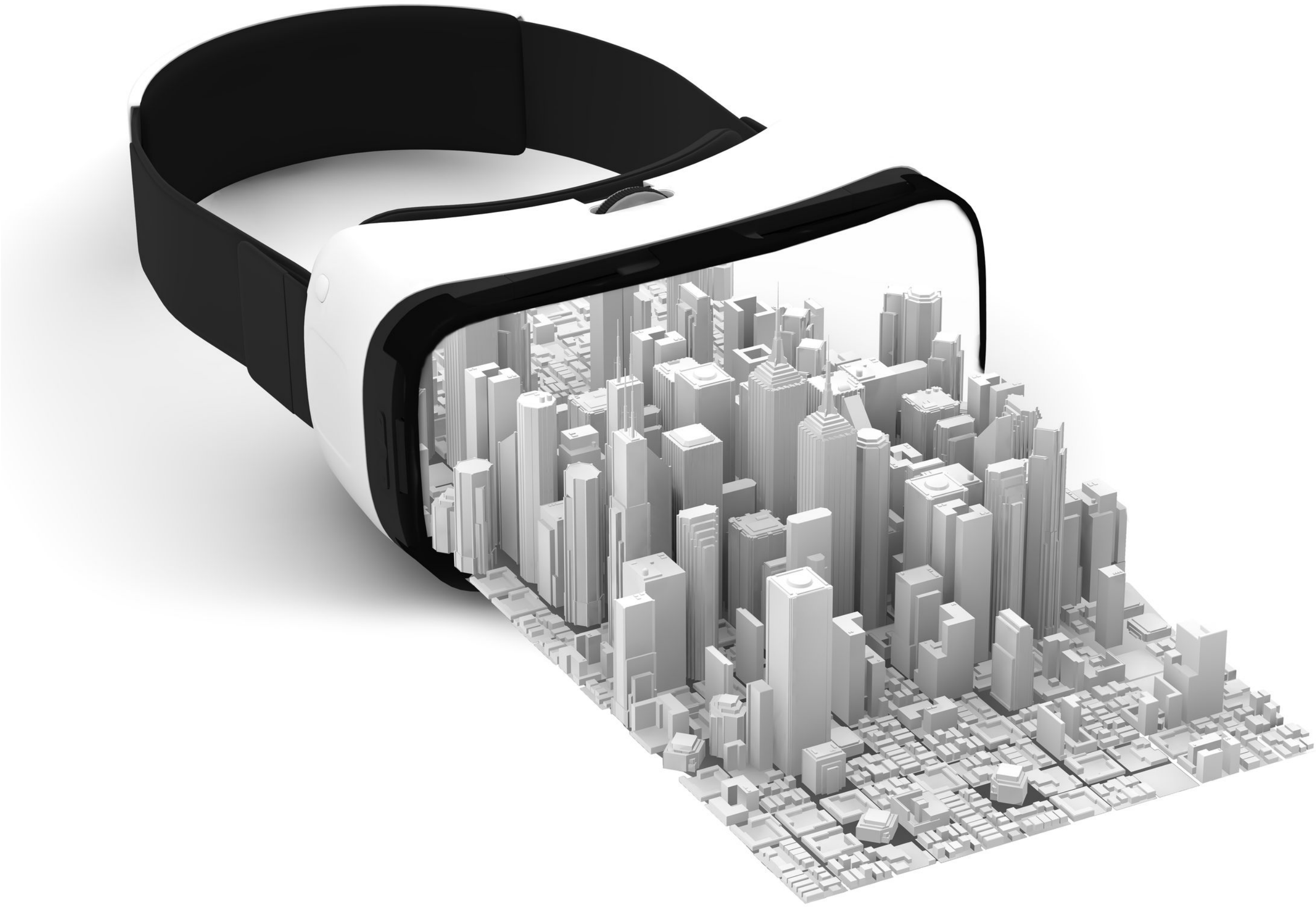
Immersive Technologies:

Cool or Tool?

The Added Value of
Immersive Virtual Reality
in Participatory Planning



"If, as it is said to be not unlikely in the near future, the principle of sight is applied to the telephone as well as that of sound, earth will be in truth a paradise and distance will lose its enchantment by being abolished altogether."
(Mee, 1898; found in Slater & Wilbur, 1997, p. 11)

Immersive Technology: Cool or Tool
Master's thesis Spatial Planning

Utrecht University, Faculty of Geosciences

Jidde Koekoek BSc.

E-mail Address: jiddekoekoek@gmail.com
Supervisor: Peter Pelzer
Second Reader: Stan Geertman
Supervisor Amsterdam: Marcel Tieman
Date: 28 November 2017

Preface

During my bachelor's Human Geography and Planning, and particularly the minors Entrepreneurship and Programming, my interest in technology and innovation grew. During the master Spatial Planning, this interest was fuelled by smart cities and smart urban governance. It was because of this, that I wanted to combine spatial planning with technology for this thesis. After a couple of conversations with Stan Geertman and Peter Pelzer about virtual and augment reality, this resulted in combining virtual reality (VR) with the planning practice. Eventually this led to the subject of this thesis. What I found particularly interesting about VR at this time, is that VR has taken major steps in its development, which makes current VR practices quite unknown, especially in the academic world.

Writing this thesis has been quite the journey. The original idea was to combine a hackathon organised by the municipality of Amsterdam (for exploring ways to communicate information about legislation etc. regarding the new Dutch environmental planning act), with an experiment for this research. This way, a real-life case with VR could be analysed. Unfortunately, the hackathon got postponed, which forced me to be creative and to make do with the means available. This made it a hard and sometimes somewhat disappointing journey. Nevertheless, I can say that this made it also very interesting and helped me to learn a lot.

I want to thank all the people that helped me during these last months, specifically my two supervisors: Peter Pelzer from Utrecht University (UU) and Marcel Tieman from the municipality of Amsterdam. I want to thank Tamas Erkelens for helping me with the start of my internship. I want to thank Eric, Jos and Marco from Dfab for taking the time to help me. I want to thank Harm Manders and Nathan Pfeyffer for assisting me with the second experiment. I want to thank Nathan Pfeyffer, Kia Silvennoinen and Pelle Keizer for their feedback. I want to thank my colleagues at the municipality of Amsterdam, all the interviewees, and the participants of the second experiment. I want to thank Gigi Zacheo and Desirée Barendregt for allowing me to be present during the first experiment and for letting me use the data and Jimmy Paquet-Cormier for sharing his knowledge and literature with me. Furthermore, I would like to thank Erik Wouda for acquiring the image on the front page for me. Lastly, I want to specially thank Ruben Hanssen for allowing me to use his VE, Wouter van den Bijgaart and Joep Wijnhoven from the VR Room for lending me the space and equipment and Daniel Doornink for welcoming me at VR Base. Furthermore, I want to thank you, the reader, for showing interest in this thesis and I hope that you enjoy reading it!

Amsterdam, November 2017.

Summary[1]

This thesis aims to provide a better understanding of immersive virtual reality (VR) in participatory planning processes. VR has seen major developments in recent years. New VR headsets such as the HTC Vive and Oculus Rift have become available to consumers, and provide new possibilities for the visualisation of spatial developments. Immersive VR has been researched, but since immersive VR has improved significantly in recent years, most of the literature is out-dated. Furthermore, the added value of immersive VR within participatory planning has not been elaborated on eloquently in literature. Therefore, research is needed to explore the possibilities of immersive VR in contemporary participatory planning.

An important attribute of immersive VR is the immersion. Immersion means that its user is closed off from the real world. A high quality immersive experience should result in a sense of presence, a sense of place, which should increase learning capabilities of the user in VR: the user can experience the environment.

Within the planning practice, participatory planning has gained interest since the 1960s and is seen as positive means for contemporary planning. Nevertheless, bottlenecks exist with participation. One way to overcome some of the bottlenecks of participatory planning is through planning tools. For instance, Geographic Information Systems (GIS) are well-known tools for practitioners to communicate plans. Also Planning Support Systems (PSS) can be used to aid with planning issues, often through analytical analyses. However, generally, PSS and GIS require a high level of proficiency, which can lead to the exclusion of participants that do not have this level of proficiency.

Regarding PSS, seven different added values can be distinguished: *learning about the object, learning about other stakeholders, collaboration, communication, consensus, efficiency* and *better-informed plans or decisions*. Regarding 3D virtual environments, five different learning affordances can be named: *spatial knowledge representation, experiential learning, engagement, contextual learning* and *collaborative learning*. These are used as framework to research the added value of immersive VR.

Mixed methods were used for this research. Firstly, interviews with experts were conducted. Secondly, an experiment using mobile VR was conducted. This experiment entailed an informative gathering with a VR tour about a redevelopment of 'Weteringcircuit'. Thirdly, another experiment was conducted using desktop VR. In this experiment, experts were asked to give their opinion about three different designs of the development area 'Sloterdijk I-zuid', in the western part of Amsterdam, discuss them and achieve consensus on the best design. The experts were asked about their opinion of VR as a tool for participation processes and of the workshop in general.

The interviews pointed out that participation processes differ from project to project and that they are highly dependent on the project team and the available resources. Furthermore, it was discovered that expectation management, the customer journey, and a suitable form of communication are important within participatory planning.

[1] Nederlandse samenvatting aan het eind van deze thesis.

Within VR, a distinction has to be made between mobile VR and desktop VR. Mobile VR has got lower computing power, less degrees of freedom, but is more accessible and cheaper than desktop VR. With desktop VR, the quality of the hardware is better, but you are bound to a powerful computer.

Through the interviews and experiments, it was discovered that immersive VR within participatory planning can have multiple added values. It helps to gain knowledge about the object and lets the user learn in an experiential way. With VR, it is easier to estimate heights and distances. Because the users of VR are able to experience the environment, it is easier for them to express themselves in a natural way. This also motivates them to participate actively and increases enthusiasm. Furthermore, scenario building, error prevention and simulations are added values of VR.

Overall, VR is a powerful tool to visualise spatial plans. It lets the user experience the environment in a natural way. Within participation processes, it can start and enhance the conversation about the environment on a more subjective level. It creates opportunities to take away language and professionalism barriers and to uncover lay and experiential knowledge. Therefore, VR should be seen as a serious candidate for visualising more complex spatial plans. Nevertheless, it is still uncertain what VR can contribute to the outcome of such processes and it remains unclear how presence benefits the process. This has to be researched further in the future.

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List of abbreviations

UU – Utrecht University
VR – Virtual Reality
HMD – Head-Mounted Display
ICT – Information & Communication Technology
PSS – Planning Support Systems
PSScience – Planning Support Science
CAVE – Cave Automatic Virtual Environment
CTO – Chief Technology Office
VE – Virtual Environment
GIS – Geographic Information Systems
LoD – Level of Detail
MoA – Municipality of Amsterdam
IB – Ingenieursbureau
PMB – Projectmanagement bureau
UvA – University of Amsterdam

1 Introduction

Over the last decades, a technological revolution has taken place. Smartphones and other technological developments such as tablets and communication platforms like Facebook and WhatsApp, have changed the way we live. To put these developments into perspective: one decade ago, in June of 2007 the first iPhone was released. This year, 2017, the iPhone is celebrating its 10th anniversary and a lot has changed. Smartphones have become invaluable in contemporary society. Other technologies are also developing rapidly, such as commercial Virtual Reality (VR) goggles/headsets (or Head-Mounted Display: HMD). Many systems were introduced in recent years. Samsung released its Gear VR in late 2015 and the HTC Vive and Oculus Rift (consumer version) were both released in early 2016. The developments in these technologies provide major opportunities for VR. Nevertheless, VR can take different forms, thus a distinction has to be made between these different forms of VR. In this thesis, the focus lies on immersive VR served by HMD's.

Not only is this an exciting time for VR, it is also a crucial time for VR; discrepancies between the intended and the perceived experience of virtual reality can affect the quality and the acceptance of the experience (Peer & Ponto, 2017). This means that experiences should be of high quality, for VR to become a widely-accepted (planning) tool.

The developments in VR literally opens new worlds to city visualisation and management, which are gaining importance due to the growth and size of contemporary cities. Due to these recent and rapid developments, most articles about VR are outdated and new academic research, to explore and find out if these developments in their current state are of added value within planning processes, is highly relevant. Spatial planning itself also has seen changes in the last few decades. The 'collaborative turn' has put more emphasis on participation, and experiential and lay knowledge. It is plausible that VR helps non-professionals to express their opinion about an environment and communicate with professionals. This way, lay-knowledge can be gathered and processed more easily. This makes VR and participation an interesting combination and makes it important to understand what would make VR suitable to use in a professional setting such as participatory planning.

1.1.1 Changes in planning theory

Spatial planning has a long and rich history, especially in the Netherlands. Processing and interpreting data has always been one of the key elements of spatial planning (Pelzer, 2015). But, in the last two decades something has changed in the way spatial planning is executed. This 'communicative-' or 'collaborative turn', as it is called in the academic world, has changed the emphasis from experts handling gathered knowledge, to an open process where social interaction and participation have gained importance (Pelzer, 2015). Rydin (2007) elaborates in her article on the role of knowledge within planning. She argues that knowledge is not only something to be held by experts, but that knowledge can be found almost everywhere, for instance in forms of experience and lay knowledge. It is the role of the planning professional to gather all forms of knowledge, make a selection of what is important and to listen to the unheard voices. She states that: *"knowledge is inherently multiple, with multiple claims to represent* *reality and multiple ways of knowing"* (p. 54). This quote shows the subjectivity of knowledge. It is up to the planner to handle these different forms of knowledge and incorporate them in decision making processes (Rydin, 2007). A way to include these forms of knowledge is through participation, introduced next.

1.1.2 Participation

Participation is a way for the planner to engage with different forms of knowledge. Stakeholders, citizens and other participants can contribute their knowledge and perspectives on planning issues within participation processes. Nevertheless, participation is also a complex concept and planning tool. Participation processes have bottlenecks, and what it is that makes participation effective, is quite subjective and thus hard to define. Bottlenecks of participation include: exclusion of minorities, limited resources and the whole process can be seen as undemocratic, since power between stakeholders might not be equal and participation processes might reinforce existing power structures (Hordijk et al., 2015). Still, participation is an important part of contemporary planning and governments and academics are researching and experimenting with ways to increase the effectiveness of these processes (Hanzl, 2007; Pleizier et al., 2004). One of the ways with which it is tried to improve the effectiveness of participations processes, is by using Information & Communication Technology (ICT) (Hanzl, 2007).

1.1.3 Planning Support Systems and immersive technologies

Planning Support Systems (PSS) have gained ground in the planning practice in research years, but they are still not widely appreciated by planning professionals (Vonk et al., 2005). Stan Geertman calls for 'Planning Support Science' (PSScience) to increase awareness and knowledge about PSS (Pelzer, 2015). The focus of PSScience lies on the second S: support. It focusses on how the PSS can give planning support. In other words, how a PSS can add value.

A rather new communication method is 3D visualisation of digital models, which in the last few years have translated themselves in forms of virtual, augmented and mixed reality. These technologies have been researched in the past (e.g. Feiner et al., 1997; Batty, 1997; Bowman & Hodges, 1995; Pleizier et al., 2004; Willans & Harrison, 2001; Fu et al., 2005), but recent developments such as the commercial VR Goggles mentioned before, have opened new doors. VR can be fully immersive, leading to a sense of presence when used. The Oxford dictionary defines immersive as follows: *"(of a computer display or system) generating a three-dimensional image which appears to surround the user" (Oxford Dictionary, 2017).* This means that immersive technologies are technologies in which the user is immersed, such as immersive VR. Immersive VR can be experienced through a headset with smartphones encapsulated: mobile VR, through VR goggles (HMD) attached to a computer: desktop VR, and through systems such as Cave Automatic Virtual Environment (CAVE) (Kim et al., 2013; Pleizier et al., 2004; Göttig et al., 2004). Nevertheless, since smartphones still have limitations regarding computing power and movement tracking, the possibilities of mobile VR are limited compared to immersive desktop VR. The strength of immersive VR is the immersion, which could result in a sense of presence, a sense of place. This could help users of VR to experience a place in a wholesome way, resulting in better understanding of said place. This thesis focusses on immersive VR with the use of VR goggles (HMD).

