with sound (Gallacher, 2013). In a paper titled *Audio immersion in games – a case study using an online game with background music and sound effects* (2013) by Stephen Gormanley, he likewise tested how users responded to playing a game with and without sound effects and music. The results of which were that many of the users felt more immersed with the sound effects and music in the game, echoing the results of Gallacher's study. While these studies focused on video games, as discussed previously, sounds are an element that could be introduced into a VR presentation, and is already used by some VR developers today, which is further examined in a following chapter.

5.5. Defining immersion and presence

Now that a brief overview of immersion and presence has been provided, it is time to precisely define immersion and presence in regard to this thesis. The definition of what immersion and presence is, is a hotly debated topic amongst experts and designers in the field of interactive media, some make a clear distinctions about what these terminologies each describe, while others use them interchangeably. In a paper titled *Immersion Revisited: A Review of Existing Definitions of Immersion and Their Relation to Different Theories of Presence* (Nilsson, Nordahl & Serafin, 2016), they provide a generalized overview of the different definitions and theories of the terminologies, this paper will likewise also provide this

[2]An NPC is a Non-Playable Character in a video game, these can either be friendly, hostile or neutral to the user.

thesis with a clear path that is used to find a suitable definition. In this paper they categorize the use of the term immersion into four different categories, as well as with their associated researchers; as a property of the system, as a perceptual response, as a narrative response and as a response to challenges. These categories are further defined by sub-categories regarding the specific type of immersion the individual researchers have published about. The first category, the systematic property (Nilsson, Nordahl & Serafin, 2016, pp. 112-113), is where the technology is directly tied to the users' level of immersion, i.e. with a better monitor and computer the user will feel more immersed in the virtual environment. The second category, the perceptual response (Nilsson, Nordahl & Serafin, 2016, pp. 112-113, immersion is categorized as a psychological state where the user extends his/her sense of self into the virtual environment and the environment "surrounds" the player, they write that three factors play into this type of immersion, the isolation from the real world, the feeling of inclusion in the virtual world and the extent to which the user can interact naturally with the virtual environment (Nilson, Nordahl & Serafin, 2016, pp. 112). The third type of immersion is where the user is immersed in the virtual world through the narrative, where the user accepts the world as "real" (Nilsson, Nordahl & Serafin, 2016, pp. 113-114. The fourth and last type is challenge-based immersion (Nilsson, Nordahl & Serafin, 2016, pp. 114), where the user is absorbed in the virtual environment through challenges within it, where the user tries to win the game.

The authors came up with this model to illustrate the relation between these different definitions of immersion;

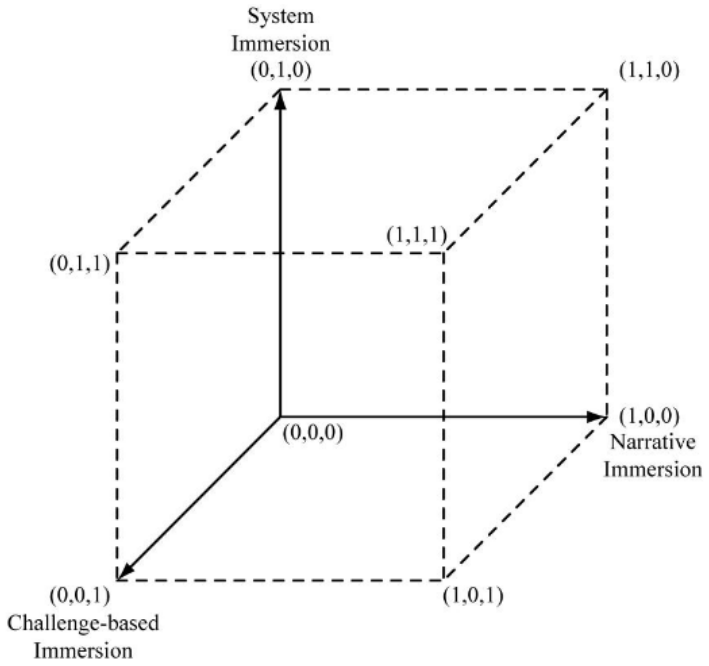


Figure 3 - Immersion model (Nilsson, Nordahl & Serafin, 2016, pp. 118)

In this paper the authors also delve into theories of presence and how the previously described definitions of immersion relate to these theories.

Due to the aim of this thesis, the most relevant definition of immersion would be immersion as a systematic property of the technology. As mentioned, this thesis aims to explore how using theories of level design, immersion and VR can improve 3D VR presentations. Therefore, the definition of immersion as a systematic property of the technology and presence as a psychological response by the user is most relevant, as this heavily relies on the use of better technology (VR HMDs) as well as higher fidelity graphics and audio. Another reason why this is seemingly the most relevant, is the fact that part of this thesis is about creating an objective set of guidelines for developers to use. Though the argument for the use of narrative immersion as the foundational definition could also be made, as the theories of level design suggest creating a believable world for greater immersion. This definition does not account for the use of high fidelity graphics and audio, which seems more relevant for the aim of this thesis.

A clearer and more descriptive definition of what systematic immersion is, can be found in the paper titled *How we experience immersive virtual environments: the concept of presence and its measurement* (Slater, et. al., 2009, pp. 195) where they wrote:

"*We reserve the term immersion to stand simply for what the technology delivers from an objective point of view. The more that a system delivers displays (in all sensory modalities) and tracking that preserves fidelity in relation to their equivalent real-world sensory modalities, the more that it may be described as being "immersive".*" (Slater, et. al., 2009, pp. 195).

On the next page in the same paper they write:

"*In order to achieve presence we could follow two different paths. The first would be to construct a system with such a high fidelity to reality that it becomes indistinguishable from reality.*" (Slater, et. al., 2009, pp. 196).

This definition is one of the closest to what is needed for 3D VR presentations. 3D VR presentations are most often about showcasing projects that are to be implemented into the real world, because of this, it stands to reason that businesses would want to create a presentation that is as close to what it'll look like in the real world. The potential of this high fidelity inducing a sense of presence in the user is an added bonus, however, the most important aspect is that these presentations are created as close to real life as possible, since that is what they're attempting to emulate. Now it becomes relevant to define presence in relation to this definition of immersion. In an interview by Peach – Presence Research in Action (2007), Slater gave a definition of presence in relation to systematic immersion. In this interview, Slater described presence as the user responding to computer generated stimuli, as if it was real. In a paper titled *Immersion, Presence, and Performance in Virtual Environments: An Experiment with Tri-Dimensional Chess* by Slater, Vasilis Linakis, Martin Usoh and Rob Kooper, they further define presence as a feeling of being present in a computer-simulated environment, as a psychological sensation. Due to the nature of this definition of presence, the primary focus in this thesis will remain on the more objective sensation of immersion.

One of the authors of the papers cited above, Mel Slater, has long been a prominent researcher into systematic immersion and its influence on presence. In a paper titled *Place illusion and plausibility can lead to realistic behavior in immersive virtual environments* (Slater, 2009), Slater explores how immersive virtual reality technology can lead to realistic behavior among users. In this paper, Slater discusses the elements that are needed in order to improve the quality of the immersive experience

(Slater, 2009, pp. 3549-3550), these elements include things like HMDs, head-tracking, framerate latency and quality of the overall graphics in the scene. One very interesting element Slater describes, directly ties into the previously described elements that improve immersion into video games, namely that immersion is improved by how the objects in the environment behave according to the user's expectations. This is very much in tune with what Rogers wrote about, how invisible walls can ruin the user's sense of immersion, as it conflicts with their expectations of what will happen if they interact with certain elements in the virtual environment. Slater also uses a rather interesting analogy to describe immersive vs non-immersive systems, writing that a non-immersive system could actually be simulated using an immersive system (Slater, 2009, pp. 3550).

6. Virtual Reality Technology

In this chapter, VR technology is examined. For starters, a brief walkthrough of the history of VR is presented, ending with the current VR HMD technologies. After this a sub-chapter on the current state of VR presentations is presented. VR presentations in academia is also examined. Finally, literature regarding the application of VR and immersion in other fields is examined.

6.1. A brief history of virtual reality

Firstly, what is virtual reality? In a broad sense, virtual reality is the emulation of reality. By using technology, the human senses such as sight, sound, touch and smell can be replicated using technology, tricking the human brain into perceiving another reality (Stanković, 2015, pp. 1-4).

Virtual reality technology has been around for decades, it's by no means a new technology. Attempts at VR can be traced back as far as old panoramic paintings from medieval times, these paintings were made extremely wide, so that the viewer when standing in front of it would be physically surrounded by the painting (Virtual Reality Society, n.d.). These attempts can also be seen in the architecture and murals of old churches around Europe where the biblical images surround the attendees in the mass hall (Stanković, 2015, pp. 15-16). Winding up the clock to the 19th century, stereoscopic images made it onto the scene, where it was discovered that by viewing two pictures of the same image slightly separated horizontally, the viewer would feel a much greater sense of depth and immersion into the scene. This was also the method used for the View-Master that was first demonstrated in 1939.

Figure 4 - https://c.slashgear.com/wp-content/uploads/2015/02/viewmaster23423.jpg An early version of the popular View-Master

With the View-Master, the user would insert the circular containers in the top of the device and would be shown two pictures of the same image, which gave a greater sense of dimensional awareness in the scene, this became a big phenomenon throughout the 20th century (Virtual Reality Society, n.d.) (Stanković, 2015, pp. 18).

In the early 20th century the first flight simulator also came onto the scene, this simulator was intended to train pilots in operating aircrafts. This device however, was entirely mechanical in nature, intended to simulate the physical effects of flying an aircraft like controlling the rudder and simulating turbulence (Virtual Reality Society, n.d.). This basic principle of this early flight simulator can also be seen in today's flight simulators used to train commercial pilots, although much more advanced and also simulating the audiovisual aspect of flying an aircraft.

In the mid-1900s the first VR device that bears resemblance to those we have today was developed. It was called the Sensorama, it was designed to get the viewer completely immersed in watching a film. The Sensorama stimulated every sense, from haptic response in its vibrating chair to imitating the smells that were featured in the films. This would be the first VR experience that bears much resemblance to the devices of today, in that it completely closed the viewer off from outside stimuli, by enclosing the viewers' head inside of the device, similar to a VR headsets and headphones of today (Virtual Reality Society, n.d.) (Stanković, 2015, pp. 25).

In the 60s the first HMDs came onto the scene. These devices would attach to the users' head with a strap, limiting the users' vision exclusively to what was on-screen. The first of these HMDs did not feature any motion tracking, however, this technology would also arrive in HMDs a little while later in the 60s, this technology however, was not for simulating virtual experiences at first, but was developed for military applications (Virtual Reality Society, n.d.). In the 60s the concept of VR as we know it today was developed by Ivan Sutherland (Sutherland, 1965). In this paper he wrote about how to create the ultimate immersive HMD experience, by using many of the same principles seen in previous attempts at immersive media, but with one major difference; the world in which the user is placed is fully interactable, every object that the user sees, they can interact with. Sutherland later developed further on this technology with a VR HMD that for the first time was run through a computer, this allowed them to display simple digital scenes, in which the user could interact with (Virtual Reality Society, n.d.). In the 90s a company called VPL research, created the first commercially available VR displays, these VR headsets were called "Eyephone" (Virtual Reality Society, n.d.). It was also the founder of VPL, Jaron Lanier, who came up with the term virtual reality.