The developments call for new insights in immersive technologies and how they can be used within the planning process. Therefore, the objective of this thesis is to understand, how these technologies can benefit the participation process. This leads to the following research question:

1.2 Research question

How can immersive virtual reality add value to participatory planning?

To answer this research question, it is helpful to split it up in multiple sub questions. These sub questions each assess a part of the main research question:

1.2.1 Sub questions

- *What is participatory planning?*
- *What is immersive virtual reality?*
- *How can the added value of immersive virtual reality as a PSS for participatory planning be conceptualised?*
- *What are the benefits and limitations of immersive virtual reality in general?*
- *How can an immersive approach add value to participatory planning?*
- *What is the potential of immersive technologies within participatory planning?*

To research the added value, added value has to be defined. Added value can, for the purpose of this research, be defined as follows: *"a positive improvement of planning practice, in comparison to a situation where this particular tool is not used"* (edited definition of Pelzer, 2015, p.43). These research questions will be answered within a certain context. Two experiments are conducted which both have their own setting and context. The first experiment concerns the redevelopment of Weteringcircuit in Amsterdam. The second experiment concerns a redevelopment area in Amsterdam. This area, 'Sloterdijk I', is situated in the west of Amsterdam and is part of the development strategy 'Koers 2025' and will develop a semi-industrial area into a residential area.

1.3 Societal relevance

It can be questioned whether and what immersive VR can contribute to participatory planning. Clearer communication, which can speak to the imagination of participants without barriers of language, and a more inclusive participation process could be contributions of this technology. Because immersive VR is becoming more and more developed (e.g. faster processing, better software, better portability, better screen resolution), the potential for these technologies increases and they could play a role in how governments and civilians communicate with one another. Furthermore, this research can contribute to the knowledge of developers on how to develop VR for planning purposes (Willans & Harrison, 2001; Vosinakis et al., 2008). This thesis can also contribute to the awareness of immersive VR for planning purposes with practitioners as well as civilians. The awareness for PSS among practitioners is not yet high enough, which is among the three most important bottlenecks for adoption of PSS, as Vonk et al. (2005) point out. Furthermore, the municipality of Amsterdam is experimenting with different kinds of new technologies, and has its own Chief Technology Office (CTO, 2017). The municipality has shown interest in how they can implement and use new technologies in the contemporary settings of the organisation and society. The municipality of Amsterdam is working on ways to use new technologies such as immersive VR and 3D environments to visualise spatial plans. Within the context of the new Dutch planning law, the 'Omgevingswet' (Environmental planning act), the municipality of Amsterdam is exploring possibilities to offer information about spatial plans in a transparent and unambiguous way, to best serve stakeholders involved in the planning process. This research can also contribute to the knowledge of the municipality if and how VR can contribute to informing citizens in an unambiguous way. Lastly, the decision tree at the end of this thesis (in Dutch) about if and when to use VR, can aid the municipality in future decisions about the usage of VR.

1.4 Academic relevance

Interest in immersive VR dates back to the 1990s, but due to recent developments in ICT, some of the research done in that period should be handled critically. Also, VR as PSS has been researched in the past, but research that has been done is often out-dated (e.g. Feiner et al., 1997; Batty, 1997; Bowman & Hodges, 1995; Pleizier et al., 2004; Willans & Harrison, 2001; Fu et al., 2005). In case of immersive VR, changes in for instance mobile computing power and screen resolution contribute to the quality and accessibility of this technology and these improve rapidly. This thesis can give new insights into how immersive VR can contribute to the planning process, specifically within Amsterdam. Furthermore, this research aims to map the added values of immersive VR as PSS within participatory planning, which is not yet done. It also contributes to the aforementioned PSScience called upon by Stan Geertman.

1.5 Outline of this research

To answer the research questions, it is necessary to explore the current literature about immersive technologies regarding participatory planning, and their added values. Due to the lack of up-to-date academic literature, expert-interviews will be conducted. These will be conducted with experts with different areas of expertise: VR specialists, participation professionals and academics regarding PSS and VR. Furthermore, two experiments are conducted to evaluate immersive VR as a tool for participation and to evaluate the immersive approach for participation as a whole. Within the first experiment, citizens are informed about the redevelopment of the area Weteringcircuit, whereas in the second experiment different scenarios, virtual environments (VE) of the redevelopment area Slotderdijk I are used to start a conversation with professionals about the redevelopment of this area. The experts are asked about their opinion of VR as a tool for participation processes and about the setup of the workshop in general.

This thesis starts with an introduction about (smart) governance and smart cities to give the reader overview of the context of VR as participation tool. It then focusses on participatory planning. Subsequently it discusses immersive VR as PSS and the theoretical part ends with the concept added value. Hereafter, the methodology of this research is explained. This is divided in: interviews, experiment I and experiment II. After the methodology, the results are elaborated on in the same structure. This thesis ends with the conclusion, discussion and recommendations for practice.

2 Immersive Technologies within Participatory Planning

In this chapter, current literature about the context, participatory planning, immersive technologies and added value is explored.

2.1 The context: (smart) urban governance and smart cities.

Before zooming in on participation processes, immersive technologies and added value, it can be helpful to get an overview of the context. This starts with cities. Cities are growing and it is projected that 66% of the world population will live in cities in 2050 (Gupta et al., 2015). This calls for effective and fair city management. Governments can facilitate effective city management by using ICT systems (Dameri, 2013); this is called smart urban governance. This is important, because participation is often part of (smart) governance structures. The word 'governance' can be traced back to Latin and ancient Greek words for the steering of boats (Jessop, 1998). Nowadays, governance is often seen as antithesis of government. Governance is, as government, a way of governing. But moreover, governance is a way of coordinating interdependent activities (Jessop, 1998). It is a complex system where different stakeholders work together to a particular end-goal, often steered by the government, but not exclusively.

Smart cities are also closely connected to the subject of this thesis. Smart cities are built on technology and the potential of technology to increase effectivity, efficiency and to make the life of the civilian easier in general. High-quality services and connection to the internet are central to smart cities. Furthermore, focus on social inclusivity and the empowerment of citizens with information are key for smart city development (de Jong et al., 2015). Nevertheless, smart cities start with the effective use of technological developments. The recent boom in ICT has created an increased interest in smart cities and smart governance. The concept of smart cities can still be seen as a fuzzy concept with multiple different interpretations, but a common agreed upon definition of a smart city is as follows:

"*we believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance*" (Meijer & Bolívar, 2015, p. 7; de Wijs et al., 2016, p. 3; Dameri, 2013, p. 2546).

This definition shows that participation, collaboration and making use of technological developments are ingredients of smart city development. Therefore, the concept of smart city seems to be closely related to the subject of this thesis and it gives an overview of the broader context of VR within planning. The next paragraphs elaborate in depth on the following topics: participatory planning, immersive technologies and the added value of these technologies within the participation process.

2.2 Participatory planning

"*the idea of citizen participation is a little like eating spinach: no one is against it in principle because it is good for you. Participation is, in theory, the cornerstone of democracy-a revered idea that is vigorously applauded by virtually everyone.*"
(Arnstein, 1969, p. 216).

Since the 1960s, there has been an increasing interest in public participation within the planning practice (Gupta et al., 2015). The quote by Arnstein illustrates the long-standing tradition of participation within the planning process and the positive attitude towards it. But what is participation? Hordijk et al. (2015, p. 130) define participation as: *"to have a part or share in something"*. This definition shows the broadness of participation. Participation can take different forms, from being an informative gathering to being more co-creative of nature (Pleizier et al., 2004). Nonetheless, in general, participation is often seen as a means to strengthen democracy within the planning process and to counter forces as global capital, politics and technology (Hordijk et al., 2015), since the direct (limited) democracy of the ancient Greeks is substituted for represented democracy; this has created a gap between the authorities and the residents (Hordijk et al., 2015). Furthermore, it is expected that including citizens in the participation process to a high level of control, can not only contribute to a certain level of support, but also to the effectiveness of certain innovations (Meijer et al., 2016). Furthermore, it is argued in the theory of Social Action by Jurgen Habermas, that social action is both socially oriented, as well as instrumentally oriented (Vosinakis et al., 2008). This indicates that tools such as PSS contribute to social action and therefore could increase the effectiveness of participation processes. Nevertheless, there also exists a critique towards participation as will be elaborated on next.

2.2.1 Critical movement against participatory planning

Some claim, that participation in its current form is not truly democratic due to multiple issues; a lack of control of the participators still exists since the government is often leading the process (Arnstein, 1969; Hordijk et al., 2015), the level of influence can vary between the different stakeholders (Hordijk et al., 2015) and there are problems to include everyone in the process (Hordijk et al., 2015; Fu et al., 2005). Also, effective use of scarce resources such as money and time can be challenging (Hordijk et al., 2015). These different problems are complex and they raise the question, who can be held responsible: who is responsible for inviting participants, how often, when, how and who will make the final decision (Hordijk et al., 2015)? This is influenced by the budget and time available, also when we look at the participants themselves; they too are influenced by their available time and money. Furthermore, Boonstra and Boelens (2011) state in their article that overall, public participation has come up with disappointing results. They argue that this is the result of a government controlled process, and that because of the lack of adaptiveness of the government, they fail to address the current complexity of contemporary society (Boonstra and Boelens, 2011).

As shortly mentioned in the previous paragraph, the lack of inclusivity within the public participation process is also seen as a downside of contemporary participation processes. In some cases, there is a danger of only highly educated people participating (elite capture), because the lower educated citizens cannot communicate well enough with the practitioners, since they do not speak the (professional) language (Meijer et al., 2016; Hordijk et al., 2015). Furthermore, the level of democracy can be questioned when only well-organised interest groups, who represent only a small part of society and thus cannot be seen as a representative group, participate (Hordijk et al., 2015; Fu et al., 2005). The problems of inclusivity can raise questions about the fairness of the participation process. It seems that in some cases, participation processes reinforce existing power structures and that they might sharpen conflict of interest (Hordijk et al., 2015), instead of providing a holistic overview of many stakeholders their opinion.

Thus, it seems that participatory planning copes with different kinds of problems. The democratic level of the process can be taken into question, there is a lack of control by participants, influence may vary between stakeholders, resources are scarce and there is a lack of inclusivity, often due to language barriers. ICT could potentially aid with some of these problems, such as inclusivity. Therefore, the combination of ICT and participatory planning is discussed hereunder.

2.2.2 Participatory planning and ICT

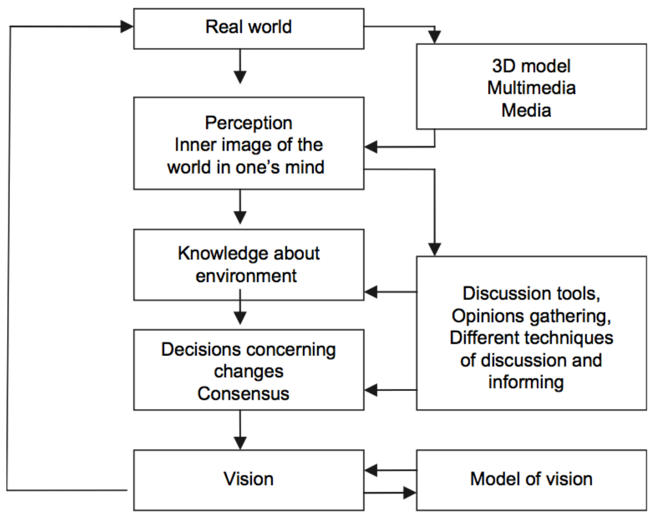
As mentioned at the beginning of this chapter, within smart cities/governance there lies an emphasis on public participation, and thus, researching ways to use ICT systems for participation processes is inherently part of smart cities/governance. The rise of ICT has given the opportunity to experiment with different ways of participation. Participation and communication can now take place online through for instance websites or apps (Hordijk et al., 2015; Al-Kodmany, 2002). Participation through technology can take on different forms as Meijer et al. (2016) elaborate on in their article. Citizens can namely be seen as participant, but also as data source. In the latter case, the citizen provides information through, for instance, his or her phone. This can be seen as a form of passive participation, where citizens provide knowledge by allowing the government to monitor, for example, their movements. These new ways of interacting with citizens can provide valuable information for (local) governments (Meijer et al., 2016). Fu et al. (2005) add that, the use of ICT within participation could potentially solve some of the problems found within participation processes. They argue that inclusivity problems such as not being able to reach disabled and old people, or people with little time or transport options, could be solved by using ICT within participation.

Thus, technology provides different opportunities to add value to participatory planning. The lack of inclusivity could be seen as a potential problem to be solved by using ICT. It could reduce the problem of physical distance. It would be a plausible scenario that, in a decade, people could access participatory virtual environments from their homes and enter these VE's with multiple people at the same time. In the next paragraph is discussed how to visualise spatial plans and specifically elaborated on the current digital ways to visualise spatial issues.

2.2.3 Current (digital) visualisation methods

In general, visualisation has great advantages over other forms of communication such as the written word (Portman et al., 2015). Feldman et al. (1989, p. 740: found in Al-Kodmany, 2002, p. 189) state that: *"an estimated one-third of the human brain is devoted to vision and visual memory. Engaging that sense can help scientists and* *nonscientists alike better understand complex natural phenomena. Reduced to visual imagery, vast amounts of abstract data can be conveyed in concise and dramatic form"*. According to Al-Kodmany visual information has the ability to overcome racial, social and language barriers. A commonly used visualisation method within urban planning is through Geographic Information Systems (GIS). GIS have become an important tool in spatial processes, due to the developments in ICT. But GIS requires a high level of proficiency, which limits the system to professionals. This makes GIS, in many cases, not suitable for public participation (Hanzl, 2007). Therefore, it is necessary to explore other options, other tools for communicating and informing citizens about spatial plans and ways to facilitate participation processes. One way to make it easier to interpret spatial plans, is by using 3D models. Using 3D technologies to visualize spatial plans and landscapes has gained ground (Al-Kodmany, 2002; Ghadirian and Bishop, 2007) and according to Ghadirian and Bishop (2007) landscape visualisations have become an important communication tool, because it can communicate complex information about the land and how it might change. It is especially effective within groups and policymakers, and it is also an effective tool for public understanding (Ghadirian & Bishop, 2007; Al-Kodmany, 2002). Figure 2.1 shows a scheme that explains how reality, but also 3D models and multimedia, are interpreted and how they result in a person's vision. This explains the power of 3D models and multimedia in creating someone's perception of a particular environment.

Figure 2.1. The vision of reality.



Hanzl (2007).

The scheme shows that in order to make decisions concerning changes in the environment, the perception of that environment has to be constructed. If, for example, decisions have to be made in an environment which does not yet exist, 3D models or other forms of media are necessary to create this perception. Tools which provide these 3D models within a spatial context, can therefore, potentially, help in creating someone's perception of reality and assist with making changes which concern this environment. A special case of these 3D environments are immersive technologies, on which is elaborated in the next paragraph.

2.3 Immersive technologies as Planning Support System

As mentioned before, the combination between ICT and participation seems to be an interesting one, according to various researchers (e.g. Hanzl, 2007; Al-Kodmany, 2002; Pleizier, 2004; Fu et al. 2004). It holds potential for themes such as accessibility, communication and non-professionalism barriers. When linked to the planning practice, we can speak of PSS. Stan Geertman defines PSS as:

"… geo-information technology-based instruments that incorporate a suite of components that collectively support some specific parts of a unique professional planning task" (found in: Pelzer, 2015, p. 14).

Thus, PSS are technology based systems which support a particular planning task. Therefore, immersive technologies supporting participation processes can be seen as a potential PSS. In recent years, immersive VR has matured, and has become more suitable for certain practical contexts. Nevertheless, there is no consensus on what level of detail (LoD) a VE should have, to accomplish the goals and accompany the process for which immersive VR are chosen to be used for. Nevertheless, it is stated that it is highly related to the chosen task (Portman et al., 2015). Therefore, it is necessary to test whether immersive technologies are, in their current state, suitable for processes such as participation processes. To do this, insight into the current state of immersive technologies is needed.

2.3.1 Current state of immersive VR

Due to the rapid technological developments, it can be helpful to give an overview of the current specifications of VR systems, specifically immersive desktop VR system using HMD's. According to Peer & Ponto (2017), the Oculus Rift CV1 and the HTC Vive have similar specifications: OLED screens with a resolution of 2160x1200, 90Hz refresh rates and a 100-degree field of view. Göttig et al. (2004, p. 106) state in their article that: *"For smooth simulations at least 24 (the framerate of movies) or better 30 fps need to be displayed."* This would indicate that at least the framerate of the current hardware would be sufficient. Nevertheless, it can be questioned if these demands do not grow over time.

2.3.2 Limitations of immersive VR

Immersive VR is dependent on the capabilities of current technologies; screen resolutions, computing power and software capabilities influence the quality of VR. These improve over time, so the question remains: is the current hardware and software good enough to aid in processes such as participatory planning? As argued in the paragraph above, is that it seems that current framerates are sufficient, but this can still be taken into question, as well as the other specifications. Also, the VE itself can be of too low quality and can be too complex, which limits the experience and can confuse the user (Al-Kodmany, 2002).

Furthermore, there exists a potential ethical pitfall in using VR as a planning tool; since almost everything is possible when creating a VE, it is up to the developer to do his or her utmost best to create an environment that reflects the 'real' situation as best as possible. It could be a potential pitfall if planners and developers would use VR in an artist impression kind of way, potentially misleading people (Al-Kodmany, 2002). This could then lead to abuse of power by developers or real estate developers, to lure people into buying real estate which is visualised in a utopian way, and does not closely resemble real life settings. Therefore, developers have to work with integrity and ethically when developing VE's.

Moreover, even though the costs of VR goggles and systems have dropped, the cost of VR is still quite high. It can also still take a lot of time to create high quality VE's, potentially due to software not being designed specifically for urban designing.

2.3.3 Immersive VR in planning

Some cases of using VR within the planning process can be found in literature. But as stated, most of them are out-dated. For instance, Pleizier et al. (2004) researched VR as an information tool in spatial planning. They acknowledge the potential of using VR for public participation, since, as they foresee, it would need a lower level of proficiency than other tools such as GIS. Al-Kodmany (2002, p. 198) states that: *"It has been argued by Mewby (1993) that VR is the most promising new area for human-computer interaction since the Macintosh computer Graphical User Interface. He claims that VR has the potential to effect changes in the integration and convergence of technology more than any other innovation in recent history."* Al-Kodmany also claims the potential of VR for public participation processes, because of the resemblance of the VE and the 'real world', especially because this could lift the communication barriers of diverse backgrounds. Luigi et al. (2015) connect immersive VR to the urban environment. They state that, within the urban environment, in every environment for that matter, people experience the environment with multiple senses. According to them, this holistic approach is needed when designing a VE. This means that, for instance, the use of sound and touch could improve the quality of the experience of a VE's drastically. They compared a real-world environment in Naples with a simulated VE and they concluded that there was no difference in the visual perception of the real environment with the perception of the simulated VE. They suggest (with caution) that this is due to the high quality of the simulated VE.

Nevertheless, VR for participation processes can also be limiting in terms of accessibility. To let everyone immerse in a VE, multiple different VR goggles would be needed and there could potentially be a lack of face to face contact between participants (Al-Kodmany, 2002). Also, older people could find it hard to use and thus hard to participate. Furthermore, interactivity is also a potential pitfall of using VR within participation processes. For everyone to participate, there would have to be a VR system present for every participant. Since these systems are still somewhat expensive, this would be unlikely to be the case and there would probably only be one or a few systems available. This means that not everyone could use the VR set up, at least not at the same time (Al-Kodmany, 2002). Furthermore, being immersed means that the user is closed off from reality, thus making interaction with the surrounding 'real world' less likely, which could be a bottleneck for engaging with participants. Nevertheless, technology has come a long way, prices of hardware have dropped and these systems have become more accessible and insight in how to use VR as a planning tool could help to improve the set-up of these systems. In addition to how to use the systems as a planning tool, it is also important to have knowledge about the usability of these systems. Therefore, usability of immersive VR is elaborated on next.

2.3.4 Usability of immersive VR

Pelzer (2015, p. 70) has created an overview of commonly used usability variables in PSS research, based on Arciniegas (2012), Goodspeed (2013), te Brömmelstroet (2010, 2014) & Vonk (2006). These usability variables are: *transparency, communicative value, user friendliness, interactivity, flexibility, calculation time, data quality, LoD, integrality* and *reliability*. Some of these usability variables are applicable for immersive VR and can be used for this research. These can be found in table 2.1.

Table 2.1. Relevant usability variables of PSS for immersive VR based on Pelzer (2015).

Usability Variable	The Usability features of Immersive VR as PSS
Communicative Value	The extent to which spatial information is aptly presented.
User Friendliness	The extent to which participants are able to use the tool themselves.
Interactivity	The extent to which direct feedback is given by the instrument.
Flexibility	The extent to which the tool can be applied for different planning tasks.

Within immersive VR, there are multiple ways to move around within a VE. The user can walk in the real world (often to a certain extent: within the limits of the sensors), which then translates to walking in the VE, or fly, walk or teleport using controllers. Since the user is immersed, the user cannot see the real world around him or her, so when walking in the real world, a clear space has to be provided so the user will not bump into objects. In: 'A toolset supported approach for designing and testing VE interaction techniques', Willans & Harrison (2001) indicate the importance of usability features, such as the *interaction technique*, of VE's. They state that usability problems are serious obstacles when it comes to VE's and the development thereof. Regarding the interaction technique, different ways of navigating within VE's have been tested: flying, walking, teleporting or even combinations of these (Willans & Harrison, 2001), Because of the different options, the users and developers can make choices in the way of moving around and can choose for ways of moving around that are not possible in the physical world, such as flying and teleportation (Willans & Harrison, 2001). Nevertheless, it is important to use a suitable interaction technique. A specific part of usability is the user interface of the VE itself, which is discussed in the next paragraph.

2.3.4.1 User interface

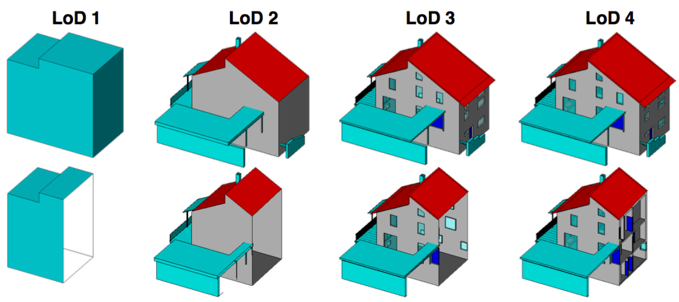
Many different variables influence the user interface of a VE. Not everyone using VE's are experts in this field, making it important to make sure that the user interface is easy to understand and use (Bowman & Hodges, 1995). Three guidelines are discussed: *affordances*, *mappings* and *feedback*. *"Affordances are those elements of an object or tool that give away its purpose and usage"* (p. 2). Mappings are described as follows: *"… an input by the user via the interface should produce a proportional response within the system"* (p. 2). Lastly, *"Feedback refers to the process of sending back information to the* *user about what has been done"* (p. 2). Furthermore, a fourth principle is discussed: *constraints*. Constraints are limits, which are necessary to perceive a given VE as a plausible environment. Constraints include: input devices, objects, tools, navigation, user commands, object selection and object manipulation (see Bowman & Hodges (1995) for further elaboration). These principles provide guidance towards a usable VE, so an immersive feeling can be induced. When simple and small details are off, the experience can be perceived as bad, which could result in the user rejecting VR as a tool.

Usability of VR is thus restricted by both hardware and software. The above stated usability principles of immersive technologies can be added to table 2 (by Pelzer, 2015), so an in-depth layer regarding the usability and user interface of immersive technologies can be incorporated. A specific part of the trait of the VE and thus the user interface, is the LoD in which the world is created. This is discussed next.

2.3.4.2 Level of Detail

The LoD is highly important in 3D modelling and thus also within VR. Within literature, there is no clear consensus on how to classify LoD (Biljecki, 2013). This is partly because there are many different disciplines working with 3D data. Nevertheless, having the right LoD in VR is crucial, but may depend on the task for which VR is used. Figures 3 and 4 show two different perspectives on LoD. Figure 2.2, by the Open Spatial Consortium is based on the use of CityGML data. It shows four levels of detail, with LoD 1 only being a block and LoD 4 being the same as LoD 3, but with the interior added.

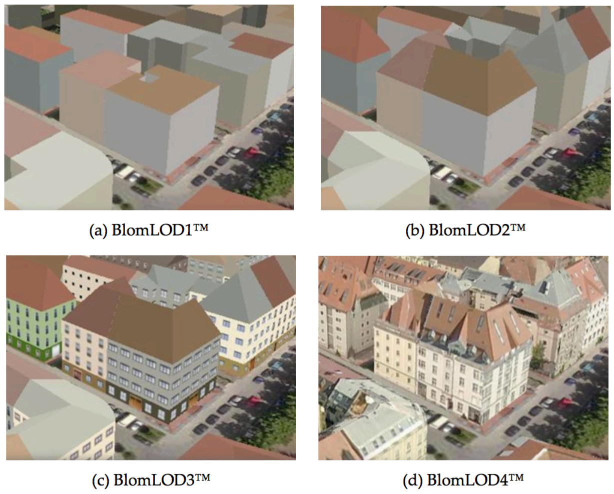
Figure 2.2. Different Levels of Detail according to the Open Geospatial Consortium for CityGML.



Biljecki (2013, p. 16).

Figure 2.3 shows four levels of detail according to the Norwegian Geomatics company called BLOM. LoD 1, 2 and 3 are quite similar to the ones in figure 2.3, but LoD 4 is different. Here the interior is not included. Instead of the interior, texture is added to the model, as well as more detailed rooftops. These are extracted from areal images (Biljecki, 2013).

Figure 2.3. Different levels of detail according to BLOM.



Biljecki (2013, p. 17).

Taking these levels of detail into account, Biljecki (2013, p. 21) argues that the three most prominent variables when it comes to visualising 3D data are:

• Exterior geometry, or simply: exterior.
• Interior geometry, or furniture (not correct, but common).
• External texture, or simply: texture.

It is important to recognize these different levels and variables, since different tasks ask for different levels of detail. A specific attribute of immersive VR, related to the way a virtual environment is perceived, is depth, which is discussed in the next paragraph.

2.3.4.3 Depth

Real depth cannot be seen on a normal 2D screen. Regarding depth, two cues can be distinguished: binocular and monocular cues. Also, two different binocular cues can be distinguished: binocular convergence and retinal disparity. Binocular convergence has to do with the fact that we have two eyes (Grondin, 2016). The further an object is from its observer, the smaller the angle between the focal point and the eyes (Grondin, 2016). To create this level of depth, VR goggles have two screens with slightly different images, similar to the vision of the eyes. This is called retinal disparity. The brain processes these images so that real depth can be perceived by its observer (Grondin, 2016). These so called binocular cues are not the only cues which provide a sense of depth. Monocular cues also influence the perceived depth (Grondin, 2016). These monocular cues are important when creating VE's. Grondin et al. (2016) provide us with seven different monocular cues: linear perspective, texture, occlusion, relative height, relative brightness, aerial perspective and motion parallax (see Grondin et al., 2016 for an elaborate explanation on these cues). Furthermore, the accommodation of the lens and familiarity of size have to be taken into account, but these cannot be influenced by the environment.

To add to the subject of depth within VE's, Peer & Ponto (2017) state in their article that the perception of depth with VR often does not match. This results in users making estimation errors of the perceived distance. This can then, lead to discrepancies between the intended and perceived VR experience, which can result in people rejecting immersive VR as a tool for planning purposes.

All the usability aspects discussed in the previous paragraphs are combined and added to table 2.1. *Communicative Value, User Friendliness, Interactivity and Flexibility* are four of the general usability variables of PSS by Pelzer (2015), which also apply to immersive VR. *Interaction technique* was added to this section. Furthermore, specific usability variables regarding user interface were added below. Lastly, specific usability features for immersive VR (regarding the immersiveness) were added to the bottom of the table. The usability features regarding immersion are also incorporated and are discussed in the next paragraph.

Table 2.2. Overview of usability aspects of immersive VR as PSS based on Pelzer (2015), Willans & Harrison (2001), Bowman & Hodges (1995) and Slater & Wilbur (1997).

Usability Variable	**The usability variables of immersive VR as PSS**
Communicative Value	The extent to which spatial information is aptly presented.
User Friendliness	The extent to which participants are able to use the tool themselves.
Interactivity	The extent to which direct feedback is given by the instrument.
Flexibility	The extent to which the tool can be applied for different planning tasks.
Interaction Technique	The extent to which the interaction technique matches the task.
User Interface	**The user interface variables of immersive VR as PSS**
Affordances	The extent to which objects or tools are intuitive in usage.
Mappings	The extent to which the system responds accordingly to user input.
Feedback	The extent to which the system provides the user with feedback about what has been done.
Constraints	The extent to which the user is limited to certain 'natural' constraints.
Level of Detail	The extent to which the LoD of the tool matches the perspective of participants.
Depth	The extent to which the depth is accordingly integrated.
Immersion	**The variables regarding the immersion of immersive VR as PSS**
Inclusiveness	The extent to which the 'real' environment is shut out.
Extensiveness	The extent to which the range of senses are accommodated.
Surrounding	The extent to which the vision is panoramic.
Vividness	The resolution, fidelity and the variety of energy simulated in a particular modality.

2.3.5 Immersion

"We modern, civilised, indoors adults are so accustomed to looking at a page or a picture, or through a window, that we often lose the feeling of being surrounded by the environment, our sense of the ambient array of light… We live boxed up lives."
(Gibson, 1979, p. 193)

This quote by Gibson illustrates a great part of our lives, instead that, about forty years later, we have replaced most pictures or pages with screens. Computers, tablets, smartphones, people are used to looking at flat screens nowadays. What makes immersive VR interesting is the immersion. It may be the case that it is still, in essence, a flat screen that you are looking at, it does resemble very closely to 'real world' perception. As mentioned, immersion means that you are closed of the 'real world' and immersion tries to create a level of presence. The line between immersion and presence is not always clear in academic literature (Cummings & Bailenson, 2016). Some academics even use the terms synonymously. Nevertheless, there exists a subtle difference between immersion and presence. Immersion can be seen as a quality of a particular system, whereas presence is an inherent function of one's psychological state (Cummings & Bailenson, 2016). The quality of the immersive technologies and thus of the immersion then influences the psychological state of presence. The goal of immersion is to create a sense of 'realness', a sense of being there, a sense of presence (Slater & Wilbur, 1997). Slater & Wilbur (1997) provide four parameters of immersiveness: *inclusive*, *extensive*, *surrounding* and *vivid*. Inclusive means that the surrounding 'real' environment is shut out. Extensive means the range of senses that are accommodated. Surrounding relates to the panoramic vision. And vivid relates to the: *"resolution, fidelity and the variety of energy simulated in a particular modality (such as the visual and colour resolution)"* (p. 3). Furthermore, to create immersion, 'matching' is required. Matching means that, real world movements are matching with digital movements. For the creation of a sufficient level of 'matching', minimal lag is required (Slater & Wilbur, 1997). Slater & Wilbur also state that in order to create presence, a plot has to be present in the VE. A clear story-line helps the user to navigate throughout the VE. Immersion should result in a sense of presence, which is discussed next.

2.3.6 Presence

Slater & Wilbur (1997) state that presence is a state of consciousness, a psychological sense of being. The common idea is that by feeling a sense of presence, an experience which closely reassembles to a real-world experience is created. Furthermore, it would create an experience where the user would have the feeling of having visited the place, instead of just merely have seen some pictures (Slater & Wilbur, 1997). It is also stated by Cummings & Bailenson (2016) that presence is commonly thought of as contributing to the effectiveness of mediated environmental applications (e.g. for entertainment, learning, training). Slater & Wilbur (1997) state that the higher the sense of presence is, the more likely the user is to behave in a similar manner as one would in the 'real world'. By creating this 'real world' experience, it would be expected that this would lead to a better understanding of the given environment and by better understanding, also a better judgement of that environment.