In the 90s VR technology finally started becoming available for the average consumer, especially manufacturers of home video game systems started approaching technology. Both SEGA and Nintendo tried their hand at VR technology, SEGA showcased a VR headset for the Sega Genesis console (Called the Sega Mega Drive in Europe), this VR headset looked much like the VR headsets of today. Nintendo made a dedicated VR home console called Virtual Boy, this console was quite different to the one showcased by SEGA, the console would be placed on a stand and the user would place his or her head into the device, surrounding their vision. Both of these technologies proved quite unsuccessful, SEGAs VR display was abandoned after they showcased their prototype, and Nintendo's Virtual Boy was mired by issues and proved a commercial failure for the company (Virtual Reality Society, n.d.).

Though technology in the 90s wasn't quite there to take full potential of VR, this didn't deter tech companies from pursuing that truly immersive VR experience. 2012 marked the year where VR technology finally entered the mainstream in full force again, when the Oculus Rift was first shown to the world. The showing of the Oculus Rift kickstarted the pursuit of the ultimate VR experience yet again, with most of the major tech companies trying their hand at the technology from HTC with the Vive to Sonys VR headset for the Playstation home console to Samsungs Gear VR. This time though, it seems as if the technology might stick, as the technology is being embraced by many different industries, from the entertainment sector to the industrial sector, and there is a growing community of

businesses dedicated to developing software utilizing VR technology, as is demonstrated in the following sub-chapter.

6.2. VR presentations – State of the art

Before we can delve into how to one might improve 3D VR presentations, it's important to take a look at what's is already on the market. In this thesis, the Danish VR industry is examined, this is done by going through their websites and taking a look at their past projects relating to VR presentations.

Kanda is a business based in Aarhus, who make VR products for business, either for commercial or internal use, they use a variety of different VR technologies from the HTC Vive, Samsung Gear VR to Oculus Rift. Taking a look at their past cases, they've created VR experiences for several different businesses, one in particular is of relevance to this thesis, recreating a Maersk oilrig using Gear VR. In this case, Kanda describes that they aimed for "… total immersion…" (Kanda, n.d.), to do this they created a 360 video of one of their oilrigs, along with adding other 3D objects, in this scene the user could interact with the oilrig, although there is no mention of sound for this presentation. Compared to the immersive elements as described in sub-chapter 5.3, this presentation has quite a few of the elements that should in theory contribute to user immersion. Based on the description however, we must assume that there is no sound in this application, or that it wasn't considered an integral part of the immersive experience. Another case Kanda has on their site, was a VR solution for a company called Nordlux who produce in and outdoor lighting solutions, to simulate their light products they wanted a VR experience to accompany their show booth. Here, Kanda used an Oculus Rift to simulate their lights in a virtual environment. In Kanda's description, they again mention immersion as one of their goals, in the description however, they neither mentioned interaction, user movement or sound.

Taking a gander at some the projects of Khora Virtual Reality, another Danish business specializing in VR experiences, one of their projects was made for Danmarks Naturfredningsforening (Danish union for nature conservation). This project was made to spark the debate of how much nature should be a part of the landscape of Denmark in the future (Khora Virtual Reality, n.d.). In this project they made a full 3D scene complete with sound and high-fidelity graphics, it has many of the elements contributing to an immersive experience, even positional sound effects. One thing that this project does lack though, is interactivity, the user stands still next to a tree where they can look around in 360 degrees, they cannot

move from this position or otherwise interact with the virtual world around them. Another project from Khora made for the company Keofitt, who makes sterilized valves, was made to demonstrate the difference between sampling from conventional valves and Keofitts new sterilized valve (Khora Virtual Reality, n.d.). This VR experience is more akin to a game than their other projects, however, looking at the elements of the VR experience, this is the first to feature most of the previously described elements, from high-fidelity graphics, sound, interactivity and consistent level design, from the video clip it's not possible to determine whether the sound was positional or not. This experience is very complete, for instance when turning one of the valves, it is accompanied by the sound of a knob turning as well as the sound of liquid dripping into the sampling bottle.

Another use of VR in businesses today, is as a tool for conceptualization. Using computer-aided design tools (CAD), businesses can create visualizations of new concepts in 3D graphics (Stanković, 2015, pp. 5). In a paper titled *An investigation into the implementation of virtual reality technologies in support of conceptual design* (Ye, et. al., 2006), the usage of CAD tools and VR technologies was explored, and a new CAD tool was developed. This new tool called *LUCID*, enabled the designers to create concept design in 3D and made use of several different VR technologies from stereoscopic 3D glasses to sound and haptic feedback (Ye, et. al., 2006, pp. 77-81). This paper was published prior to the arrival of modern VR HMDs, but it nonetheless demonstrates that the use of VR for conceptualization is not a new idea, the technology of today though, gives us new ways of using VR in businesses.

6.3. VR presentations in academia

Now we've taken a small peek at a couple of prominent VR businesses, there are a few more examples in the realm of academia. One example of this can be found in the book *Complex Artificial Environments: Simulation, Cognition and VR in the Study and Planning of Cities* (2006) by Juval Portugali. As the title suggests this book is about the use of VR technology in the planning of cities, creating 3D cityscapes in order to visualize the future of the cities. They made two VR simulators, one called *MultiGen paradigm* and one called *Skyline*, with both of these simulators they can create a cityscape which can then be explored by the user, the advantage of Skyline compared to the other was that it could be viewed on the internet (Portugali, 2006, pp. 96-99). These technologies are both called VR simulators, however, seeing how they're used in this book, makes one question their use of the term "VR simulator". It's unknown

exactly how the MultiGen paradigm simulator runs, but in the book a picture of the Skyline simulator is shown.

What they show in the picture in the book is difficult to connect to the term VR as we know it today, there is no HMD, stereoscopic imagery or head tracking, the user flies over the cityscape using a mouse as well as a headset while looking at a regular monitor. Compared to the previous examples of VR experiences, this seems to miss a few things, the interactivity is limited to flying over the cities and the graphics seem to be low-fidelity. This book illustrates a dilemma between the usage of the term VR between the industry and the common understanding of what VR is, and its use in academia. In common language, the understanding of VR is that, VR is an electronic experience powered either by the use of a head-mounted display, the use of haptic gloves or otherwise a physical interaction between the user and the technology ("Virtual Reality", n.d., para 1). The book uses the term VR for the simulations, however, their simulations are quite different when compared to the VR experiences offered by the VR companies previously mentioned. There is no use of HMDs, gloves and it uses a regular display, headphones and mouse as the tools of interaction. One can however understand this problematic difference between the usage of the terms, because looking at the words "virtual reality", the simulations are technically accurate, they are simulated in a virtual space and they attempt to simulate reality, in this case the city of Tel Aviv. However, this differing use of the term can be problematic, as the differing use of the term could lead to confusion for future research attempting to research VR as it's understood in the common sphere.

Another VR study titled *Development of a Virtual Museum Including a 4D Presentation of Building History in Virtual Reality* (Kersten, Tschirschwitz & Deggim, 2017) also utilized VR for presenting a historic building in the city of Bad Segeberg in Germany. The historic building in question was the Old-Segeberg house which now functions as a museum, they wanted to create a virtual museum exhibition, so that people could experience the museum from afar (Kersten, Tschirchschwitz & Deggim, 2017, pp. 361). To do this, they utilized the Unreal Development Kit, that is originally intended for video games, but can be used for any virtual experience in 2D and 3D environments. They developed the experience for both regular displays and VR, the difference was when using a regular display, the user could only move to predetermined spots in the museum, whereas with the HTC Vive, they could "teleport" to any visible part of the house using the controller (Kersten, Tschirchwitz & Deggim, 2017, pp. 364-365). What they ended up with was an immersive, virtual museum exhibition using the latest in commercial VR technology as well as development software. This includes many of the previously described elements

needed for an immersive experience in a virtual environment, although there is not mention of sound being included in the experience.

When examining these two papers, the loose use of the term VR can be witnessed as there is a stark difference between what they refer to. The first paper uses VR to describe their application simply because it features a 3D environment that the user can fly above, whereas the second paper refers to the HTC Vive headset as a VR system. This difference in usage could potentially be a problem with VR research, especially among practitioners who are looking for academic research to implement into their products. Likewise, this could pose a problem for researchers as well, if there isn't a common understanding of what VR refers to, finding studies that relate specifically to the problem at hand could prove difficult.

6.4. VR, immersion and presence in other fields

Through the years, a lot of research has been made into immersion and VR, one of the most prominent fields of research in recent years, is the field of Virtual Reality Exposure Therapy (VRET). What this field researches, is the use of VR technology in psychological therapy, by exposing the user to their phobias in a virtual setting. In VRET much of the same theoretical background on immersion is also in use, as these therapy methods often try to get the user as deeply engaged in the exercises as possible. While the subject matter of these studies is not particularly relevant to this thesis, their use of immersion as a tool to engage their target group to make the VR therapy more effective, is. This way of using immersion is very relevant to this thesis, as it demonstrates the power of immersion in VR experiences.

In one such paper by Ted Jones, Todd Moore and James Choo titled *The Impact of Virtual Reality on Chronic Pain* (2016), they researched whether VR HMDs could improve the condition of chronic pain sufferers. In this paper, they also asked the participants to rate their level of immersion into the VR experience. This rating was to assess the correlation between the effectiveness of the session on their chronic pain and their immersion into the experience (Jones, Moore & Choo, 2016, pp. 3). The correlation here being that the more distracted and engaged the participants were in the virtual world, the less pain they would experience. The results of the study was a 60% reduction in the pain level and the average rating of immersion into the experience was 8.4 out of 10 (Jones, Moore & Choo, 2016, pp.

6). This suggests that there could be a correlation between how immersed a user is in a virtual environment, to how much the user reacts to stimuli from the real world.

Another study titled *Treatment of acrophobia in virtual reality: The role of immersion and presence* (Krijn, et. al., 2004) also used theories of immersion as well as presence in their study of VR exposure treatment on patients awaiting treatment for acrophobia[3]. In their study they used two different kinds of VR technology, the first simply being a HMD connected to a PC, while the second was a cave automatic virtual environment (CAVE) which is a VR system where the images are projected onto walls surrounding the user (Krijn, et. al., 2004, pp. 232). Their study found no difference in effectiveness from using one VR technology to the other. What they found though, was that patients who used the VR treatment while awaiting conventional treatment suffered from less anxiety than those who didn't (Krijn, et. al., 2004, pp. 237). In the study the authors stated that immersion and presence were assumed to be important for VR treatment to work, as they needed the patients to feel like they were actually there, in order to induce a feeling of anxiety (Krijn, et. al., 2004, pp. 230-231). In this study they specifically define immersion as systematic immersion (Krijn, et. al., 2004, pp. 231). Although their findings did not suggest how integral the use of presence was to the experience, as there were no notable differences between using the HMD and the CAVE system. Another important note on this topic was the level design of the VR experiences, as seen in the pictures in the paper, these were all consistently designed as well as using high-fidelity graphics (Note the year this study was published), which may also have been a factor in creating the immersive experience.

A third study on this topic by Matthew Price and Page Anderson titled *The role of presence in virtual reality exposure therapy* (2007) studied the relevance of presence in VRET. In this study they suggest that the use of presence had yielded mixed results in studies of VRET (Price & Anderson, 2007, pp. 742-743). In this study they found that there was a correlation between self-reported presence and the level of anxiety felt during the sessions (Page & Anderson, 2007, pp. 748). The end result of this study suggested that presence functioned as a gateway to the increased feelings of anxiety, thus the authors suggest that while presence might not be the all-important aspect in the treatment of these disorders, but that the function of presence was nonetheless important to get the users into a distressed state (Page & Anderson, 2007, pp. 748-749).

[3] A fear of heights

7. Questionnaire

Up until this point in this thesis, the primary focus has been on the academics' theories on what can improve immersion, but these aren't the people who are actually designing the VR presentations. From a hermeneutical standpoint, it's important for this thesis to get the interpretations of practitioners on these topics, so that the whole can be understood. So, in order to get their opinions on what elements of a VR presentation improves the immersive experience, a questionnaire was created and released on VR development forums on the internet. These forums were a general VR development forum on Reddit, VR/AR sub-forum on the Unreal development forum, HTC development forum and the Oculus Rift development forum. The questionnaire was also sent out to several Danish VR developers. Before respondents completed the questionnaire, they were introduced to the specific definition of immersion that this thesis uses (Systematic immersion) and that the questions in the questionnaire are based on this definition. This questionnaire was created based on Alan Brymans' book *Social Research Methods* (2014), the questionnaire was as short and precise as possible, in order to avoid respondent fatigue.

The description posted on the forums:

"*Hello everyone. I'm currently in the process of writing my Master's thesis, the subject matter of this thesis is how to use theories of immersion and video game design, to improve 3D VR presentations for professional and commercial use. In addition to the views of academics, I'd very much like to see what you, the VR developers, think of immersion and VR.*

This questionnaire uses a specific definition of immersion as its' base, immersion is a systematic and perceptual response by the user, what this means is that the user is further immersed through technology and that immersion is likewise created as a perceptual response, i.e. if the user interacts with a car within the virtual world, opens the door and sits on the driver seat, the visual and auditory ques like the sound of sitting on the leather seat, makes it more immersive for the user.

The questionnaire is completely anonymous, and your responses will only be used for this thesis.

Under each question there is an optional text box, feel free to further explain your answers within these. The questionnaire will take no more than 5 minutes of your time.

Thank you for your participation."

As mentioned above the "questions" in the questionnaire were clearly structured, this was also true of the possible answers. The questionnaire was based on the Likert scale (Bryman, 2014, pp. 166), where the questions are actually statements, in a Likert scale these are called *Items* (Bryman, 2014, pp. 166). To answer these items, the respondents could choose one of the following answers "*Strongly agree, somewhat agree, neither agree or disagree, somewhat disagree & strongly disagree*", to indicate their agreement or disagreement with the statements. For example, one of the statements was "VR is inherently more immersive than a regular display" to which the respondents could then choose their level of agreement or disagreement. For this questionnaire, it was also decided to include a comment box below all of the items, while the Likert scale questionnaire can show general tendencies, it doesn't answer the reasoning behind the answers. The items on the questionnaire were all mandatory, commenting however, was voluntary.

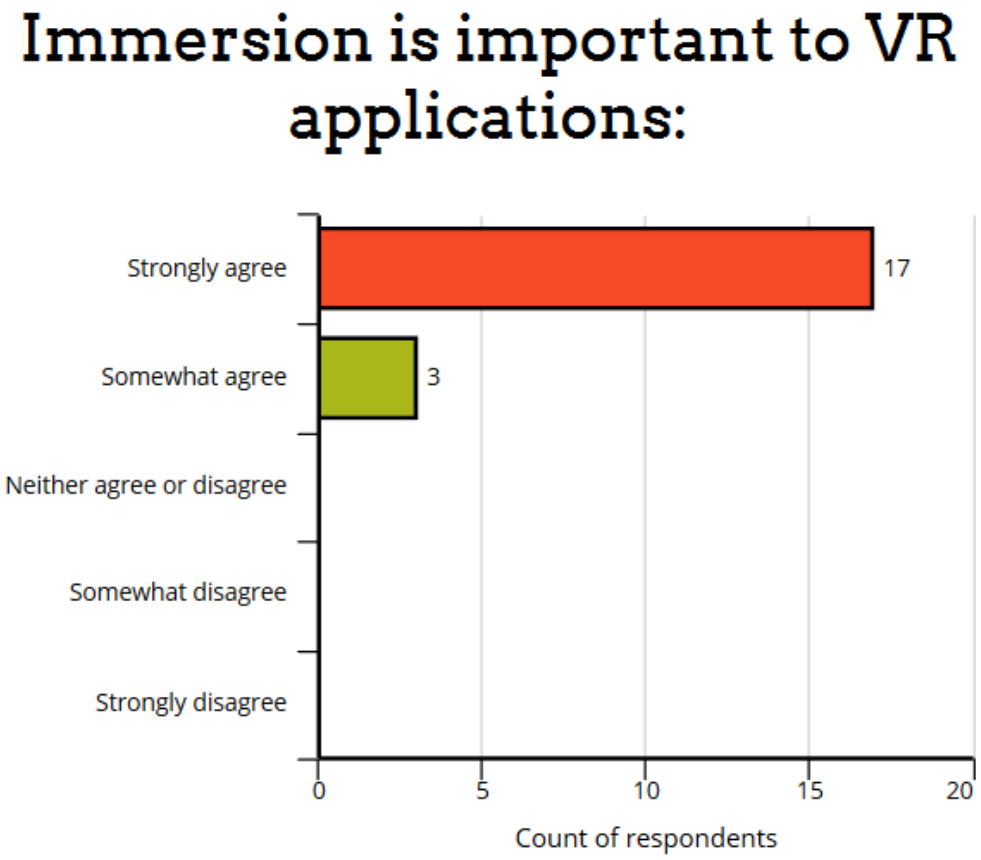
The reason behind the use of a Likert scale questionnaire, was the ability to paint a clear picture of how the developers viewed the term immersion in comparison to the scholars. Using a Likert scale, it was possible to show clear discrepancies between the two groups, and the addition of the comment box enabled the developers to give further insight into their answers. The complete questionnaire and the results can be found in Appendix 1 and Appendix 2, respectfully. Please note that the results in Appendix 2 are not visually the same as those below, the platform used for the questionnaire changed the categorical order based on number of respondents and couldn't be changed, and the alternative chart maker (BEAM, n.d.) was visually different to the platform used for the questionnaire.

The platform used for the questionnaire was Google Forms. The reasoning behind this choice was two-fold, Google Forms allowed reasonable accessibility for free, as well as providing a simple analysis of the data.

7.1. Developer questionnaire on VR, immersion and level design

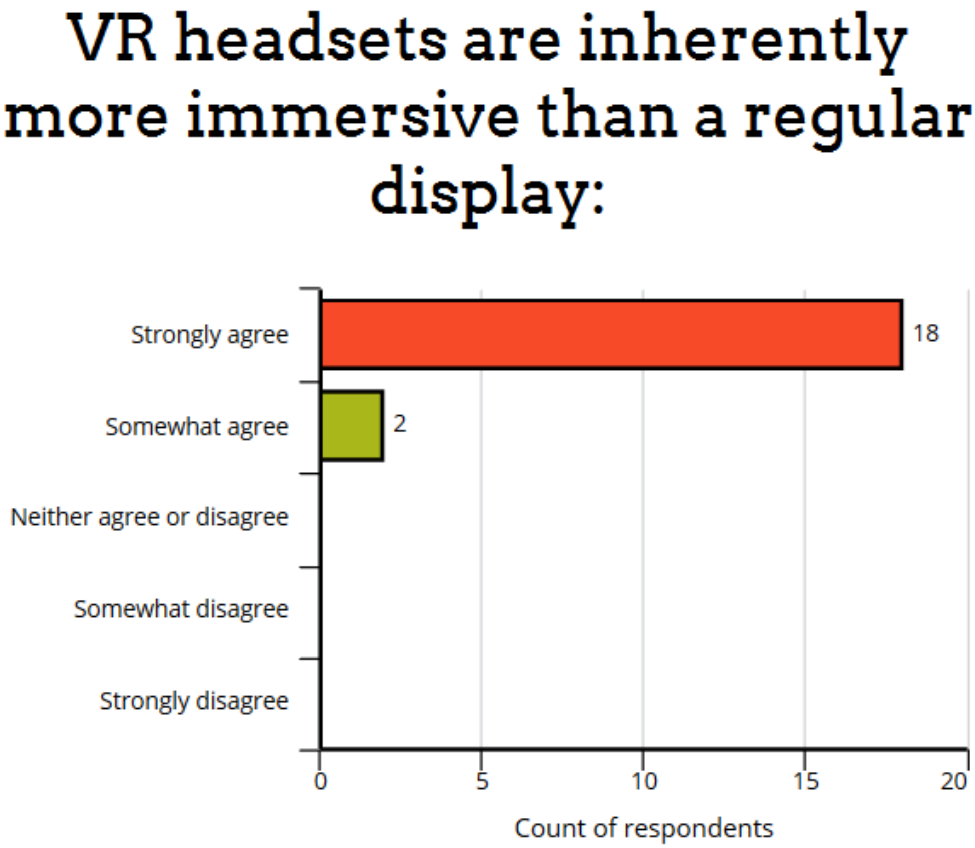
The questionnaire was left up for 18 days, it was intended to be there for just 14 days, however, the response rate was less than ideal even after 18 days, 20 respondents had participated. Out of those 20, 16 responded that they were VR developers and the remaining four were not, two of the respondents had simply used VR technologies while the remaining two had worked on VR in a quality assurance capacity. The population size was based on a rough estimate of how many people were involved with VR development in Denmark, this was estimated to be somewhere around 200 people.