2.3.6.1 Self presence

To create this feeling of presence, a number of scholars have come up with a theoretical outlining of the psychological process by which presence is experienced (Cummings & Bailenson, 2016). The process is seen as a two-step process where, firstly, the user has to draw upon spatial cues to perceive the environment as a plausible space and secondly, the user has to perceive him or herself within the virtual environment: self-presence (Cummings & Bailenson, 2016). Carrie Heeter (1992) also acknowledges the importance of self-presence. She provides us with three different examples of self-presence:

- I see my own hand.
- The virtual world gives me a sense of déjà vu, as if I've been here before.
- Although the rules of this world are different that the laws of physics in the real world, there seems to be a consistent pattern which I can learn to recognize.

Heeter (1992, p. 2).

These examples illustrate the concept of self presence. Heeter also adds two other forms of presence to this. Social presence and environmental presence. These will be shortly described.

2.3.6.2 Social presence

In the examples in the last paragraph, the user is provided with a sense of self presence, an acknowledgement of existence. This strengthens the experience of the user. In addition to self-presence, social presence can also contribute to the feeling of presence. Heeter (1992, p. 2) describes social presence as follows: *"Social presence refers to the extent to which other beings (living or synthetic) also exist in the world and appear to react to you."* It can come from interacting with different human beings or animals. These other entities can both be artificial as well as real humans controlling a virtual character. The idea of social presence can be related to the 'social construct of reality', or in this case of VR (Heeter, 1992), where you interact with society through interpersonal communication, or mass media. Social presence adds to the feeling of being present in the (virtual) world.

2.3.6.3 Environmental presence

Furthermore, environmental presence can be distinguished. *"Environmental presence refers to the extent to which the environment itself appears to know that you are there and to react to you."* (Heeter, 1992, p. 2) This means that there should be a responsiveness of the environment to the actions of the user. This can be, for example, turning on the lights when you enter a room, or opening the door when you are in front of it (Heeter 1992, p. 2). Most VE's are created as a world to explore, but lack forms of interaction. It is argued that this form of interactivity with the environment strengthens the sense of presence (Heeter, 1992). In addition to this, because the designer of a certain environment can basically do whatever he or she wants, the world can also have more interactivity with the environment than the 'real world', which opens new possibilities of interaction (Heeter, 1992).

To add to all the discussed forms of presence above, it is stated by Heeter (1992) that experience also helps in creating a sense of presence within a VE. Thus, if someone had an experience with immersive VR before, the chances to reaching a sense of presence are increased.

To conclude, it seems to be agreed upon that the higher the quality of the hardware and the quality of the VE, the higher the quality of the immersion, which potentially leads to an increased sense of presence. Furthermore, to increase the level of perceived presence, specific cues should be used within the VE. One of the most important cues of creating a sense of self presence is that you, as a person, are acknowledged within the virtual world. This means that you can for instance see your hands and feet (a virtual representation of them) and that you can move independently from the virtual world, creating a sense of being there in an autonomous way. Presence seems to be one of the benefits of using immersive technologies for spatial issues, which leads to the next point: added value.

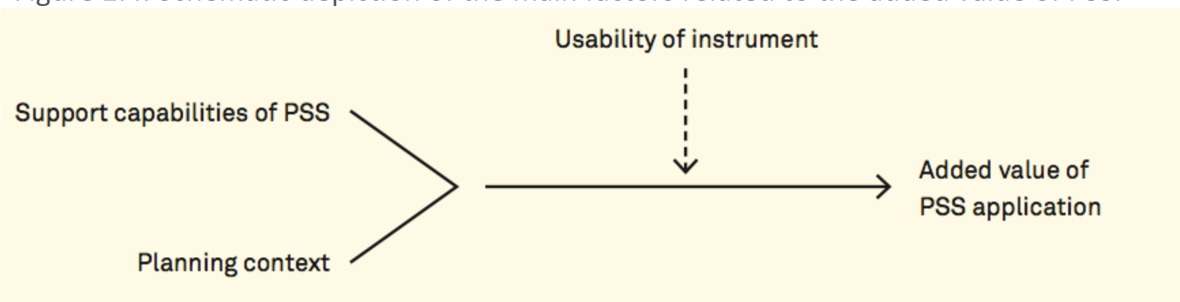
2.4 Added value

In respect to the added value of Planning Support Systems (PSS), Pelzer (2015) has come up with a conceptual model, shown in figure 2.4. This model shows the added value as a dependent variable, which is influenced by the support capabilities of the PSS, the planning context and the usability of the instrument. Pelzer (2015, p. 71) defines support capabilities as follows: *"the features of a PSS that facilitate a specific dimension",* and distinguishes three different classes:

- *Informing:* refers to the primary capability to send information uni-directionally from the PSS to the user.
- *Communication:* refers to the primary capability of the PSS to improve the knowledge exchange among multiple users.
- *Analysing:* refers to the primary capability of the PSS to answer users' questions, particularly through quantitative modelling and analysing.

Pelzer (2015, p. 71)

Figure 2.4. Schematic depiction of the main factors related to the added value of PSS.



Pelzer (2015, p. 68).

If these variables are connected to immersive VR as a PSS, it can be argued that analysing is not one of the primary support capabilities of immersive VR, that informing is one of the support capabilities of immersive VR and communication could potentially be one of the support capabilities of immersive VR. Furthermore, regarding the context, the planning context involves multiple external factors, such as: the users involved, the process characteristics and the content of the planning issue.

Thus, it can be concluded that the added value of a PSS is a product of the planning context and the support capabilities of the PSS and that the added value is influenced by the usability of the instrument. This framework lies at the basis of conceptualising the added value of immersive technologies as PSS. This conceptualisation of the added value of PSS can be translated in specific added values on three different levels: the individual level, group level and outcome level (Pelzer, 2015). On the individual level, learning is the most important added value. Two types of learning can occur. Learning about the object, and learning about the other stakeholders. At the group level, collaboration, communication, consensus and efficiency are key potential added values for the use of PSS. Lastly, at the outcome level, better informed plans or decisions can be added values of PSS. These levels with their added values are shown in table 2.3.

Table 2.3. Summary of added values of PSS applications at three levels.

Added value	***Definition***	***Source***
Individual		
Learning about the object	Gaining insight into the nature of the planning object.	Te Brömmelstroet (2013), Van der Hoeven et al. (2009)
Learning about other stakeholders	Gaining insight into the perspective of other stakeholders in planning	Innes and Booher (1999), Pelzer et al. (2013), Schön (1983), Schön and Rein (1994), Te Brömmelstroet (2013)
Group		
Collaboration	Interaction and cooperation among the stakeholders involved	Healey (1997), Klosterman (1999), MacEachren (2000), Vonk and Ligtenberg (2010), Vonk (2006)
Communication	Sharing information and knowledge among the stakeholders involved	Te Brömmelstroet (2010), Arciniegas and Janssen (2012), Geertman (2008), Vonk (2006)
Consensus	Agreement on problems, solutions, knowledge claims and indicators.	Innes and Booher (1999, 2010), Boroushaki and Malczewski (2010)
Efficiency	The same or more tasks can be conducted with lower investments.	Te Brömmelstroet (2013)
Outcome		
Better informed plans or decisions	A decision or outcome is based on better information and/or a better consideration of the information	Hopkins (2001), Klosterman (2009), several examples in Geertman & Stillwell (2009)

Pelzer (2015, p. 49).

Regarding immersive VR, some of these added values also apply. Nevertheless, it seems that, regarding immersive VR, the learning aspect is the most apparent added value. Therefore, the added value of using 3D virtual learning environments, is described next.

2.4.1 The added value of 3D virtual learning environments.

To go into more detail about the benefits of 3D virtual environments, Dalgarno & Lee provide five affordances of 3D virtual learning environments:

- Affordance 1, spatial knowledge representation: 3-D VLEs can be used to facilitate learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain.
- Affordance 2, experiential learning: 3-D VLEs can be used to facilitate experiential learning tasks that would be impractical or impossible to undertake in the real world.
- Affordance 3, engagement: 3-D VLEs can be used to facilitate learning tasks that lead to increased intrinsic motivation and engagement.
- Affordance 4, contextual learning: 3-D VLEs can be used to facilitate learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualisation of learning.
- Affordance 5, collaborative learning: 3-D VLEs can be used to facilitate tasks that lead to richer and/or more effective collaborative learning than is possible with 2-D alternatives.

Dalgarno & Lee (2010, pp. 18-23).

These affordances come forth from the representational fidelity and user interaction. They result in a sense of presence and co-presence and in the construction of identity. Through the affordances, a fivefold set of learning benefits arise: *Spatial knowledge representation*, *Experiential learning*, *Engagement*, *Contextual learning* and *Collaborative learning*. This would indicate that, if immersive VR can create a sense of presence, learning benefits will arise from this.

Keeping the added values by Pelzer (2015) in mind, it has to be noted that some overlap can be discovered. Collaboration and learning is stated by both scholars, and thus these can be joined together. Furthermore, it can be argued that the learning affordances can be added to some extent to the added value *learning about the object*.

2.4.2 The (potential) added value of immersive Virtual Reality

"The grand aim of immersive virtual environments research is to be able to realise that same 'stepping through the glass' or 'rolling down the window' with respect to computer generated environments, as can be experiences when stepping through a barrier that in normal circumstances screens some aspect of reality from us."
(Slater & Wilbur, 1997, pp. 2-3)

A potential added value of using immersive technologies as a visualisation method for spatial plans, can be found in the sense of reality that it creates, a sense of place. Because of this realness, it could be the case that the number of miscommunications is reduced, since it feels as if you are present in the environment and perception is less open to interpretation. This could make it easier to 'feel' the environment and discuss it. Al-Kodmany (2002) argues this as well: being able to communicate in a visual language such as VR, could help with the communication amongst people with different backgrounds. Furthermore, different scenarios can be created and viewed, making VR suitable for the debate around different scenarios.

VR facilitates the understanding of a particular spatial environment (Portman et al., 2015; Göttig et al., 2004). Portman et al. (2015) argue that VR also has advantaged in architecture, which is closely related to spatial planning. It is stated that it helps with identifying and designing 'lost space', which is space that can potentially be hidden when using other visualisation methods (Portman et al., 2015). Göttig et al. (2004) add to this that, when designing or evaluating a spatial environment, changes like variation in size or quantity of housing blocks can easily be made. This makes VR suitable for exploring different scenario's.

Furthermore, in combination with the internet, VR can contribute to participation from a distance. This would solve (some of) the inclusivity problems regarding participation processes (Al-Kodmany, 2002). With adding also multiple persons to a VE, the social presence regarding the participants could also be enhanced, possibly contributing to the learning aspects.

2.5 Conclusion

In this chapter, participation, immersive VR and added value have been elaborated on extensively. It can be concluded that participation is desirable, but not always leading to the wanted results. Therefore, it is useful to experiment with new ways of participation, by, for instance, using new support systems to aid the process. In case of immersive VR, it can be expected that the most important added value is related to '*learning about the object*', thus the visualising strength of VR, and that by creating a level of presence, the learning is enhanced. To induce presence, immersion is needed. Immersion is created by four variables: *inclusiveness*, *extensiveness*, *surrounding* and *vividness.* A multitude of usability and user-interface features which concern immersive VR, have be taken into account when designing a VE and when using or researching immersive VR. Presence can be divided into three different forms. These forms are summarised in table 2.4.

Table 2.4. Overview of the different forms of presence.

Different forms of presence	Explanation of these forms
Self Presence	Self presence is the most important and most basic form of presence. It means that the person can exist autonomously in a virtual environment.
Social Presence	Social presence is related to social interaction. If other beings acknowledge your existence, presence is increased.
Environmental Presence	Environmental presence is related to the extent to which the world acknowledges you as a person in that world, to the extent the world around you responds to you.

Within the added value of learning, the affordances provided by Dalgarno & Lee (2010) show that VR can assist with learning about spatial environments, even if they do not exist or cannot be accessed. Moreover, it can increase motivation and engagement amongst its users and can potentially increase the effectiveness of collaboration compared to 2D alternatives. The added values which could apply for immersive VR within participation processes are shown in table 2.5. It shows the potential of immersive VR as tool for participatory planning. Herein, the added values of Pelzer (2015) and Dalgarno & Lee (2010) are synthesised in one table.

Table 2.5. Overview of the (potential) added values of immersive VR as tool for participation based on: Pelzer (2015) and Dalgarno & Lee (2010).

Added Values	Description of the added value
Individual level	
Learning about the object	Gaining insight into the nature of the planning object: - Enhanced spatial knowledge representation of the explored domain. - Experiential learning tasks that would be impractical or impossible to undertake in the real world. - Improved transfer of knowledge and skills to real situations through contextualisation of learning.
Engagement	Increased intrinsic motivation and engagement.
Learning about other stakeholders	Gaining insight into the perspective of other stakeholders in planning.
Group Level	
Collaboration	Interaction and cooperation among the stakeholders involved.
Collaborative learning	Richer and/or more effective collaborative learning
Communication	Sharing information and knowledge among the stakeholders involved.
Consensus	Agreement on problems, solutions, knowledge claims and indicators.
Efficiency	The same or more tasks can be done with lower investments.
Outcome	
Better informed plans or decisions	A decision or outcome is based on better information and/or a better consideration of the information.

Some additional comments can be made about the synthesis of these two different frameworks. Collaborative learning could also be placed as a subset of learning about the object. Nevertheless, collaborative learning builds on the fact that it is a collaboration and thus that it takes place on a group level. Nevertheless, spatial knowledge representation, experiential learning and contextual learning can be seen as subsets of learning about the object.

The support capabilities of immersive VR are mainly found in the informative nature of immersive VR. It can be questioned if communication is also a support capability of VR, but analysing can be ruled out for this purpose of this research, since this cannot be measured. The context depends on the case, the nature of the planning issue and the persons involved. In case of this research, two different cases are used. The planning issues in the participation processes and the participants differ per experiment.

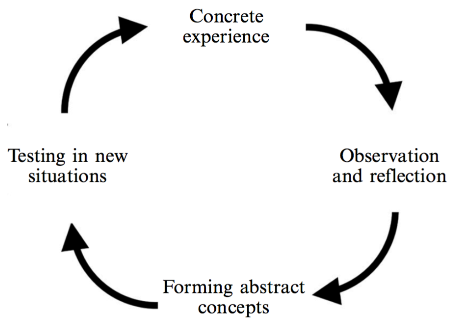
3 Research Methodology

Due to the explorative, experiential and complex nature of this research, multiple research methods were used to fully grasp upon the added value of immersive technology within participatory planning. Furthermore, due to the complexness of conducting a big, real life setting experiment with immersive desktop VR, mixed methods were chosen which include two smaller experiments and expert-interviews. The interviews that were conducted, were with experts with different fields of expertise. These fields were: VR, VR in planning, PSS, ICT in Amsterdam and participation. The interviews provide extra insights, in addition to the (out-dated) literature and could also be used as handles to guide the experiments.

For the second part of this research, two experiments were conducted. The first experiment was conducted to get more insights on how residents of a certain area value immersive VR as a tool for communication and visualisation purposes. It gives insights in the learning benefits of using immersive VR as communication tool. The goal of the second experiment, was to let professionals of the municipality of Amsterdam and academics in different fields evaluate immersive VR as a PSS for participation processes.

This research is set up in an experiential way. It can be argued that the experiential learning cycle created by Straatemeier et al. (2010), shown in figure 3.1 is followed during this research.

Figure 3.1. The experiential learning cycle.



Straatemeier et al. (2010).

Since most of the interviews were done before the experiments, this helped particularly with shaping the second experiment. The experiment was set up based on the gathered knowledge from the literature, the interviews and first experiment. The interviews and the experiments are described hereafter.

3.1 Interviews

Ten expert-interviews were conducted to add to both the theoretical framework, as well as provide insights for the experiments. The interviews were conducted with people in different fields of expertise. In table 3.1, the different persons, the field of work, expertise and date of conduction are shown in chronological order.

Table 3.1. Interviewees and their area of expertise (MoA: Municipality of Amsterdam).