Item 1



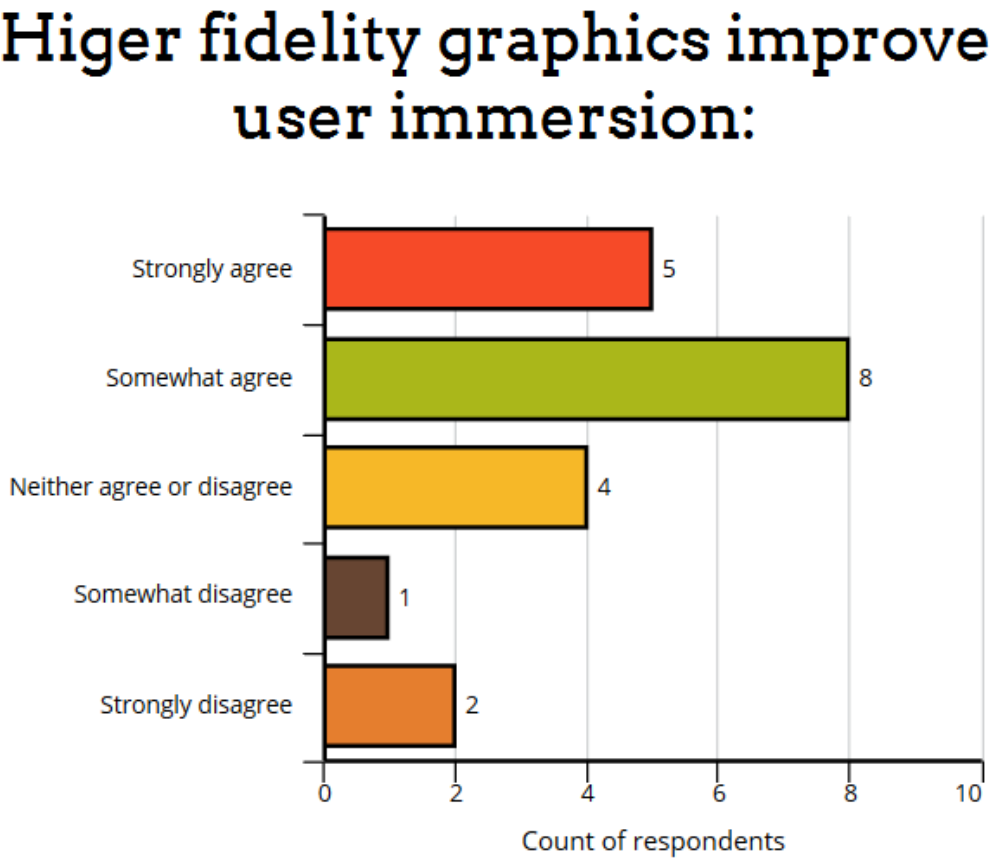
As shown in the above graph, the respondents definitely supported the statement, one respondent commented by writing that immersion is a key element of the VR experience, but as VR technology becomes more common, our definitions of immersion might change.

Item 2



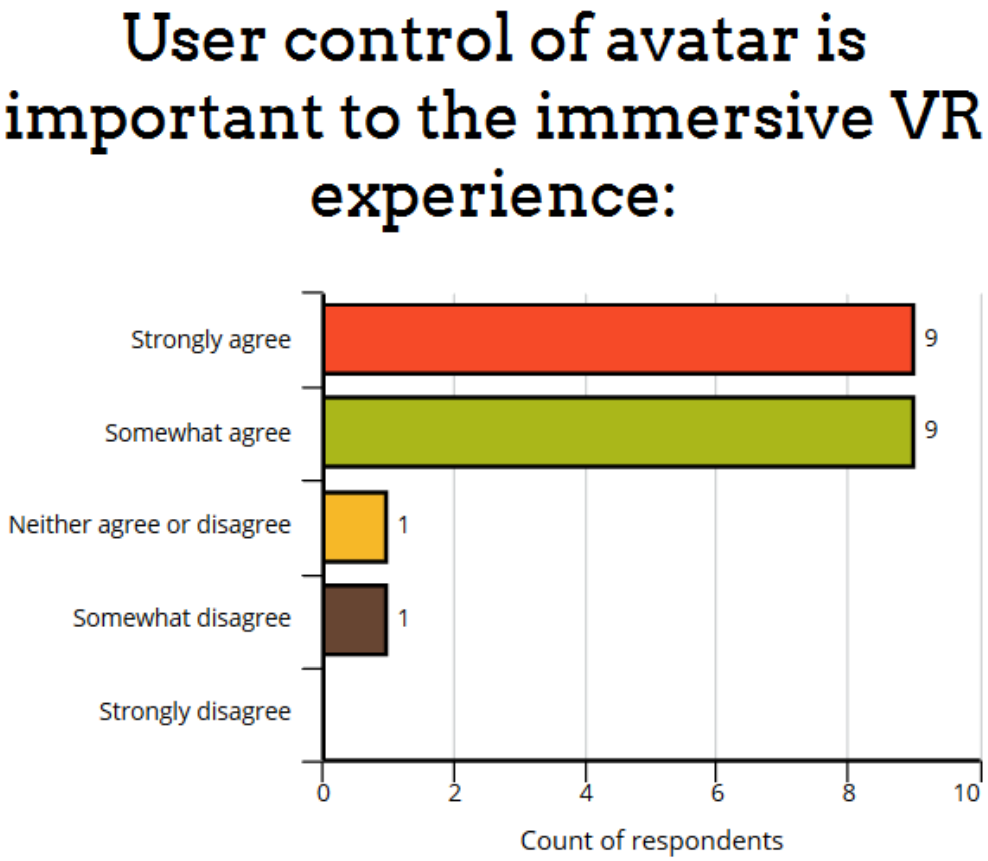
Again, the respondents were in agreement with theorists, that VR headsets are more immersive in and of themselves when compared to a regular display. This is also very much in tune with scholars like Slater, who views immersion as a given when using VR HMDs, where real world stimuli are substituted for virtual replicas (Slater, 2009, pp. 3549-3551).

Item 3



The respondents were mostly in agreement, however, as can be seen in the chart there were some disagreement. One respondent who neither agreed or disagreed commented "*Depends on what kind of world you are building for and to whom. Better graphics doesn't necessarily immerse the player better. Depends on the context and purpose of the VR experience.*". This comment is quite in line with some of the productions that the previously examined VR companies made, in that, depending on the context of what and who they were developing them for, they varied significantly. A respondent who strongly disagreed commented "*I believe embodiment is key to spatial VR. As a former photogrammetrist, I am definitely a proponent of high-fidelity graphics but they're only appropriate in some scenarios. I believe reactive graphics and shaders are far more immersive than photorealistic graphics.*". This is also in line with what we've seen from VR developers, that the graphics are tailored to specific experiences, however, it conflicts with what some of the scholars have said about graphics, in that the more technologically advanced graphics are used, the more immersive the experience (Slater, 2009, pp. 3549-3550).

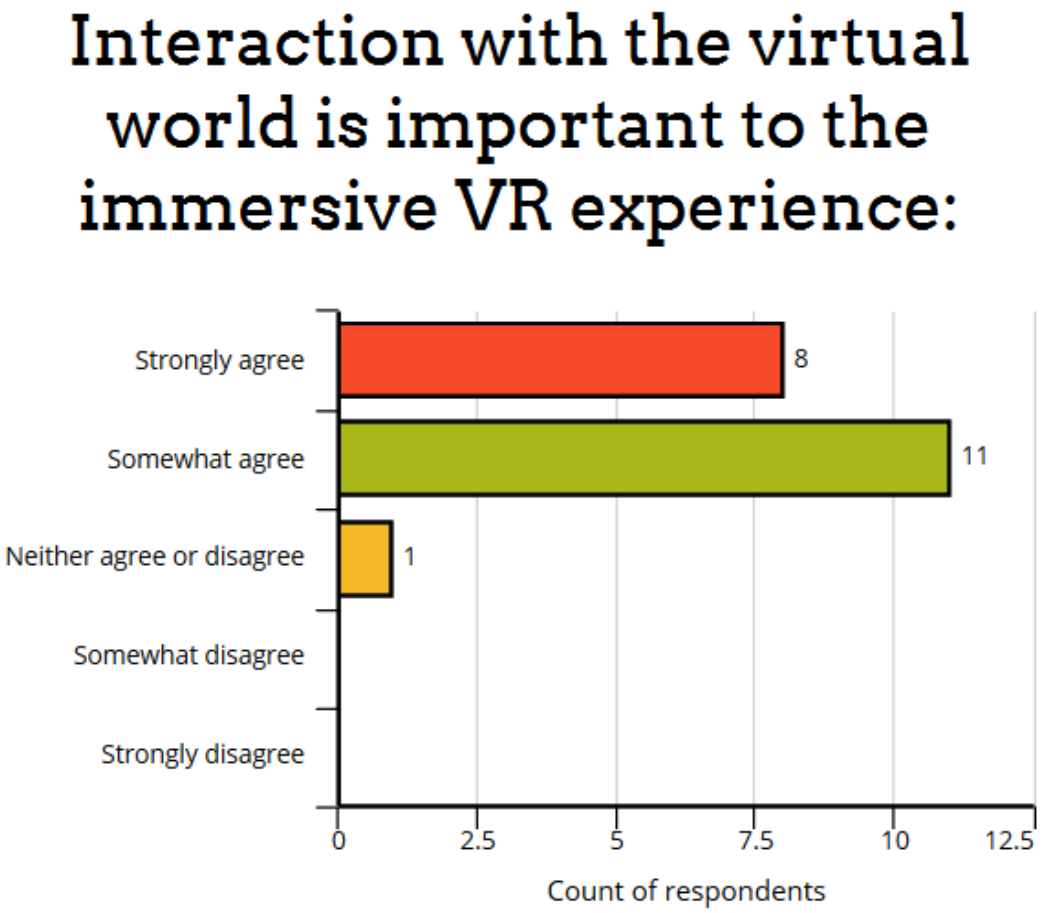
Item 4



On this item, most of the respondents were in agreement with the theoretical stance on avatar control and immersion. One respondent who was somewhat in agreement commented "*Depends on the context. What do you want to display/show. The use of avatar makes the player becoming more grounded ind the world.*". Another respondent who was somewhat in agreement commented: "*I believe the user's viewpoint should be tracked in 6DoF and that it's a good rule of thumb to allow users to have 100% control of their embodiment but I don't believe it's appropriate in all situations.*". These comments demonstrate what we've seen in the VR productions, that some of the productions don't have full avatar movement, but they all have full head-tracking. 6DoF refers to six degrees of freedom, where the user has control of a 3D object on X, Y and Z axis (Stanković, 2015, pp. 89). In an article titled *The Sense of Embodiment in Virtual Reality* (Kilteni, Groten & Slater, 2012), they examined embodiment, the sensation and feeling of extending ones' biological body in VR. This is assumed as the sensation the respondent was referring to. 6DoF for the user's viewpoint could refer to the head-tracking capabilities of modern VR HMDs, where the user can look in any direction as in real life. Based on this, it is assumed

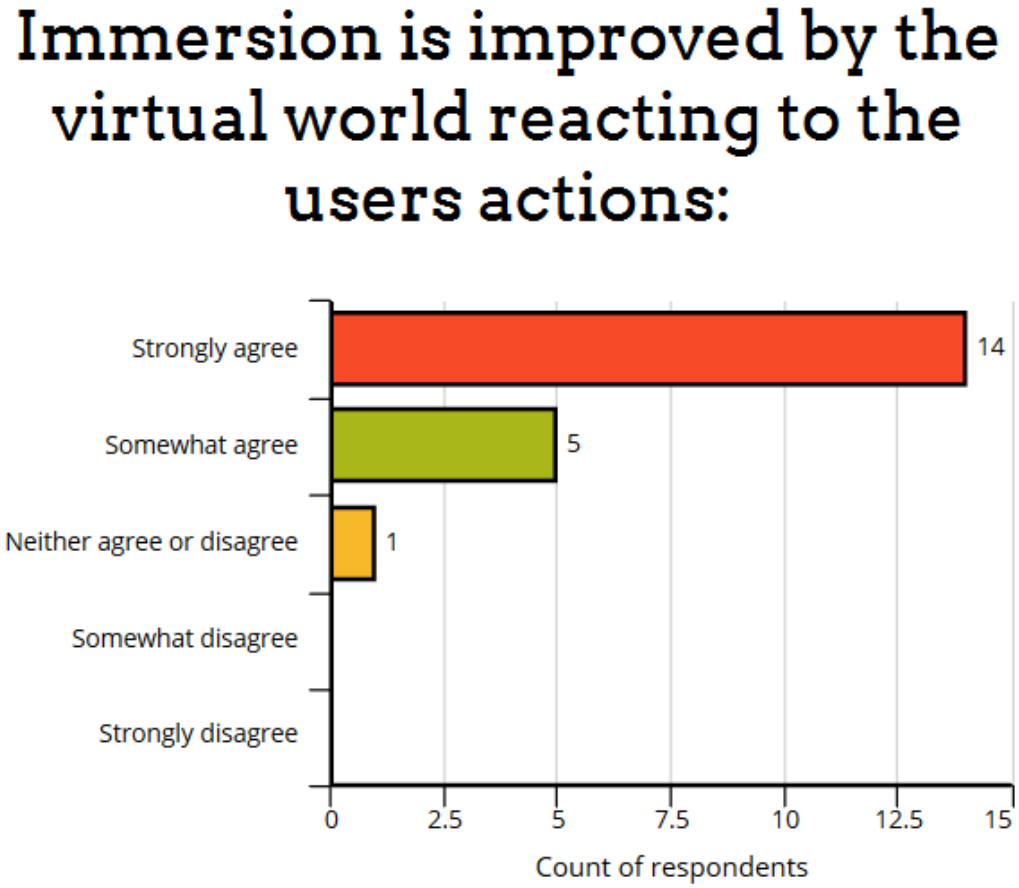
that the respondent believes that granting 6DoF to users, increases their embodiment in the VR experience.

Item 5



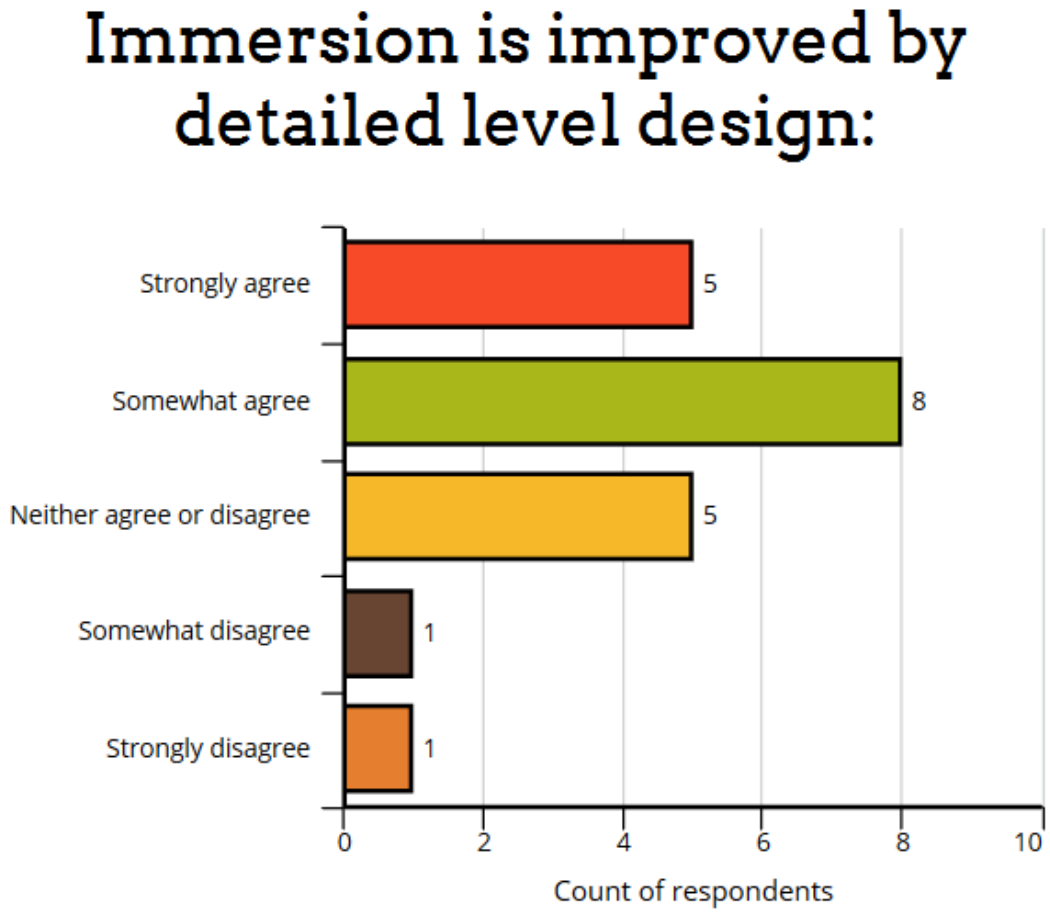
All of the respondents were in agreement with this statement, the one respondent who selected the neutral option commented "*VR Game, strongly agree. VR Experience, somewhat agree.*". This opinion was shared by another respondent who wrote that context was the deciding factor. Another respondent who was strongly in agreement commented "*As long as it is meaningful interaction. If the purpose is solely observant, then interaction is not dependent. Depends on the context of use. For a game, sure interaction is important.*", so again context is the deciding factor. Another respondent who was strongly in agreement commented "*As you have hands in VR, the interactive element of the experience is so much more important*", one can assume that the respondent refers to VR headsets like the HTC Vive, where the user has a controller in each hand.

Item 6



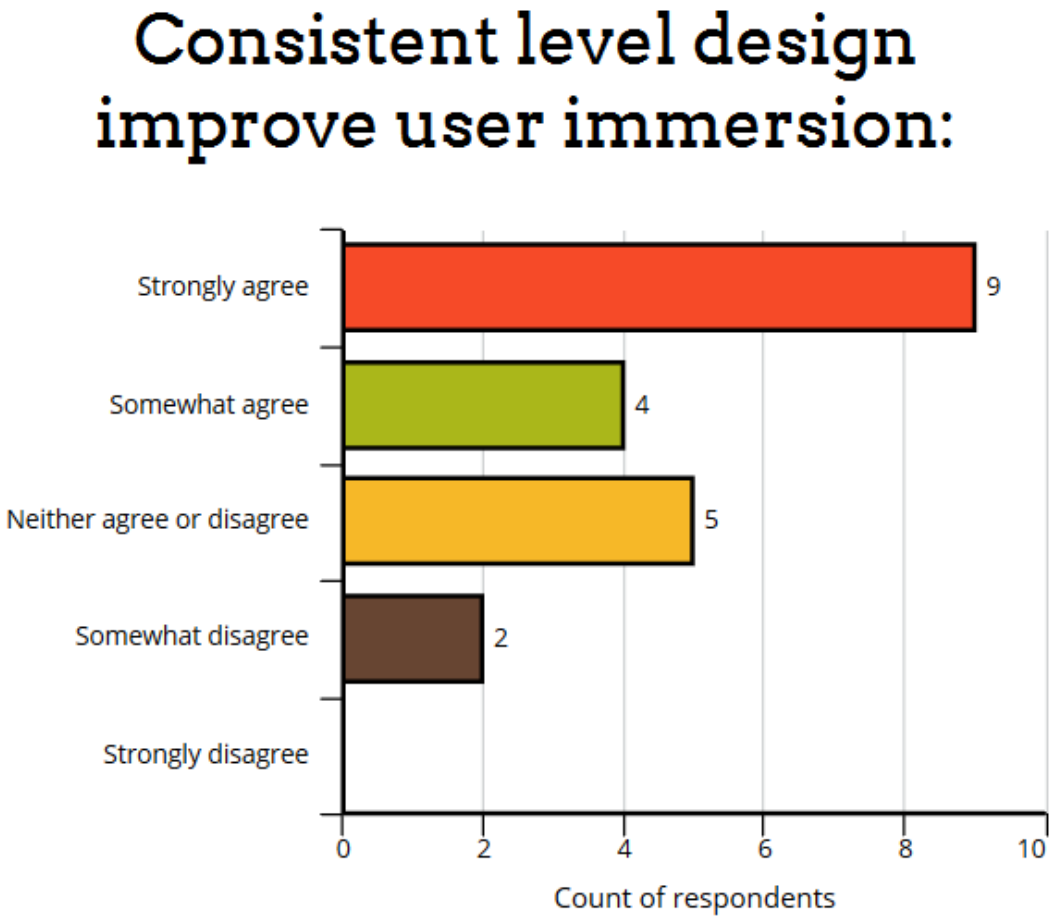
On this item, the majority were strongly in agreement with the scholars, one respondent who was strongly in agreement simply commented "*Feedback is key!*". One respondent commented that it wasn't required but was very helpful.

Item 7



While the majority of the respondents were in agreement with the statement, there were quite a few who were either neutral or in disagreement. While it can be assumed that most of the respondents understood the statement due to their answers, one neutral respondent commented "*Not sure what you mean by this.*", because of this, the validity of this particular item might be in question. One respondent who was strongly in agreement commented "*I agree with this but from a human experience standpoint rather than a gaming standpoint. I do not wish to live in a game world.*". This is an interesting comment, especially regarding immersion in video game worlds, from a human experience standpoint, the respondent seems in agreement with the theorists.

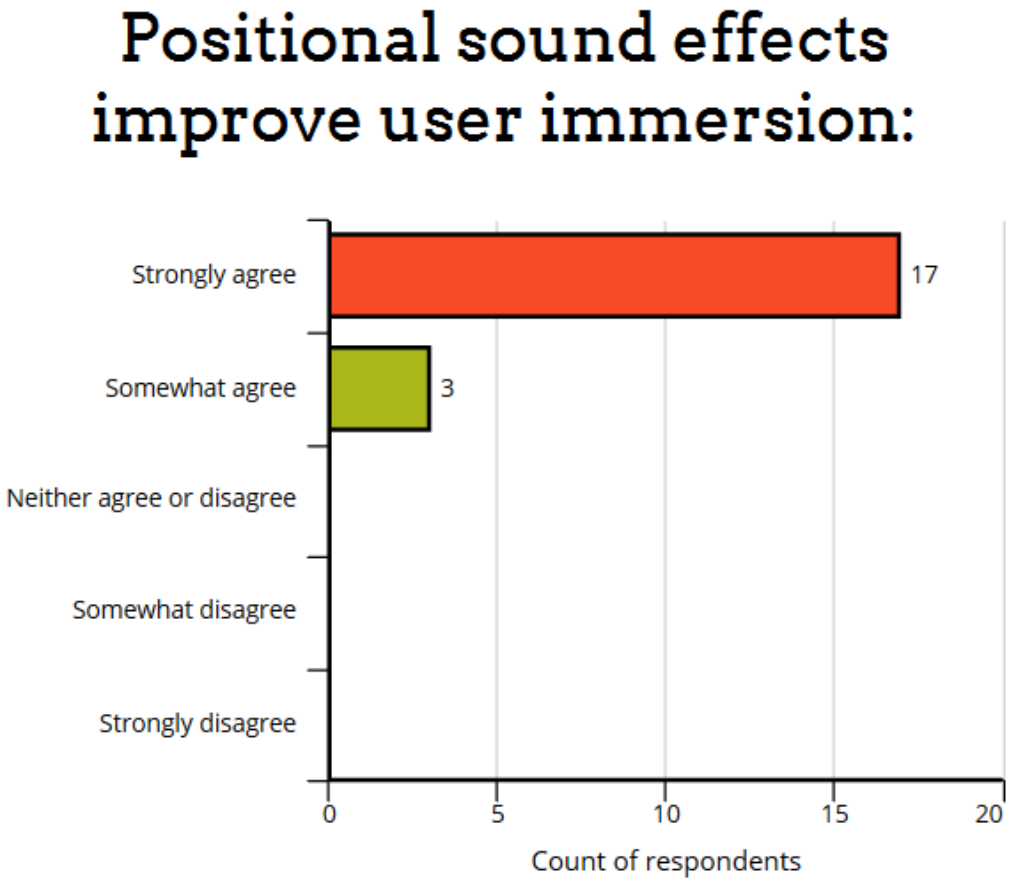
Item 8



While again, the majority were in agreement, there were still several who was either neutral or in disagreement. As with the previous item, this item might be called into question as a neutral respondent commented "*Not sure what it's asking tbh.*". One respondent who was strongly in agreement commented "*I think this is very important at this stage of XR but that it's an easy way to fall into complacent design that doesn't push the boundaries of the technology.*"[4]. This is a very interesting insight, using consistency as a design choice as an excuse boring designs. In terms of 3D VR presentations, this is not too much of a worry, as they try to replicate real world scenarios to present to stakeholders, and not experiment with the technology when used for professional presentations. Another respondent who was strongly in agreement commented "*Consistency is important for the overall user experience.*", echoing the scholars' conclusions.