Person	Field	Expertise	Date
Eric Lugtmeijer	Owner VR company	VR – VR in Participation – Participation	29 March 2017
Daniel Doornink	VR entrepreneur	VR	12 June 2017
Tamas Erkelens	MoA (CTO)	Technology in Amsterdam	12 June 2017
Stan Geertman	Academic (UU)	Planning Support Systems	21 June 2017
Robert Heit	MoA	Urban designer	3 July 2017
May-Britt Jansen	MoA: Stadsdeel West	Participation Open Stadsdeel	5 July 2017
Jimmy Paquet-Cormier	Academic (McGill)	VR in planning/participation	7 July 2017
Pien van der Ploeg	MoA	Sloterdijk I Participation	7 July 2017
Saskia Beer	MoA	Participation TransformCity	20 July 2017
Maaike Zwart	MoA	Participation	20 July 2017

These persons were selected because of these diverse knowledge sets, their availability and because they were reachable within the network of the author. Because this thesis was partly written for the municipality, people within the municipality could easily be reached through the internship and with assistance of intern-supervisor Marcel Tieman and Tamas Erkelens (CTO).

The first interview with Eric Lugtmeijer, was done as an explorative interview and was therefore unstructured. The rest of the interviews were prepared in advance and were semi-structured. For each interview, some topics/questions were laid out[2]. The main goal of the interviews was to get a wholesome picture of the concept of immersive VR as PSS for participation processes and to gain more knowledge about the current participation practices. The interviews were coded and analysed using NVivo for Mac.

3.2 Experiment I

Experiment I was conducted by Gigi Zacheo. Gigi, also intern at the municipality of Amsterdam, had developed a roadmap toward VR/AR development for the municipality[3]. To validate this roadmap, he conducted an experiment to gain more insight into the attitude of residents towards VR and AR as communication tools for planning issues. During this experiment, approximately twenty residents from the development area 'Weteringcircuit' were presented with the redevelopment plans, also by using mobile VR. Through a questionnaire, the residents were asked about the experience of the immersive mobile VR system as communication tool for spatial plans[4]. In addition, it was also chosen to conduct participant observations.

[2] Topic lists can be found in the appendix.

[3] The roadmap can be found in the appendix.

[4] The questionnaire can be found in the appendix.

3.2.1 Research methods: questionnaire and participant observation

As mentioned, a questionnaire as well as participation observations were conducted during the session. The questionnaire was made by Gigi and the project team of the municipality, and therefore extra questions specifically for this research could not be added. Therefore, it was chosen to also conduct participant observation. It was tried to blend in with the other residents, to have as little interference with the session as possible and also to give to participants less incentive to give socially desirable answers to the questions asked. It could, namely, be a plausible scenario that the participants would give more enthusiastic answers to the product owner and people associated with him/her and that they would not, or give less critical feedback. After the session, some of the participants were asked a few questions about the VR to gain more insights in the experiences of the participants.

3.2.2 Location

The location that was used for the informative gathering, was near the redevelopment area: Weteringcircuit. It was located at Eerste Weteringpantsoen 2C. The space is normally used as a Turkish community centre. Photo 1 shows the setup of the space before the start of the session and photo 2 shows the posters of the plans, which were connected to the walls.

Photos 1 & 2. Setup of the space before kick-off.

3.2.3 Used system

It was chosen to make it an accessible experience. Therefore, during this experiment, mobile VR was used. The Gear VR was used in combination with Samsung smartphones. The Gear VR's and the smartphones were all provided by the company which created the VE: VR Owl, and therefore it was not needed for the residents to use any of their own equipment. Photo 3 shows four of the Gear VR's and three of the phones that were used.

Photo 3. Four Gear VR's and three Samsung smartphones.

3.2.4 The virtual environment

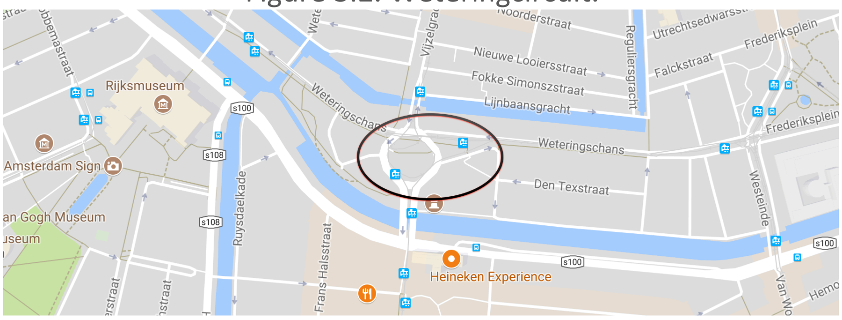
The VE used during this experiment differs from the one used for the second experiment. The VE was created by VR Owl and commissioned by the 'ingenieursbureau' (IB) of the municipality of Amsterdam. It was chosen to create a VE which could be presented and used to/by the masses, using mobile VR. Therefore, it was chosen to create a VR environment (360 video) which could be viewed through YouTube. Thus, to simplify: the VE was a 360-degree video on YouTube. The video can be accessed through the following link:

https://www.youtube.com/watch?v=z0OSbrdt8Hg&feature=youtu.be

There exists a trade-off when choosing for mobile VR. Users do not have the degrees of freedom one would have with using a desktop VR setup and thus, it will most likely not create a well enough experience to result into a feeling of presence. This could negatively impact the learning process. But, the upside to using mobile VR is that it is cheaper, and more accessible.

Figure 3.2 shows the location of the redevelopment project. The VE exists of different phases which are shown consecutively in the 360-degree video. Figure 3.3 shows a screenshot of the VE[5]. The screenshot is made in normal video mode, not VR mode. One screenshot is also added to show how the VR mode is displayed on the smartphone and can be viewed in figure 3.4.

Figure 3.2. Weteringcircuit.



Based on Google Maps.

[5] Extra screenshots of the different phases can be found in the appendix.

Figure 3.3. Example of the VE of experiment I:
Overview of the current situation of Weteringcircuit.

Screenshot of YouTube 360 video created by: VR Owl, (2017).

Figure 3.4. VR mode on YouTube.

Screenshot of YouTube 360 video created by: VR Owl, (2017).

3.2.5 The session

The session was organised with the project manager and the project team from the IB of the municipality of Amsterdam and took place on Tuesday the 11th of July 2017 from 17:00 until 18:45. The goal of the session was to inform nearby stakeholders (residents) about the redevelopment project. The session consisted of three different phases:

- Walk-in.
- Plenary session.
- Walk-out.

During the walk-in, stakeholders were asked to fill in the first part of the questionnaire. This part of the questionnaire was about the participants' current knowledge of the redevelopment area. The first part was also about some background information of the participant and about the satisfaction of the current ways of communication of project information. During the walk-in, people could also ask questions about the project and look at the plans on paper posters. This is shown in photo 4.

Photo 4. Facilitator explaining the plans to a resident during the walk-in.

During the plenary part, the project manager (facilitator of the gathering), explained the different phases of the project and their implications. This was done by a PowerPoint presentation. Photo 5 shows the facilitator explaining the plans in the plenary setting.

Photo 5 & 6. Facilitator explaining the plans in the plenary setting; Participants engaged in VR.

The VR simulation of the area was shown at the end of the plenary part of the session. During this time, participants could make use of VR systems to see the visualisation of the different phases of the plans. Photo 6 shows the participants with VR goggles on and immersed in the VR experience.

After the plenary part, the second part of the questionnaire was filled in and there was an opportunity to ask more questions about the project. The second part of the questionnaire evaluated how much knowledge about the project was gained during the VR visualisation and how the participant valued the VR experience. These questions can be found in the questionnaire. The questionnaire aimed to provide knowledge in the following area:

> *"Sharing information with stakeholders, the general opinion of using VR as a future tool for these kind of events and in a more general perspective shows the contribution of Virtual Reality as a tool for projects during the preparation and construction phase."*

(Zacheo, 2017a, p. 11)

These insights contribute to this research as well, since, within participation processes, providing participants with knowledge about a certain project is often one of the most important goals. Furthermore, since mobile VR was used, more insights are gained in the use of different forms of VR.

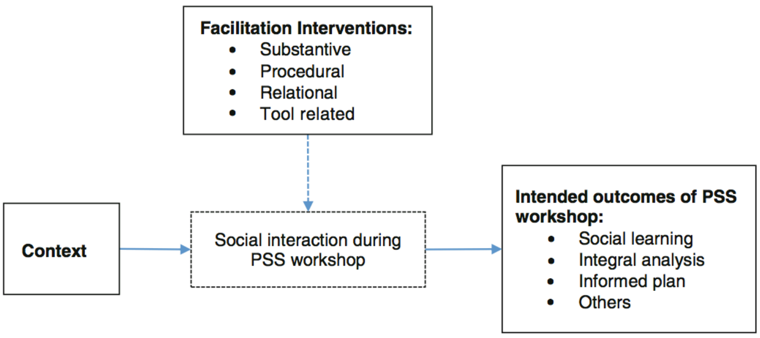
3.3 Experiment II

The second experiment was set up to evaluate immersive VR as a tool for participation processes, to find out how immersive VR can add value to participatory planning, to improve the tool and to evaluate the immersive approach of the workshop as a whole. The latter means that not only the tool itself was taken into account, but also the setting of the workshop. This is referred to as an immersive approach. The next paragraph gives more insight to the immersive approach as a method for a participation workshop.

3.3.1 Immersive approach

Participatory planning is done by taking multiple stakeholders and their opinions, and collaborating to create a wholesome plan. Since it is not only the tool that can influence the process and the outcome of the workshop, but also workshop itself, the facilitator, cultural context, background of the participants (Pelzer et al., 2015), for this experiment, it is better to not focus exclusively on immersive VR as a tool, but also on the approach of the workshop itself. Pelzer et al. (2015) mention four different kinds of interventions: *substantive*, *procedural*, *relational* and *tool related*, where procedural and relational can arguably be seen as relevant for any kind of group meeting. A schematic overview of the variables involved within PSS workshops and these facilitation interventions is shown in figure 3.5.

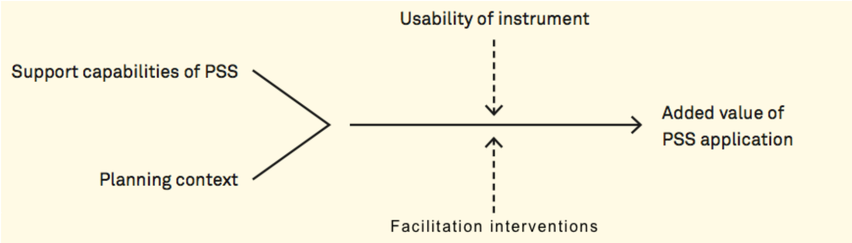
Figure 3.5. Variables in play regarding PSS workshops.



Pelzer et al. (2015).

These influences also apply within this experiment. Therefore, the second experiment, also focusses on the immersive approach as a method for participatory planning; how do the participants feel about the workshop as a whole and how can both the setting and the tool be improved? Regarding the conceptualisation of the added value of PSS, it can be argued that usability of the instrument is not the only factor influencing the added value of PSS. The interventions done within the workshop also influence the outcome. Therefore, these interventions can be added to the original conceptualisation of the added value of PSS.

Figure 6.1. Schematic depiction of the main factors related to the added value of immersive VR as PSS for participation workshops based on Pelzer (2015).



3.3.2 Research methods: questionnaire and group session

It was chosen to conduct a questionnaire and to organise a group session after the experiment. This combination was chosen because it is particularly powerful in this setting; the more straightforward questions and measurements, like Likert-scale questions and ranking, could be done through the questionnaire, whereas the more subjective themes and broader perspectives could be discussed in the group session. This is important because in this case, VR is about perceiving the environment, which is always somewhat bound to the perception of the individual and therefore hard to measure quantitatively.

3.3.3 Location: the VR Room Utrecht

The experiment took place at the VR Room. All the needed equipment was available at this location and the owner, Wouter van den Bijgaart, granted access to the location for the time needed. The experiment was done on the 25th of July. At the VR Room, one room with one VR setup was available for the experiment. Most preparations were done on Monday the 24th. The setup was as follows: one person could be immersed in VR at the time and a TV monitor displayed the visual of the user, so the people that were not immersed in VR, could still monitor the virtual world and the movements of the person that was immersed. This setup is shown on photo 7. There was also made use of another room, the conference room, which was setup as shown in photo 8.

Photo 7 & 8. Setup of the VR system and overview of the conference room.

3.3.4 Used system

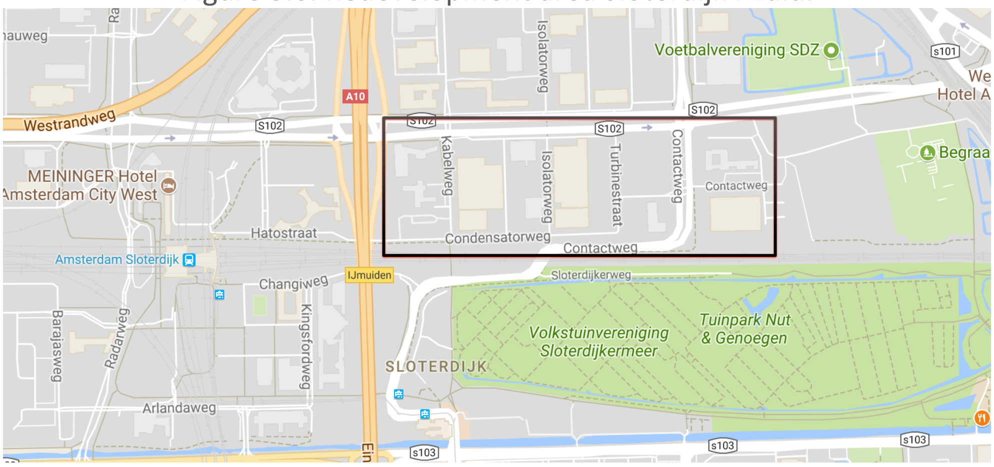
The HTC Vive was used in combination with a desktop PC with the following specifications: i5 6500 processor, 16Gb RAM, a 256Gb SSD and a NVidia GTX 970 video card**.** Unreal Engine was used for running the VE. Furthermore, in the conference room a Dell XPS 15 9550 with the following specifications was used: i7 6700HQ processor, 16Gb RAM, a 512Gb SSD and a NVidia GTX 960n video card. Finally, a MacBook Pro and beamer were used for giving a presentation and two iPhones and one Nexus 6p were used to document video recordings, photos and audio recordings.

3.3.5 The case: Sloterdijk I-zuid

The case used for the experiment was Sloterdijk I-zuid. Sloterdijk I is a redevelopment area situated at the outskirts of the city of Amsterdam, close to railway station Amsterdam Sloterdijk. Sloterdijk I is part of the development strategy ‘Koers 2025’. This strategy is part of the so called ‘Structuurvisie 2040’, a strategic vision of the municipality of Amsterdam for 2040. The development strategy Koers 2025 entails the building of 50.000 homes until 2025. Amsterdam is growing by 11.000 residents per year, which drives these developments.