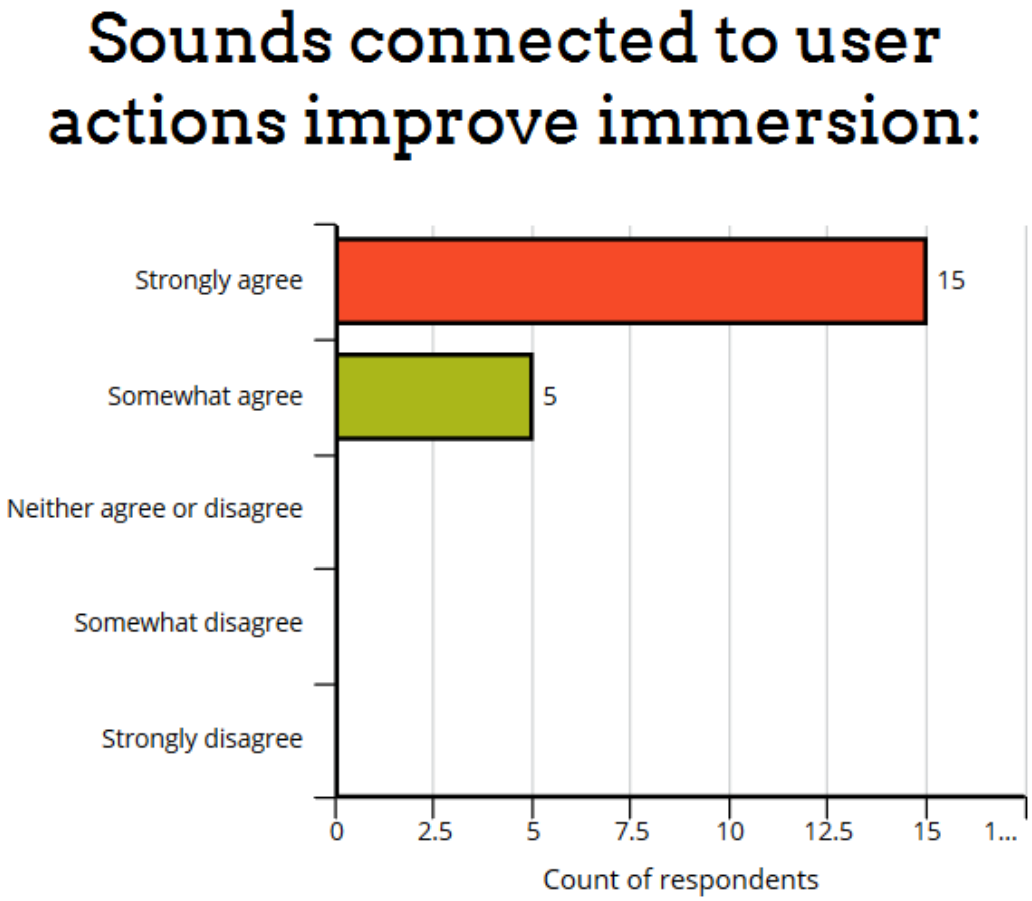
[4] XR is assumed, in this instance, to stand for Extended Reality, which is an unbrella term that covers all alternate reality technologies from augmented reality, mixed reality and virtual realiy.

Item 9



There isn't much to dig into regarding this item, as the respondents seem to be overwhelmingly in agreement with the academic findings.

Item 10



As with the previous item, all respondents are in agreement with this statement, with most being strongly in agreement. There was only one comment to this item, a respondent who was strongly in agreement simply wrote "*Feedback is key!*".

7.2. Summary of the questionnaire

Though this questionnaire had some serious issues with validity, given that it was anonymous, had a small sample size and the respondents' understanding of some of the items were doubtful. Another issue with the questionnaire was whether or not the respondents read the description before beginning the questionnaire and as such, not be aware of the particular definition of immersion used within.

That being said, it nonetheless showed that VR developers generally shared the views of scholars, with some notable differences. The developers were notably more context oriented, in that interaction, graphics and level design heavily depended on the context in which they were used in, and that some of

the elements that might boost immersion, could potentially be a hinderance if it was used in the wrong context. If these views are applied to 3D VR presentations, they generally support the views of the scholars regarding immersion, in that context is the deciding factor, which when applied to 3D VR presentations, would make the majority of these statements true. From a phenomenological point of view, this context could be viewed as the essence of the respondents' attitude towards many of these items. Although, there were some disagreement as to whether interactivity would improve immersion in a VR experience, although based on this questionnaire it isn't possible to know whether that sentiment would apply specifically to 3D VR presentations as well.

The VR developers seem to be mostly in agreement with scholars like Mel Slater, given that they in general were in agreement with the statements based on systematic immersion, that immersion is a property of the system and improves with the use of better technologies. Interestingly however, there were some aspects of systematic immersion in which the VR developers were not in complete agreement. The first of these were higher-fidelity graphics, while the majority of the developers were in agreement with the statement, there were a few who were neutral, and some were in disagreement. This is quite interesting seeing as they were in such overwhelming agreement with the statement regarding inherent immersion with VR headsets, this would suggest that not all VR developers are in total agreement with all aspects of systematic immersion.

8. From theory to practice

Now that a clearer view of what elements could improve immersion in 3D VR presentations, it's necessary to attempt to demonstrate how this could be put into practice.

This demonstration utilizes the editor that is included with the video game Far Cry 5 (2018). The reason for using this particular editor is that it includes a variety of assets to put into the 3D scene, as well as being easy to use for this purpose. Likewise, the editor also features high-fidelity graphics due to the game being released so recently. This demonstration will not utilize a VR headset, as it it's not necessary for this particular purpose.

8.1 Setting up the scene

To set up the scenario: Let's say that you want to showcase the concept of a new car to potential stakeholders, the car is not in the stage where a physical concept car can be manufactured, so you're relying on presentations to pitch the concept for further development. The car itself is intended to be sold as a budget car for the American market.

Figure 4 - The car itself

This is the car, this is also the bare minimum of what is needed for a 3D VR presentation, a virtual version of what you're pitching.

Figure 5 - An illustration of looking at the car from different angles.

Following the last image, as VR existed long before the ability to use head-tracking this might not be called a bare minimum as the last one. However, the ability to look around using a VR headset is expected when using modern VR headsets, as these are base features in these headsets.

Figure 6 - Building up the scene by adding a related structure

Now it's time to build upon the scene, by adding elements that fit with the car, in this instance a mechanic's garage. Adding a mechanic's garage might not be the most ideal structure to include in a presentation of a car, as it could imply that the car is faulty. However, it was the most relevant structure to a car that was available among the assets of the Far Cry 5 editor (2018).

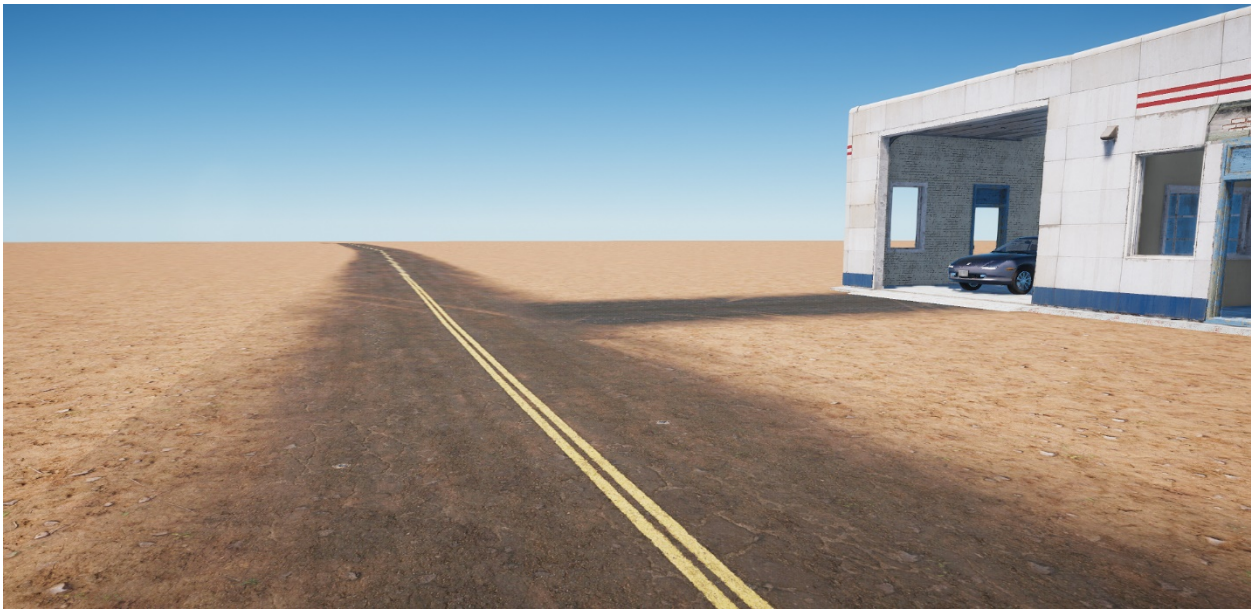


Figure 7 - Detailing the ground of the environment

Then the environment requires editing, to create a coherent world. In this case, the entire ground has been given a dirt texture, along with roads. The environment is quite bare and still not particularly believable.

Figure 8 - Adding relevant objects to fill the scene

In the previous image you could still clearly see the edges of the virtual environment, which could potentially be an immersion breaker. In this image, the ground has been made more uneven, trees and bushes that fit the environment have been added. There is a threefold reason for adding these, the first one being that it fills the environment and fits with the ground texture, the next being that they help hide the edges of the environment and the third being that it obstructs the user from reaching the invisible walls.

Figure 9 - Adding smaller details to situate the user

Figure 10 - Different angle of the previous state

Now that the larger details have been added, it's time to focus on the smaller details. In these two images, the focus was on detailing the garage by adding elements such as a store front, tool boxes, tires, gas pump and to situate the environment even further adding by an American flag.

Figure 11 - Basic interaction with the car

Now that the environment has been completed, comes the aspect of interactivity. In the image above, basic interactivity with the car can be seen. Here you can enter the car.

Figure 12 - Animation of avatar entering car

After pressing the button to enter the car, an animation of the user avatar entering the car plays to keep a level of consistency, instead of the user magically teleporting into the driver's seat.

Figure 13 - Illustration of the user driving the car

After entering the car, the user can now drive the car and get a virtual feel of the envisioned product.

Figure 14 - Illustration of the user looking around

Figure 15 - Different angle of the previous illustration

While driving the car, the user can move his or her head with the VR headset, while doing so the user can see the entire interior of the car or look outside the driver's side window, again substituting the user's real world stimuli with virtual ones.

8.2. Short video demonstration

https://youtu.be/I7ucs0KqooQ

The video in the above link, showcases a small drive with the car. The intention of this video is to showcase the element of sound. For starters something as simple as the sound of the user avatar's footsteps helps ground the user into the scenario, as does the sound of the wind blowing in the background. Upon entering the vehicle, the user hears the sound of the door opening as well as the character's movement when entering the car and closing the door. Upon starting the drive, the user hears the wheels spinning against dirt and tarmac, the user also hears the engine accelerate and shift gears. Further down the road, the user hears the car break and the tires squealing on the road. Nearing the end of the video the user can hear the parking break being pulled, and after exiting the parked car, the user can hear the unmistakable sound of a hot engine. All of these sound elements might seem small and insignificant, but they aid in the immersion of the player, by simulating the real sounds a car would make in reality.

8.3. Summary of demonstration

This short demonstration showcases a rough example of how developers can implement the theoretical knowledge into practice. By setting up a 3D scene as realistically as possible, you help immerse the user further into the experience, and thus provide the user with a much clearer picture of the concept being presented. With this, it's not difficult to imagine that a stakeholder would be more inclined to go along with a project, if they can see it "in action" so to speak, although this would require further study to conclude. Lastly, today there's a wealth of different editors to use to create a realistic 3D scene, as well as many assets that can be downloaded either for free or for a small fee, to be used in the scene. As mentioned, the above demonstration utilized the editor bundled with the video game Far Cry 5 (2018) and was quite easy and accessible to use. Although it might not be legal to use said editor for business purposes, however Far Cry 5's editor is just one among many. This easy accessibility to a competent editor or development kit, could make the use of these for 3D VR presentations more attractive to businesses looking for new ways to visualize and demonstrate their latest products.

9. Discussion

In this chapter other avenues this project could have taken to approach the problem are explored. In this chapter the shortcomings of this thesis are also examined and scrutinized.

9.1. Immersion through different lenses

This thesis used systematic immersion as its' foundation, the resulting showcase of the theory in practice was a direct result of this definition, as its' focus was mainly on substituting real world stimuli with virtual replicas. As has been argued, this was due to 3D VR presentations likely needing to simulate future projects in real life, however, as mentioned, the argument for using a different definition of immersion could also have been made, namely narrative immersion (Nilsson, Nordahl & Serafin, 2016, pp. 113-114). When presenting a new project to stakeholders, presenters often try to use very descriptive language in order to elicit a mental image for the stakeholders, they try to put their project into a scenario in which the stakeholders can imagine the project in use, out in the world. If this was applied to 3D VR presentations, the focus of the presentation would be different than while using the systematic definition of immersion. One could imagine that using narrative immersion would put less of a focus on the substitution of the sensory modalities during development and direct the focus on a narrative, perhaps having something like a narrator speak to the user during the presentation. If narrative immersion was applied to the previous showcase of the car, the user might not drive the car in the virtual environment, but perhaps sit in the car while a narrator gave a thorough walkthrough of the car's features. Similar to the project Khora Virtual Reality made for Keofitt (Khora Virtual Reality, n.d.), where a narrator walked the user through features of the valves. The challenge-based definition of immersion was not further explored for the particular problem of this thesis, as challenge-based immersion places its focus on elements usually attributed to video game gameplay, where the user immerses him or herself based on skills, points or other challenges within the game. This definition would most likely not have been particularly beneficial for this thesis, as this definition is contingent on the fact that the virtual environment included some elements of gameplay, in the form of something like a points system or a system requiring the use of motor skills.

9.2. The problems with defining immersion and presence

As presented in the sub-chapter on defining immersion (chapter 5.5.), there are numerous definitions of immersion, each with their own focus and each with their own uses. While this thesis aligned itself with the systematic definition, and therefore with Slater's definition of what immersion is (Slater, et. al., 2009, pp. 195), this doesn't inherently mean that the other definitions don't hold any validity as well. After writing this thesis, I am of the belief that it's impossible to produce a singular definition of immersion or how this phenomenon is created, as the gulf between these definitions is so wide that creating a singular definition will require it to be so generalizing that it might border on useless. I think the usage of a particular definition of immersion requires its' users to thoroughly examine *what* they're trying to accomplish with a particular problem or product, before subscribing to one definition. The choice of definition will invariably affect the end result of whatever it's being used for. This opinion is likewise shared by the authors of the previously cited paper *Immersion Revisited* (Nilsson, Nordahl & Serafin, 2016, pp. 129) where they conclude by writing that these varying definitions of immersion all have a use and a place.

With that being said though, having all of these varying definitions of immersion do come with its' own complications, least of which is presence. As some of these definitions of immersion also include presence as a part of their definition, presence itself becomes a problematic term in need of its' own definitions depending on what definition of immersion is being used.

9.3 The future of VR

Researchers and developers of VR have been at it for decades, but today most people in developed nations could relatively easily get their hands on some of the latest VR technology, simply by walking to the nearest computer store, it's no longer the property of sci-fi novels and movies but a technology available to the average person. Along with this new wave of VR technology, video game development kits such as Unreal Development Kit, Unity Development Kit and CryEngine (among others) are also optimized to handle VR technology as well as is available to the average person and business. Besides which, the engines are becoming easier to use with each iteration, with some of them even having simple drag and drop functions for quick accessibility. Lastly, as clearly demonstrated in the state of the art sub-chapter (chapter 6.2.) developers of varying sizes are being opened across Denmark, which

presumably is likewise happening in many other parts of the developed world. With all of these factors taken into consideration, the VR industry has never had such a strong foundation with so many stakeholders all taking part in this evolving industry. I personally believe that VR technologies, especially VR HMDs, has finally come to stay, as the technology has progressed to such an advanced stage that the visions of researchers such as Sutherland are finally coming to fruition (Sutherland, 1965). What will be interesting to witness in the coming years, will be where the developers, both developers of VR hardware and developers of VR software, will take VR technology next. However, as this thesis has attempted to solve, developers need specific guidelines to maximize the potential of VR technology. From the lens of systematic immersion, VR technology in and of itself is inherently immersive, however, to properly aim for a more complete immersive experience, developers need a specific set of elements to follow during development. Although, some VR presentations do include the full spectrum of these elements (again referencing the Keofitt application by Khora), these are the exception rather than the rule. When more of these elements of immersive design are implemented into VR development of 3D presentations, I posit that the VR industry will gain even further interest by businesses looking for new ways of showcasing their products or future projects.

9.4. Shortcomings

While every care was made to cover as much ground as possible with this thesis, there are a few areas which could have been improved.

9.5. Presence

Firstly, presence. The primary focus of this thesis has been on immersion; however, immersion and presence often go hand in hand, they are two separate but inseparable phenomena. As such, including presence as a focus when creating a template for VR developers could've been beneficial to the overall quality of the end result. However, when using systematic immersion as the definition, including presence in the guidelines for creating an immersive 3D VR presentation could've been a difficult task. Creating the guideline through the lens of systematic immersion provides an objective measurement of how immersion can be improved through design, when using this definition however, presence presents

an issue if it were to be included in a guideline that attempts to provide developers with an objective set of tools, as presence is a subjective response, varying from user to user.

9.6. Haptics

This thesis has focused almost exclusively on VR HMDs, without much mention of another central aspect of VR, namely, haptics. Haptics is a term which refers to the sensation of touch (Stanković, 2015, pp. 48-49). For as long as VR HMDs have been a topic of interest, so has the use of haptics along with these technologies. Going back to flight simulators at the start of the 20th century, haptics was used to simulate the movement of an airplane, even the previously mentioned Sensorama featured a vibrating chair, a feature that would later become a standard in controllers for video game consoles. As with VR HMDs, the technology of haptics has been making great strides, one of the main technologies of interest in this field is haptic gloves. One such glove, the VRgluv (VRgluv, n.d.), enables the user to "physically" interact with the virtual environment. This glove has features such as force feedback which simulates the physical response of objects in the virtual environment. In a demonstration video on their website they showcase a user holding a baseball in the virtual environment using the glove, the force feedback of this action is the glove stiffening to the size of the virtual object, so that the user cannot further close his or her hand in the physical world while wearing the glove.

The response that haptic VR technologies provide would go hand in hand with the systematic definition of immersion, as the system would substitute even more sensory modalities. So why was haptics not discussed and perhaps included in this thesis? There are a few reasons behind this decision, first and foremost a practical reason; including haptics as an element of consideration in this thesis, would simply have required more time in order to do a thorough study of how these technologies could be implemented into the development of 3D VR presentations. Secondly, the use of modern VR HMDs is a relatively new trend for business presentations, it's only since the rise of the Oculus Rift that more businesses have started incorporating VR HMDs as a tool in their businesses. Lastly, this thesis aimed to create a set of tools for setting up 3D scenes for use in VR presentations, and as such the primary focus was on the virtual environment itself and how immersion could be improved through design.

9.7. Questionable questionnaire

The questionnaire in this thesis is most likely the largest area of criticism. First of all, the definition provided within the questionnaire for respondents was vague and undescriptive, because of this, respondents could've interpreted it in a multitude of ways, which means that the results could be completely invalid. Secondly, the sample size at 20 respondents was quite small and as such makes it difficult to make generalized conclusions based on the results. Thirdly, some of the items within the questionnaire were aslo called into question, as some of the respondents commented that they didn't understand the statements, which could've called the results of those particular items into question. Lastly, the anonymous nature of the questionnaire makes it impossible to say with certainty that the respondents were in fact VR developers. However, even with all of these flaws, the comments the respondents added to some of the items gave a good insight into the priorities of the VR developers and because of these, the questionnaire was included in the thesis. Based on those comments, a better approach to gathering that information could've been conducting interviews with those developers, rather than a questionnaire.

10. Conclusion

In what way is it possible to improve 3D VR presentations by using theories of immersion and level design?

The primary problem identified with this thesis, was a lack of standardization in 3D VR presentations. As described in the chapter on VR (chapter 6.) developers use the term immersion to describe many of their VR products, however, when examining the theories behind immersion and what elements improve this phenomenon, many of those presentations using that term were lacking many central elements that was outlined by theorists. The central elements identified for improving immersion in 3D VR presentations, through the lens of systematic immersion, were:

- Realistic, high-fidelity graphics that resemble the real world, in a virtual environment that emulate the area in which the project or product is envisioned to be implemented.
- Consistent level design of the virtual environment only containing objects and environmental 3D assets that fit with the theme of the presentation.
- Adding interactivity with the virtual environment is important to the immersive system.
- Immersion is improved by covering as many sensory modalities as possible, from head-tracking, stereoscopic 3D imagery to surround and positional sound effects
- Adding sound effects to the background as well as sound effects that respond to the user's actions, improve immersion.
- Designing the 3D presentation to consistently conform to the expectations of the user, improve immersion.