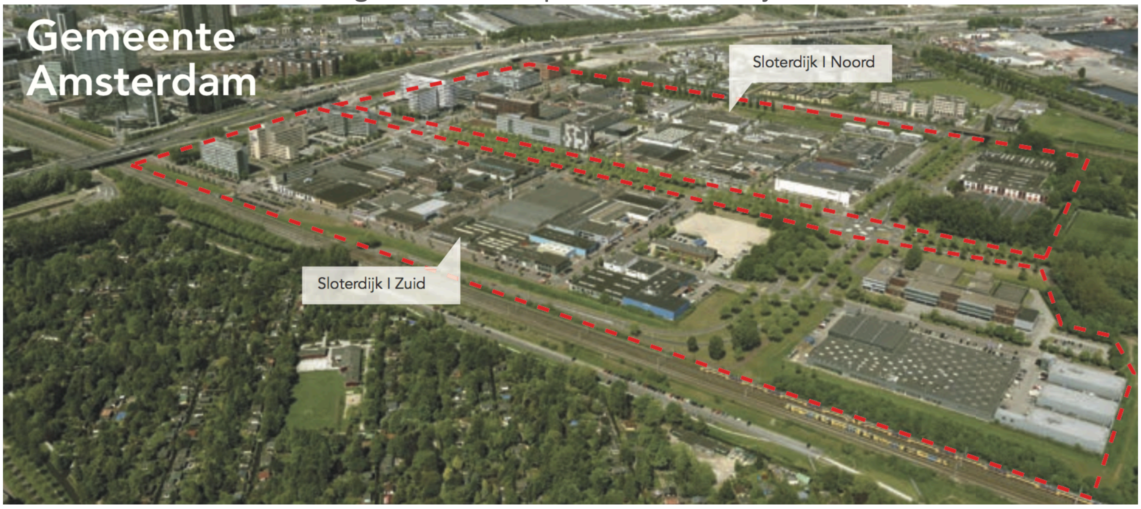
Sloterdijk I is split in two parts, Sloterdijk I-noord and Sloterdijk I-zuid. The VE was created for a part of Sloterdijk I-zuid. Sloterdijk I-zuid is shown in figure 3.6. Sloterdijk I-zuid will be redeveloped from a semi-industrial location to a residential area with approximately 2000 homes (Municipality of Amsterdam, 2016a). Figure 3.7 shows an aerial image of Sloterdijk I.

Figure 3.6. Redevelopment area Sloterdijk I-zuid.



Based on: Google Maps (2017).

Figure 3.7. Arial photo of Sloterdijk I.



Municipality of Amsterdam (2016b).

3.3.6 The virtual environment

The experiment was conducted with a VE created by Ruben Hanssen (2017). The environment was created for his master's thesis for Urbanism at the TU Delft. It was initially created to evaluate VR as an urban design tool. Therefore, changes in the environment could be made in VR mode. This is also an interesting feature for participatory planning. Nevertheless, due to the complexity of this system and due to the limited time available for the experiment, it was chosen to exclude this feature from the experiment. However, it was mentioned to the participants that this possibility existed. The environment entails three different designs of part of the redevelopment area Sloterdijk I-zuid. The designs were created using three different programs, each for a particular part of the designing process: Illustrator, Autodesk Maya and Unreal Engine 4 (Hanssen, 2017). The blueprint of the area was made with Illustrator, the building blocks were extruded with Maya, which was then imported in Unreal Engine. In Unreal, the design could be modified in VR mode (Hanssen, 2017).

The municipality had set specific ambitions for the development of the area as well as some preferences for the designs. The area should be:

1. An attractive residential area.
2. It should have intensive land use.
3. The design should have high spatial and functional quality of both buildings and public space.

(Hanssen, 2017)

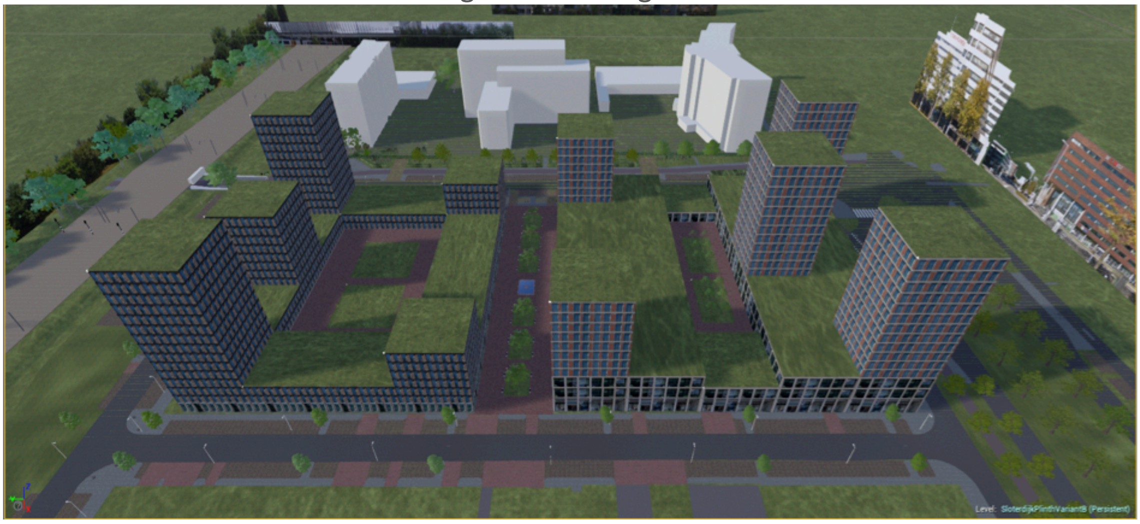
The preferences of the municipality were: maximum building heights of 40-50 meters, but also variation in building heights. Qualitative criteria such as sun exposure, wind hindrance and inner courtyards were also set. Connection streets could have a more intimate character (Hanssen, 2017). All different designs are individually described hereafter.

3.3.6.1 Design A

The first design is described by Hanssen (2017, p. 63) as follows:

“This design variant was designed with little diversity and setbacks and straight alignments of buildings. The result is a design with hard ‘gestalts’ (Prak, 1979): the buildings seem to be different entities than the plinth blocks, especially the north side of the plot. The plot is divided in two blocks by a single connection street, which has a less intimate character...”

Figure 3.8. Design A.

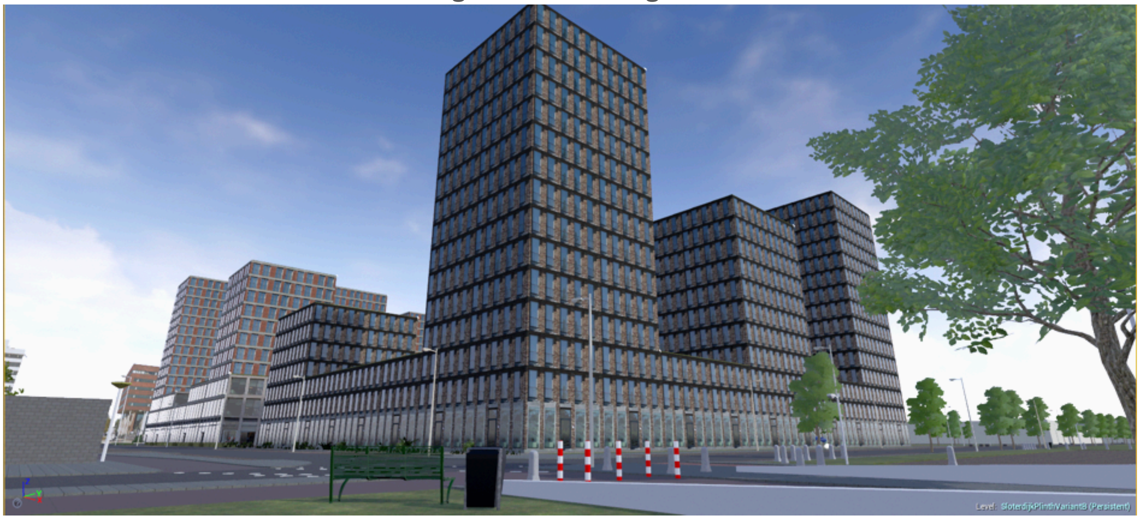


Hanssen (2017).

Figure 3.9. Design A.

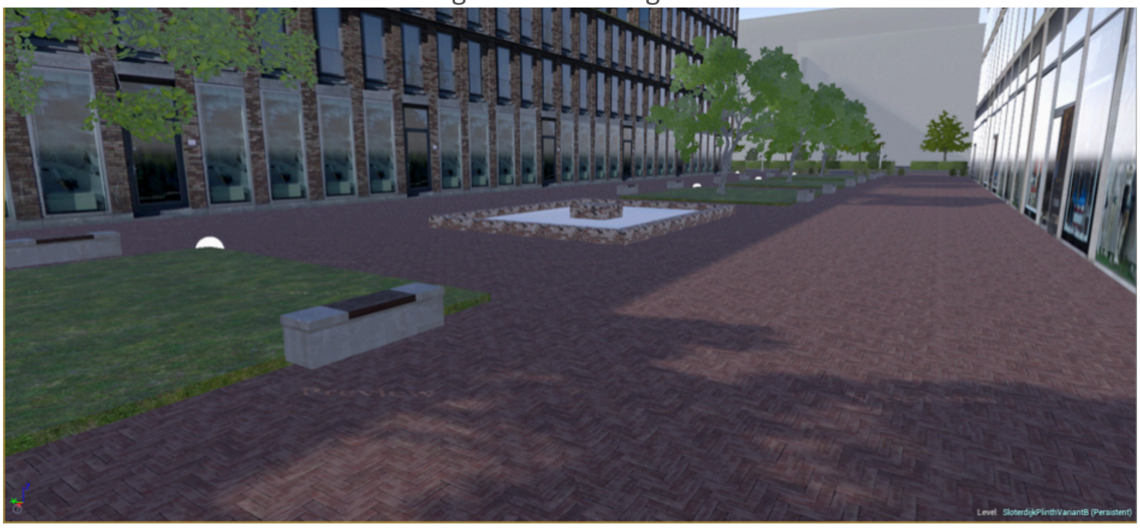
Hanssen (2017).

Figure 3.10. Design A.



Hanssen (2017).

Figure 3.11. Design A.



Hanssen (2017).

3.3.6.2 Design B

The second design, design B, is described by Hanssen (2017, p. 66) as follows:

"This design variant was designed to achieve diversity of materials, setbacks and variety of building alignment. The goal was to 'soften' the design in order to make the experience from eye level more appealing, as well as to offer increased visual complexity. The plot is divided into three smaller plots, separated by two connection streets. The blocks each offer elevated inner courtyards, one of which is open to the public."

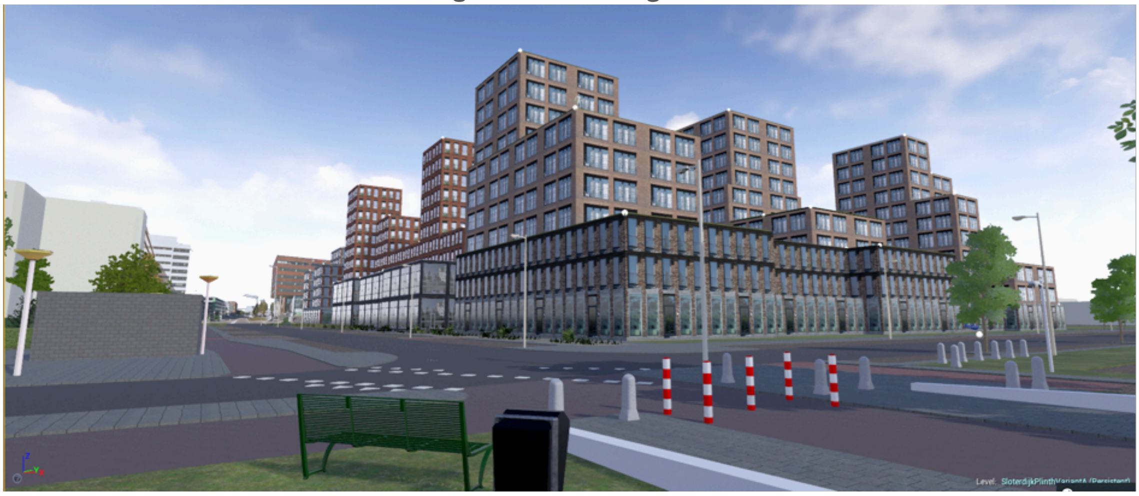
Figure 3.12. Design B.

Hanssen (2017).

Figure 3.13. Design B.

Hanssen (2017).

Figure 3.14. Design B.



Hanssen (2017).

Figure 3.15. Design B.

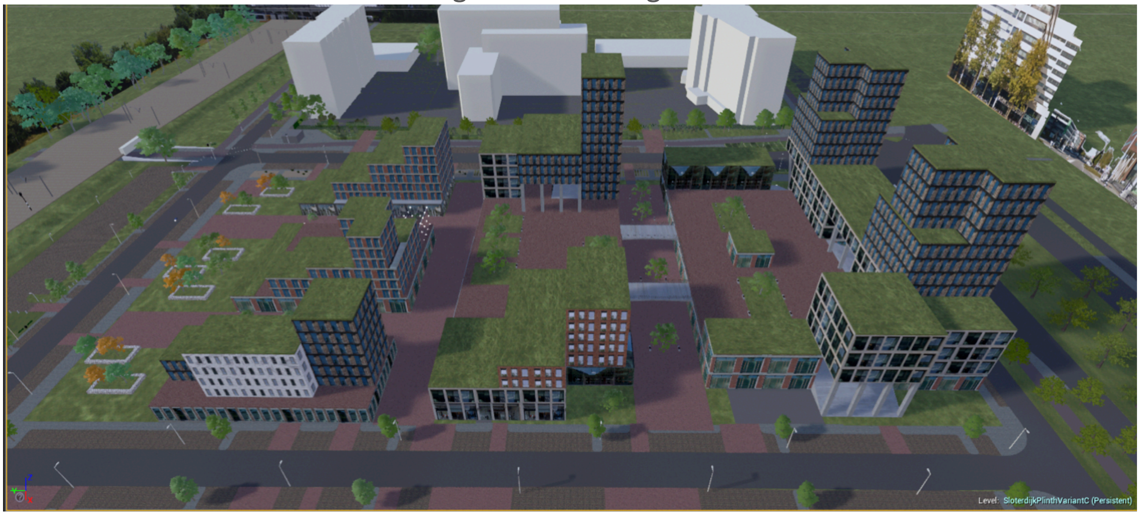
Hanssen (2017).

3.3.6.3 Design C

The third design, design C, is described by Hanssen (2017, p. 72) as follows:

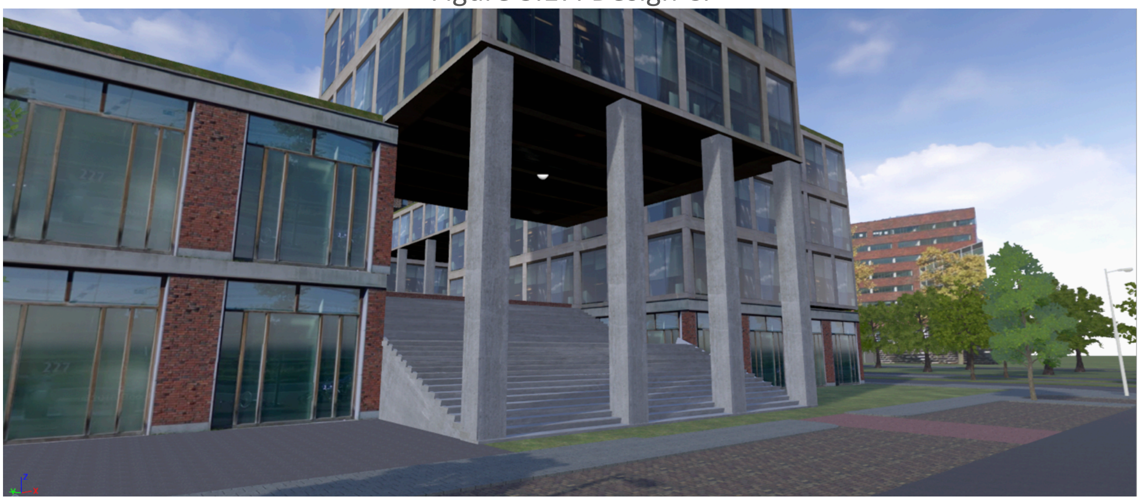
"It immediately shows how the south part of the design is characterized by lower building heights, which was caused by an overestimation of the size of the plain volumes. It also shows how big the influence of the façade detail is on the experience of the design. The design uses more overhanging parts, gaps in buildings and elevated public spaces..."

Figure 3.16. Design C.