These elements should be taken with a grain of salt, as these conclusions have been derived from literature and the questionnaire, without testing these conclusions in practice.

Research questions:

- What definitions of immersion and presence are most relevant for developing 3D VR presentations?
    - This research question was partly answered in the sub-chapter defining immersion and presence (chapter 5.5.). Systematic immersion is seemingly the most relevant, as this is

the most objective way of looking at immersion, which makes it easier for developers to create a virtual environment, when they have a set of objective guidelines to develop from.

- What elements of level design should developers focus on, to improve 3D VR presentations?
    - The two primary focus points from level design that developers of VR presentations should focus on, are consistency and detail in the virtual environment. It was also discovered that developers should anticipate the expectations of users, so as to not break their immersion.

- What is the current state of VR development and its' implementation into businesses?
    - Currently, there are numerous VR developers here in Denmark alone, the businesses range in size from small to large. Larger companies and government are likewise following the surge of new developers, with many incorporating VR technologies into their businesses.

- How much of a difference exists between the academics' understanding of immersion and level design, and the developers'?
    - According to the questionnaire, the developers and academics are quite similar in their views on immersion and level design, however, some notable differences were shown, in particular, developers were a lot more concerned with the context of what the VR application was developed for.

11. Future works

This thesis has only scratched the surface of immersion and presence in VR, there are a lot of possibilities to take this subject much further. Firstly, with this thesis being entirely derived from literature and limited communication with VR developers, it would be beneficial to work more closely with VR developers, perhaps in a case study, and test the guidelines outlined in this thesis in practice. Next, as this thesis did not dive far into the phenomenon of presence, a future study into this phenomenon would be ideal. By diving deeper into this phenomenon, it stands to reason to assume that it could add more depth and detail to the current guidelines, and possibly make 3D VR presentations an even more compelling avenue for businesses. Then comes haptic technologies, as already discussed, these technologies were not included as part of this thesis, however, as these technologies are evolving side by side with VR HMDs, its inclusion into 3D VR presentations would be a natural subject matter for further study that, again, could add to the guidelines. Lastly, a further study of the relationship between 3D VR presentations and video games would be of great interest, because, where does one draw the line between these two mediums?

12. References

12.1. Books

Brinkmann S. & Tanggaard L. (2010) *Kvalitative Metoder – En Grundbog*. Hans Reitzels Forlag.

Bryman, A. (2012) *Social Research Methods Fourth Edition*. Oxford Press.

Collins, K. (2013) *Playing with Sound: A Theory of Interacting with Sound and Music in Video Games*. The MIT Press.

Gadamer, H. (2004) *Truth & Method*. Continuum.

Gerrig, R., J. (1993) *Experiencing Narrative Worlds: On the Psychological Activities of Reading*. Yale University Press.

Portugali, J. (2006) *Complex Artificial Environments - Simulation, Cognition and VR in the Study and Planning of Cities*. Springer. 322 pages

Rogers, S. (2014) *Level Up! The Guide to Great Video Game Design*. Wiley & Sons ltd.

Schell, J. (2015) *The Art of Game Design – A Book of Lenses*. CRC Press.

Kennedy Schmidt, L. (2006) *Understanding Hermeneutics*. Acumen Publishing Limited.

Stanković, S. (2015) *Virtual Reality and Virtual Environments in 10 Lectures*. Morgan & Claypool Publishers.

Van de Ven, A., H. (2007) *Engaged Scholarship: A guide for Organizational and Social Research*. Oxford University Press.

12.2. Papers

Brown, E. & Cairns, P. (April, 2004) *A Grounded Investigation of Game Immersion*. University College London Interaction Centre (UCLIC). pp. 1297-1300

Ermi, L. & Mäyra, F. (2007) *Fundamental Components of the Gameplay Experience: Analysing Immersion*. Worlds in Play. pp. 37-55

Gallacher, N. (August, 2013) *Game Audio - an investigation into effect of audio on player immersion*. The Computer Games Journal (Vol. 2, issue 2). pp. 52-79

Gormanley, S. (August, 2013) *Audio immersion in games - a case study using an online game with background music and sound effects*. The Computer Games Journal (Vol. 2, issue 2). pp. 103-124

Jones, T.; Moore, T. & Choo, J. (2016) *The Impact of Virtual Reality on Chronic Pain*. PLoS ONE. pp. 1-10.

Kersten, T., P.; Tschirschwitz, F. & Deggim, S. (March, 2017) *Development of a Virtual Museum Including a 4D Presentation of Building History in Virtual Reality*. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences (Volume XLII-2/W3). pp. 361-367

Kilteni, K.; Groten, R. & Slater, M. (August, 2012) *The Sense of Embodiment in Virtual Reality*. Presence: Teleoperators & Virtual Environments (Vol. 21, No. 4). pp. 373-387.

Krijn, M.; Emmelkamp, P., M. G.; Biemond, R.; de Wilde de Ligny, C.; Schuemie, M., J. & van der Mast C., A., P., G.. (2004) *Treatment of acrophobia in virtual reality: The role of immersion and presence*. Behaviour Research and Therapy Vol. 42, issue 2). pp. 229-239.

McCreery, M., P. ; Schrader, P., G. ; Krach, S., K. & Boone, R. (2013) *A sense of self: The role of presence in virtual environments*. Computers in Human Behavior (Vol. 29, issue 4). pp. 1635-1640

Mikropoulos, T., A. & Stroubloulis, V. (2004) *Factors That Influence Presence in Educational Virtual Environments*. CyberPsychology & Behavior (Vol. 7, issue 5). pp. 582-591

Minsky, M. (1980) *Telepresence*. OMNI Magazine.

Nilsson, N., C.; Nordahl, R. & Serafin, S. (2016) *Immersion revisited: A review of existing definitions of immersion and their relation to different theories of presence*. Human Technology (Vol. 12, issue 2). pp. 108-134.

Price, M & Anderson, P. (2007) *The role of presence in virtual reality exposure therapy*. Journal of Anxiety Disorders (Vol. 21, issue 5). pp. 742-751.

Slater, M., Linakis, V., Usoh, M. & Kooper, R. (1999) *Immersion, Presence and Performance in Virtual Environments: An Experient using Tri-Dimensional Chess*. CiteSeerX

Slater, M. (2007) *"If you respond as if it were real, then it is Presence."*. Peach, Presence Research in Action.

Slater, M.; Lotto, B.; Arnold, M. M. & Sánchez-Vives, M. V. (2009) *How we experience immersive virtual environments: the concept of presence and its measurement*. Anunario de Psicologia (Vol. 40). pp. 193-210.

Slater, M. (2009) *Place Illusion and plausibility Can Lead to Realistic Behaviour in Immersive Virtual Environments*. Philosophical Transactions: Biological Sciences (Vol. 364, no. 1535). pp. 3549-3557.

Sutherland, I. (1965) *The Ultimate Display*. Proceeding of IFIP Congress pp. 506-508.

Taylor, N., L. (2002) *Video Games: Perspective, Point-of-View, and Immersion*. University of Florida. 35 pages.

Ye, J.; Campbell, R., I. & Badni, K., S. (January, 2006) *An investigation into the implementation of virtual reality technologies in support of conceptual design*. Design Studies (Vol. 27, issue. 1). pp. 77-97

12.3. Articles, Online dictionaries & Websites

"Immersion" (n.d.) para 1 & 2. In *Oxford English Dictionaries*. Retrieved the 12. february 2018 from https://en.oxforddictionaries.com/definition/immersion

Archive.org (2004, august 20), The Computer Chronicles – New PCs - 1996. Retrieved 14. february 2018 from https://archive.org/details/CC1331_new_pcs

”Virtual Reality” (n.d.) para 1. In *Oxford English Dictionaries.* Retrieved the 3. march 2018 from *https://en.oxforddictionaries.com/definition/virtual_reality*

Slash Gear, View-Master (n.d.). Retrieved the 3. march 2018 from https://c.slashgear.com/wp-content/uploads/2015/02/viewmaster23423.jpg

Orange, R. (2011, december 17.) *Outrage at proposals for Hans Christian Andersen ”Gay Week”*. Retrieved the 17. march 2018 from https://www.telegraph.co.uk/news/worldnews/europe/denmark/8962775/Outrage-at-proposals-for-Hans-Christian-Andersen-Gay-Week.html

Virtual Reality Society, History of Virtual Reality (n.d.). Retrieved the 26. march 2018 from https://www.vrs.org.uk/virtual-reality/history.html

Kanda, Maersk Drilling (n.d.) Retrieved the 12. april 2018 from https://www.kanda.dk/maersk

Kanda, Nordlux (n.d.). Retrieved the 12. april 2018 from https://www.kanda.dk/nordlux

Khora Virtual Reality, Back to Nature | Danmarks Naturfredningsforening (n.d.). Retrieved the 12. april 2018 from https://khora-vr.com/portfolio-item/dn-back-to-the-nature/

Khora Virtual Reality, Keofitt (n.d.). Retrieved the 12. april 2018 from https://khora-vr.com/portfolio-item/keofitt/

Reddit, VRDev (n.d.). Retrieved the 27. april 2018 from
https://www.reddit.com/r/vrdev/

Unreal Engine Forums, VR & AR Development (n.d.). Retrieved the 27. april 2018 from
https://forums.unrealengine.com/development-discussion/vr-ar-development

Vive, General Vive Discussion (n.d.). Retrieved the 27. april 2018 from
http://community.viveport.com/t5/General-Vive-Discussion/bd-p/general-discussion

Oculus Development, General Development Discussion (n.d.) Retrieved the 27. april 2018 from
https://forums.oculusvr.com/developer/categories/general-dev

BEAM Chart Maker (n.d.). Retrieved the 24. may 2018 from
https://beam.venngage.com/

Unreal, Unreal Engine 4 (n.d.). Retrieved 24. may 2018 from
https://www.unrealengine.com/en-US/what-is-unreal-engine-4

Unity, Unity (n.d.). Retrieved 24. may 2018 from
https://unity3d.com/

CryEngine, CryEngine (n.d.) Retrieved 24. may 2018 from
https://www.cryengine.com/

Behnke, E., A. (n.d.) *Edmund Husserl: Phenomenology of Embodiment*. Retrieved the 25. may from the Internet Encyclopedia of Philosophy: https://www.iep.utm.edu/husspemb/#H7

VRgluv, VRgluv (n.d.) Retrieved 24. may 2018 from https://vrgluv.com/

12.4. Movies

Osbourne, B. M.; Jackson, P.; Walsh, F. & Sanders. T. (Producers) & Jackson, P. (Director). (2001) *The Lord of the Rings: The Fellowship of the Ring* [Motion Picture]. New Zealand & United States: New Line Cinema.

12.5. Video games

Nintendo Research & Development 4 (1986) *The Legend of Zelda* [Video game]. Kyoto: Nintendo Co., ltd.

Namco (1980) *Pac-Man* [Video game]. Tokyo: Namco Limited.

Ubisoft Montreal & Ubisoft Toronto (2018). *Far Cry 5* [Video game]. Montreuil: Ubisoft.