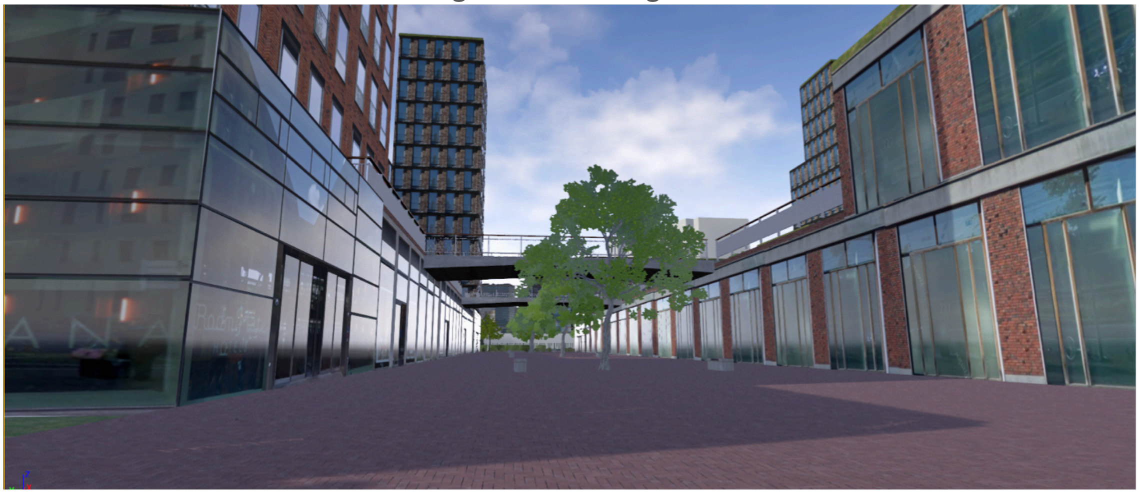
Hanssen (2017).

Figure 3.17. Design C.



Hanssen (2017).

Figure 3.18. Design C.



Hanssen (2017).

Figure 3.19. Design C.

Hanssen (2017).

All designs were used during the experiment. The designs were used to aid the conversation about the preferences of the participants regarding the development of the area. This was done to simulate the setting of a participation workshop.

3.3.7 Participants

The initial participants invited for this experiment were similar to the interviewees and were chosen by differences in expertise. Nevertheless, due to the summer period and the short timeframe, many invitees were not able to participate. Therefore, extra invitations were send out. This was initially done within the network of the author, mainly focussing on professionals at the municipality and researchers at universities. To broaden the range, additional networks of the supervisors of both the municipality and the university were also called upon. This eventually led for a widespread message within the project management bureau (PMB) of the municipality of Amsterdam and resulted in a group of professionals from different fields of expertise, mainly from within municipality of Amsterdam. In the end thirteen people signed up, but since some people cancelled at the last minute and not everyone showed up, eight people attended the workshop. The participants who were personally invited can be found in table 3.2.

Table 3.2. Participants of experiment II (alphabetically ordered by first name; MoA: municipality of Amsterdam; UvA: University of Amsterdam).

Invited Participants	Invited	Expertise	Attended
Desirée Barendregt	√	Project manager	√
Louis van Amerongen	√	'Beeld & Data' MoA	√
Marcel Tieman	√	Digital Track Environmental Planning Act (Omgevingswet) MoA	√
May-Britt Jansen	√	Participation MoA	√
Michiel Stapper	√	Participation (UvA)	√
Safia Akkus	√	CTO MoA	√
Suzanna Tomor	√	Smart Urban Governance (UU)	√
Thomsy Jongepier	√	Area Communication Zuidas MoA	√

3.3.8 The session

The workshop took place on Tuesday the 25th of July from 11:00 until 13:10. After getting acquainted with each other, the workshop started off with a short explanation and walkthrough of the workshop. The general assignment of the participants was to achieve consensus on how the redevelopment of Sloterdijk I zuid should look like. To aid in this process, people could view the three different designs in VR. During the presentation, the ambitions and preferences of the municipality were explained to the participants and it was asked to keep these in mind during the workshop.

Photos 9, 10. The VR system in action.

It was chosen to divide the group into two separate groups of four people. This was done to keep the size of the group which would be in VR to a minimum, since there was only one system available. One group first used VR to explore the different designs, and the other group first started off in the conference room with paper maps, printed screenshots and the 3D environments on the computer. The VR setup was under constant supervision of Harm Manders, who explained how the VR system worked and guided the participants through the process. This can be seen in photos 9 and 10.

To aid the process and the conversation in the conference room, maps and screenshots of the different designs were printed out (photo 11). To make this setting more interesting and interactive, a computer with a controller and the VE was presented (photo 12). Participants could 'fly' around in the VE using the controller. This way, a comparison of the experience could be made between 3D and immersive VR in the group session. Photo 11 shows the participants looking at the maps and screenshots and photo 12 shows the participants engaged in the 3D environment. At a certain point, the groups would switch rooms.

Photos 11, 12. The conference room during the workshop.

Forty minutes before the end, the participants were asked to wrap up. The groups joined together to discuss the project, to make the final decisions and come to a consensus about the project. After this the second part of the questionnaire was filled in. When everyone was finished with wrapping up and filling out the questionnaire, the group session could start. Twenty minutes was reserved for the group session after which the participants could go home. The group session ran a little late, therefore the workshop ended around 13:10 instead of 13:00. After the participants left, three people stayed to clean up and returned the rooms to their original set-ups.

4 Results: interviews

The findings regarding the expert-interviews are discussed in this chapter. The interviews were conducted to enforce the often-out-dated literature, to gain more knowledge in current practices of VR, participatory planning in Amsterdam and to gain more insights into the added value of VR. This chapter is divided into three different sections: current participation practices, virtual reality and virtual reality in planning.

4.1 Current participation practices

There are little formal rules for participation and how it is executed, Maaike Zwart pointed out. Therefore, participation is often executed in different ways. Sometimes there is a focus on participation within a project and all kinds of different digital tools such as participation platforms are used, and other times participation is executed as an informative gathering, or is not even part of the project at all. It is mostly dependent on the willingness and availability of time to incorporate participation within a project. This, in its turn, is dependent on the project manager and sometimes even on the aldermen. Tamas Erkelens also pointed out that, without the willingness of the civil servants to use and incorporate a particular technology and the work that comes with it, it will not be used. Nevertheless, within the municipality, experiments are conducted with new forms of participation. For instance, 'stadsdeel west' (city borough west) is experimenting with a platform called 'OpenStadsdeel'. This is an online platform where citizens can upload their initiatives so that the municipality can look into them. Another platform is TransformCity, where participation within area development is facilitated. This platform uses a map where residents and other stakeholders can explore an area. Saskia Beer from TransformCity pointed out that within this project it was discovered that the customer journey is extremely important. Different stakeholders have different interests and want different information. Knowing your audience can help to include as many people as possible within participation processes. Jimmy Paquet-Cormier added to this that, different age groups within society prefer different approaches. Older people are used to the physical informative gatherings, whereas the younger age groups are more familiar with all kinds of technology, making it less of a barrier to use and communicate through these technologies. Paquet-Cormier also added that it is necessary for these different forms of participation and communication to co-exist, so that the needs of people with different preferences are served accordingly. To illustrate, Janssen argued that, when she used Facebook as communication method, she reached different people than she normally does. Nevertheless, current communication methods are often chosen to suit the system of the municipality, and not to optimally serve the needs of the citizens.

Furthermore, Expectation management is also very important according to Janssen and Pien van der Ploeg. Van der Ploeg mentioned that if you have an initial design, people sometimes assume that it is the final design, and thus that this will become reality. Because VR can create a very realistic image of a design, it is easier for people to assume that this will become reality. Therefore, it could also potentially harm, when the design does not match the expectations. Thus, with VR it becomes even more important to manage expectations and to make sure that details in the VE are correctly visualised.

4.1.1 Bottlenecks of participation

Some bottlenecks can be found with traditional forms of participation, such as information/consultation gatherings. Paquet-Cormier argued that one of the most important bottlenecks of these forms of participation, is that they are often boring. According to Paquet-Cormier, this has a lot to do with the fact that the participants there, do not always speak the same technical language as the planning professionals. Also, frequently used visualisation methods such as maps, are often hard to understand for non-professionals. Something similar was indicated by Beer regarding the platform of TransformCity. She indicated that people did not always understand what they could do with the map on the platform, why this was important for them, and would leave the platform almost instantly. Another bottleneck of participation can be found in the bureaucracy and the time needed for people to participate, according to Janssen. Furthermore, the setting is often very formal, which does not attract many other people than either: people who are interested or directly harmed by a project, or the usual suspects. The question is: what motivates people? Eric Lugtmeijer gave an example of the construction of sports hall: *"the people just want to know, how high will the building become and when I'm drinking coffee in my backyard on the 3rd of September at 14:00, will I still get sunlight?"*. This example illustrates the way people think and what they find important: in what way is their situation affected? By thinking from their perspective and showing them VR, you can potentially take way many objections.

To sum up, many bottlenecks exist regarding participatory planning. Language and professionalism barriers, which can make participation boring and make them hard to understand for everyone, exist. Different kind of people expect, or at least prefer, different kinds of communication. Furthermore, the system (read: bureaucracy) does often not allow for people to avoid time consuming processes. This underlines the importance of experimenting with different forms of participation and different tools to aid these processes. The most important features regarding participation can be found in table 4.1.

Table 4.1. Takeaways from the interviews regarding participation.

Features of participation	
Form of participation	- The form of participation is dependent on the willingness of the project team/manager. - The form of participation is dependent on the resources available.
Bottlenecks	- Bottlenecks of participation include: language barriers, professionalism barriers, resource consuming, bureaucracy.
Communication	- Communication methods should be different for different target groups. Using combinations will attract different groups.
Expectation management	- Expectation management towards participants is very important.
Customer journey	- It is important to know your audience, who has which kind of interests, who prefers what kind of language, who needs to know what etc.

4.2 Virtual reality

According to Daniel Doornink, VR is currently still very early stage: "*I always compare VR in my keynotes with the Nokia 3310 instead of the iPhone 7 or 8*". He explained that VR became very big really quickly, but that the actuals are still lagging behind. This can be explained by various reasons such as: relatively high consumer costs, quality of the hardware and quality of content. Nevertheless, the prices did reach a stage where it is fairly affordable, according to both Paquet-Cormier and Lugtmeijer. This helps to drive innovation and adaptation of the technology. Also, since major companies such as Google, Facebook, Apple, Intel, Qualcomm, NVidea are investing a lot of resources in technologies such as VR and AR, it can be argued that it will be a matter of time before these problems are solved, Doornink argued.

Doornink argued that, regarding hardware, steps have to be made to improve the experience. He gave an example of current tracking possibilities; with current VR systems, solely the movements of the headset and the controllers are tracked, meaning that only the movements of your head and hands are tracked. This limits the mirroring of natural movements within VR. For instance, nothing happens in VR when you raise your knee. But, Doornink added, these are things that people are currently working on. The same goes for the quality of the tracking itself. Sometimes the tracking is off, which also has to be improved to increase the quality of the experience. The lack of quality in hardware and VE can negatively influence the experience of VR.

4.2.1 The experience

In order to create a good experience in VR, many important variables have to be kept in mind. Doornink argued that VR is the only medium that can induce presence. The only way to achieve this psychological state, is for the hardware and VE to be of high enough quality. Presence can, according to Doornink and Paquet-Cormier, contribute to learning in an experiential way. It could be the case that, since your do not need to think about the environment, because it feels real and natural, you can focus better on a particular task, Paquet-Cormier speculated. Also the transition from the real world to VR is important, according to Paquet-Cormier. In many cases, the transition from the real world to the virtual world is not smooth enough. He found that, the easier the transition was, the better the experience. Furthermore, regarding the VE, texture on buildings is of utmost importance, according to Lugtmeijer. He stated that, in order to make estimations about size, texture is needed**.** Lugtmeijer also argued that sound can really enhance the experience, but also has a downside. "*You lose people completely in VR, making it impossible to communicate with them."* Finding the right interaction method is also very important for the experience of VR. Doornink pointed out that of the current ways of moving around in a VE, teleportation is still the best. This is in line with what Lugtmeijer said, namely that moving around with normal gaming controllers was hard for a lot of people. Another problem according to Lugtmeijer, is that for having a 'perfect' VR experience, you are still bound to a very powerful computer, and that your still physically attached to this computer as well. This, of course, can be avoided by using mobile VR, but with mobile VR, other problems arise.

4.2.2 Mobile VR versus Desktop VR

With mobile VR some problems arise, according to Doornink and Lugtmeijer. First of all, computing power of telephones is low. Furthermore, there are little degrees of freedom in interacting with the VE. Doornink calls mobile VR a gateway-drug. Mobile VR is highly accessible, and therefore ideal to experience VR for the first time with. But, both Doornink and Lugtmeijer agree that mobile VR is not the real VR experience. Paquet-Cormier argued though, that all forms of VR can be relevant for different purposes. Robert Heit elaborated on his experience using a mobile VR system for a redevelopment area called 'de Sluisbuurt'. He argued that it worked very well for the purposes that they had: showing the plans. They chose five different points from where the area could be viewed and Heit mentioned that even the alderman became really enthusiastic about the plan and the experience of the VR: *"I want to live here."* Nevertheless, it was asked within the session if there was a possibility for the user to walk around within the VE, which there was not. It can be concluded that it is important to assess, what is needed, what the available resources are, what the goal is, each time. Key takeaways of VR can be found in table 4.2.

Table 4.2. Takeaways from the interviews regarding VR.

Features of VR	
Early stage	- VR is still early stage.
Bottlenecks	- Bottlenecks of VR include: relatively high consumer costs, quality of the hardware, quality of content, transition from the real to the virtual world.
Experience	- Experience of VR needs to be of high quality to be able to induce presence, which can lead to better learning. Smooth transitions, quality of the hardware and VE, sound and proper ways of moving around (teleportation) increase the quality of the experience.
Mobile VR	- Low computing power, little degrees of freedom. - Accessible, cheaper.
Desktop VR	- More computing power, more degrees of freedom. - Bound to a powerful computer, more expensive.

4.3 Virtual reality in participatory planning

4.3.1 Bottlenecks and limitations

Using VR for participation purposes still has some limitations and bottlenecks. Firstly, Lugtmeijer and Doornink question if current VR headsets are good enough. Do they have enough pixels, is the panoramic vision wide enough? These limitations of the hardware can induce nausea or dizziness. The limitations of the hardware also have to do with why, for the full experience of VR, you still need to be attached to a powerful computer, which can be limiting, logistically. Another limitation is the compatibility. Different forms of VR require differently built VE's, which makes it harder to use different forms of VR in the same project. Another bottleneck, according to Paquet-Cormier, is that people do not know about the possibilities of 3D and VR. They are not familiar with the techniques and thus lack the interest to use them. People are used to doing their tasks in a certain way and do not feel the need to change this. On the other hand, this sometimes translates into the 'wow-factor'. People are sometimes amazed by the technique which distracts from the initial planning task. Furthermore, current VR systems are still somewhat expensive. Lastly, depending on the way of using VR, being immersed, and thus shut off from the real world, can also be limiting.

4.3.2 Considerations

There are many considerations to keep in mind with both participatory planning as well as VR. Combining the two results in even more considerations to cope with. Starting off with the LoD and its influence on experience as well as expectation. Getting the LoD right (of both the VE, but also the project) is crucial for providing the right experience, but also crucial in telling the correct story to citizens and other stakeholders. Because of the realness of VR, users could think that this will become reality, and details being off in the project can result in stakeholders having different expectations than intended. Therefore, it is also crucial to use VR in the correct phase of the project. Furthermore, what kind of VR is suitable for the goals of the participation process? Is mobile VR suitable, or do you need desktop VR? This is also dependent on resources such as time and money. Mobile VR is generally cheaper and more accessible than desktop VR, but might not get the quality of the experience needed to be useful for the process.

4.3.3 Added value

One of the most important added values for PSS in general is learning about the object, according to Stan Geertman. In this regard, VR can add a lot value. All experts agreed that VR has a great visualising value. Looking at the added value of VR for planning purposes, it is evident that VR gives a better feeling, a better perception of an environment. Therefore, the evaluation of environments that leave more room to subjective feelings such as high-rise buildings of extremely dense areas are particularly suited for VR. Furthermore, the fact that you can explore the (un)built environment, and show different scenarios/designs (if they are modelled beforehand) is an added value of VR, according to Lugtmeijer, Paquet-Cormier and van der Ploeg. Furthermore, creating designs in VR could prevent building errors when used in an earlier stadium and with professionals such as builders and architects, according to Lugtmeijer and Paquet-Cormier. Preventing these failures, could potentially save a lot of resources.

Furthermore, more specialised simulations, with for instance, simulating sunlight and simulating people to gain insights in congestion and crowd control, can help planners to make better informed decisions according to Lugtmeijer. Furthermore, Paquet-Cormier experienced that with using immersive VR for consultation, people were more likely to speak up about things they noticed, instead of just liking or disliking the proposal. Participants were more able to experience the city, which enabled them to think about it. This made VR a good conversation starter. Furthermore, Paquet-Cormier found that if people were also able to relate better to the project, for instance through seeing their own house and standing in front of it. They felt more included in the project, because they had let their guard down. Paquet-Cormier also found that people were more able to share their opinion about the projects because they felt like they had experienced it in a natural way, allow them to also speak about it in a natural way, whereas normal consultations can sometimes be very technical, discouraging people to speak up. VR can open up the minds of people, because it obliges you to think visually, which most people do. It is about your brain working differently. It is about living the environment. In this regard, VR can also add value to current PSS, which are often more analytical systems such as GIS based systems. An overview of the added values of VR can be found in table 4.3.

Table 4.3. Takeaways from the interviews regarding the added value of VR.

Added values of VR	
Learning	- Learning about the object. - Learning in an experiential way, which can increase focus. - More subjective learning: how does it feel? - Easier to estimate distances and heights by experiencing the environment.
Conversation starter	- VR enables people to talk in about the environment in their own language, because they experience it in a natural way.
Enthusiasm	- VR can make people enthusiastic about the project, but also encourage people to participate.
Scenario building	- You can easily switch between different scenarios, if modelled beforehand.
Error preventing	- Architects and other professionals can use VR to review certain areas beforehand, preventing errors.
Simulations	- Simulations such as crowd-control, congestion and sunlight simulations can contribute to better informed decisions.

4.3.4 The future

No one exactly knows what the future holds, but regarding VR, some potentials can be distinguished. One of the most important things about the future of VR is that, in time, more and more people will have used and experienced VR in some way. Familiarising people with VR is important for VR to grow into more than just something cool. Another future potential can be found in a holistic system, integrating more than just the built environment into VR. Planning regulations, air quality, and many other things such as housing prices, or financial implications of certain decisions, can be integrated in a holistic system. Furthermore, with increasing computing power in devices such as smartphones, mobile VR could become a lot better. Also, combining VR with AR, where you can switch between the two could be a future potential, and improved hardware such a VR gloves can add to the experience of VR. Lastly, remotely co-creating with multiple people in VR at the same time, could also be a way in which participation through VR can take place in the future.

4.3.5 Conclusion: tailor-made solutions

VR is about experiencing, feeling the environment that you are in. It is about more than just analytical thinking. This, more subjective way of thinking, can be beneficial to participatory planning. Participants get to experience the environment before it is built, as well as different scenarios/designs: what works in this environment and why?

Beer argued that, sometimes it is important to look at the technological developments and sometimes it is important to look more from a user perspective, in a more psychological way. How can you trigger the user to engage? From the user perspective and psychology, it might be the case that VR is the perfect tool to accomplish the goals. The way of telling the story to the user and using the right tool for this is very important.

Thus, many considerations have to be made when using VR for participatory planning: which kind of VR to use, which phase of the project to use it in, how many resources are available and what kind of participants will be present. In the end, it all comes back to tailor-made solutions, especially regarding VR in participatory planning. An important thing to be aware of is to not lead with the technology, but to look from the perspective of participation and the participants. What is the goal, who is the audience, what kind of information do they want etc. Based on that, different tools can be used for participation and communication. VR can be such a tool and can be especially helpful to start the conversation about how people experience the environment.

5 Results: experiments

In this chapter, the findings of both experiments are discussed. Firstly, experiment I is discussed followed by experiment II. Within each experiment, a distinction is made between the different research methods that were used.

5.1 Results experiment I

The results of experiment I can be divided into two different sections. The results of the participant observation and the results of the questionnaire. The findings from the observation will be elaborated on first.

5.1.1 Participant observation

Participant observations were made during the session and afterwards, conversations were held with some of the residents[6]. The observations indicate that most of the participants were rather positive and enthusiastic about the VR experience. Nevertheless, during the VR tour, it was stated that some details in the VE were off. A tram went the wrong direction, which created some confusion and even irritation among some of the participants. Also, detail in general was missing, which created some confusion about what was shown during the VR tour.

After the session, some of the participants were asked about their opinion about the VR tour. In these conversations, the following things came up. Someone thought that the visualisation might be better looking than the actual situation, making it misleading. This person also mentioned that the paper maps were clear enough. Another participant indicated that the visualisation was nice, but that the person in question had enough information with the letter that was received through the mail. It was also stated that the proportions seemed off and, last but not least, that it did not seem realistic enough.

To conclude, it seems that one of the bottlenecks of the VR in this experiment, was that details of the VE were off and that it did not seem realistic enough. But, it could be used fairly easily with more than 20 people at the same time, which made it easy to manage the process. Furthermore, the overall response was positive and the participants enjoyed the experience. Nevertheless, some of the participants indicated that the paper maps and letter received through the mail were informative enough.

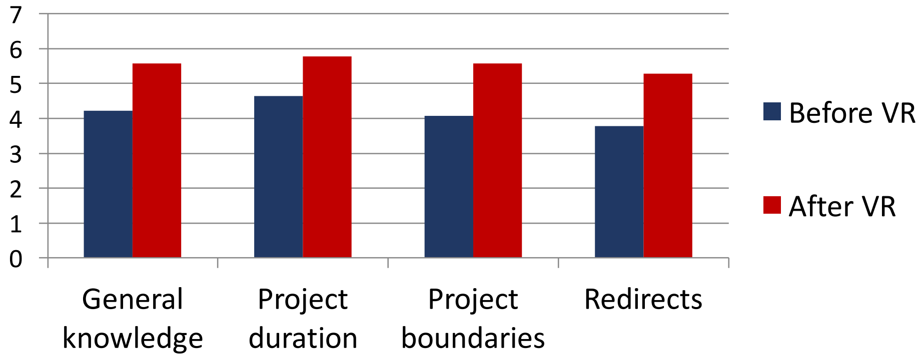
[6] Field notes can be found in the appendix.

5.1.2 Questionnaire

The participants of the first experiment were all older than 41. 50% of the participants were between 61 and 70 years old and it can therefore be argued that the average age of the participant was quite high. Even though the average age was quite high, most of the participants (57%) had at least heard of VR and 14% knew what VR was.

Most of the questions in the questionnaire were about the knowledge of the project, both before the VR tour and after the VR tour. Figure 5.1 shows that, in all areas, people had gained knowledge (Likert-scale from 1-7 with 1 totally unknown and 7 totally known.

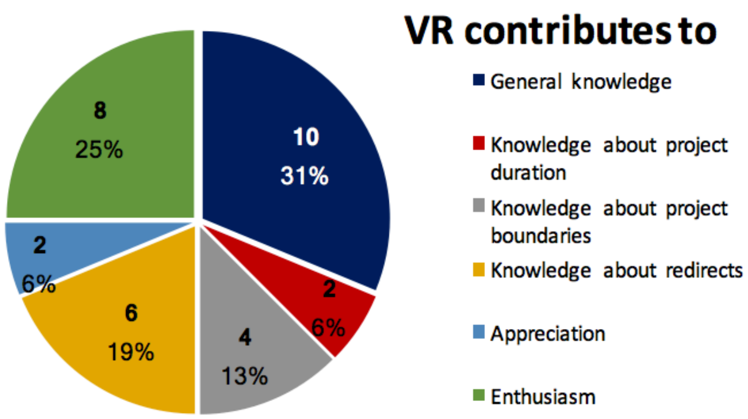
Figure 5.1. Knowledge gained about multiple different project variables.



Based on: Zacheo (2017b).

These results are in line with the findings in the literature and interviews: VR can be beneficial for learning purposes. Nevertheless, the opinions of the participants were divided regarding the added value of VR. Figure 5.2 shows that most of the people thought that the VR tour contributed most to general knowledge. Furthermore, as the figure indicates, eight out of the fourteen people found that the VR tour contributed to enthusiasm. Moreover, eleven out of fourteen participants also indicated that they would like to use VR as tool for the communication of such spatial projects in the future.

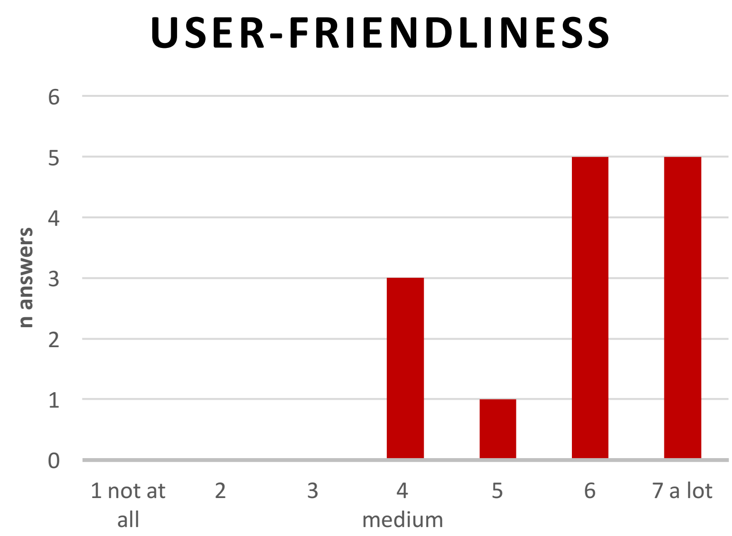
Figure 5.2. Added value of VR.



Based on: Zacheo (2017b).

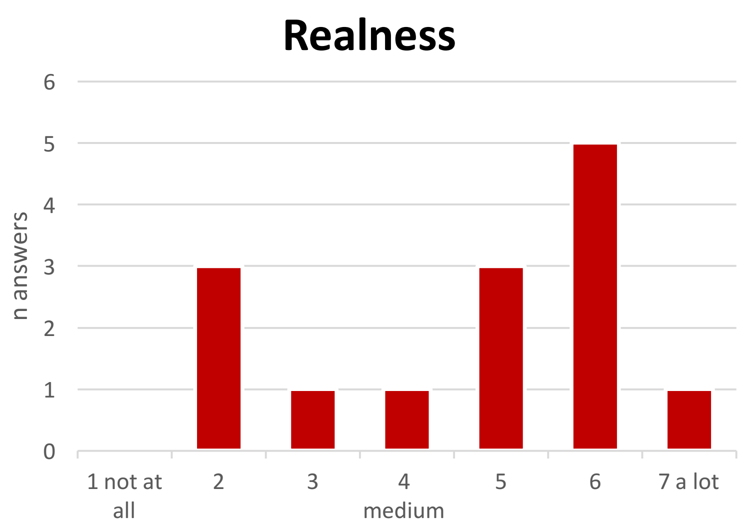
The participants were also asked about the user-friendliness of the system, as well as how they perceived the realness of the VE. Answers were given on a Likert-scale from 1-7 with 1 being not at all and 7 a lot. Figure 5.3 shows the perception of the user friendliness and figure 5.4 shows the perception of the realness of the VE. It can be seen in figure 5.3 that, in case of user-friendliness Likert 1-3 was never chosen, whereas in case of the perception of realness, only 1 was never chosen. In both cases the results are rather positive. Nevertheless, not everyone agreed on the realness of the VE.

Figure 5.3. User-friendliness: how user-friendly was the Virtual Reality tool?



Based on: Zacheo (2017b).

Figure 5.4. Realness of VR: to what extent did you feel you were really in the environment?



Based on: Zacheo (2017b).

5.1.3 Conclusion

Following the data of both the observation as well as the questionnaire, it can be argued that VR seems to contribute the most to learning about the project, during this informative gathering. Furthermore, participants were critical towards a lack of detail and errors in the VE. Moreover, not everyone seemed to see the clear benefit of using VR as a communication tool as it was said that the project maps and letters informed well enough. Nevertheless, the overall attitude towards VR was rather positive and most of the participants indicated that they would like to be able to view plans of future project through VR. Table 5.1 gives an overview of the most important findings from experiment I.

Table 5.1. Overview of important findings from experiment I.

Experiment I	
Pros	**Cons**
Positive, enthusiastic reactions.	Details were off.
Easy to use with a fairly big group.	Errors in the VE.
Contributes to knowledge about the project.	Not everyone seemed to see the benefit of VR.
Contributes to enthusiasm.	Visualisation might be better looking than the real environment.
User-friendly.	

5.2 Results experiment II

In the following paragraphs the general observations made during the second experiment and after analysing the recorded video material, results from the questionnaire and the general findings from the group session are described, starting the with general observations.

5.2.1 General observations

During the workshop, it was noticed that the groups used their resources differently. The group that started off in the conference room used the 3D environment on the computer extensively to look at the designs, whereas the group that started off in VR, almost did not use the 3D environment in the conference room at all, but instead turned towards the paper maps and printed screenshots of the designs.

Furthermore, during the VR session some interesting comments were made (translated from Dutch), such as: *"it feels like you're just standing there", "I'm missing people, or traffic, the environments seems dead, making it harder to feel it", "You can clearly feel the differences in heights of the buildings in the different designs" (someone who was looking at the TV after have been in VR), "It would probably add value to height perception of high buildings."*

It was observed that teleportation was a good way to move around, although it sometimes took some getting used to. It was not clear what the functions were in the plinths of the buildings, making it hard to have a clear opinion about that. Because of a bug, someone got stuck under some stairs. This triggered an interesting comment about the stairs offering a possibility for homeless people to find shelter, which was not desirable. Furthermore, questions about the environment were asked during VR, because an overview was missing. Also, too much contextual information was missing: who is the area for, how many houses per design, what kind of shops are present in the plinth, hospitality industries? This made it harder for the participants to know what kind of perspective they needed to look from.

In the end, a consensus about the preferences was achieved. Everyone preferred design C, but the empty green spots had to be rethought. The participants did not achieve a hundred percent consensus on how to fill in this area. Some preferred a redesigned, more functional green area, others preferred more low buildings, since the ambition of the municipality was to use the land intensively.

5.2.2 Questionnaire[7]

Eight questionnaires were filled out. The results of the questionnaire are described in different hereunder and are split up in two sections: before the workshop and after the workshop.

5.2.2.1 Before the workshop

The participants were asked if they participated in a participation process in the past, and what kind of visualisation methods were used within the process. The answers were quite diverse, indicating that there is not just one currently used visualisation method for participatory planning. Nevertheless, all participants indicated that drawings were used, and that physical models as well as posters are also general used visualisation methods within participation processes.

The participants were asked about their prior knowledge of the area Sloterdijk-I and their prior experience with VR. Most participants were familiar with the area and most of the participants were familiar with VR in general, but less than half of the group was familiar with immersive desktop VR.

5.2.2.2 After the workshop

Most of the usability aspects were evaluated positively. The VR tool was found to have a high communicative value and was found user friendly. The interaction method (Vive controllers and teleportation) was also found well-fitting. Nevertheless, not every participant agreed that the tool could be used interactively and half of the participants found that the hardware of the setup was not of sufficient quality. This was probably due to the VR goggles not being evolved enough (you can still clearly see the pixels and the panoramic vision is less degrees than what would probably feel natural).

Most of the participants felt that the objects were intuitive. Nevertheless, not everyone agreed on the system responding adequately to user input. This could be due to the fact that the teleportation did not always work adequately. Also, not everyone agreed on sufficient feedback from the virtual world. Nevertheless, according to the participants, the observed constraints felt naturally. The opinions varied about if the LoD was

[7] Additional graphs and tables can be found in the appendix.

sufficient, which relates to the quality of the hardware as well as the quality of the VE. Nevertheless, the perception of depth felt natural to most of the participants.

The top three ranking of added value was quite unanimous. The participants seemed to think that using VR contributes to learning about the object, leads to better communication and to a better-informed result. Furthermore, it seems that learning about other stakeholders, more efficiency and more consensus are not core added values of VR. Lastly, it can be questioned if better collaboration is an added value. Table 5.3 shows the results of the ranking of added values of VR for participation processes.

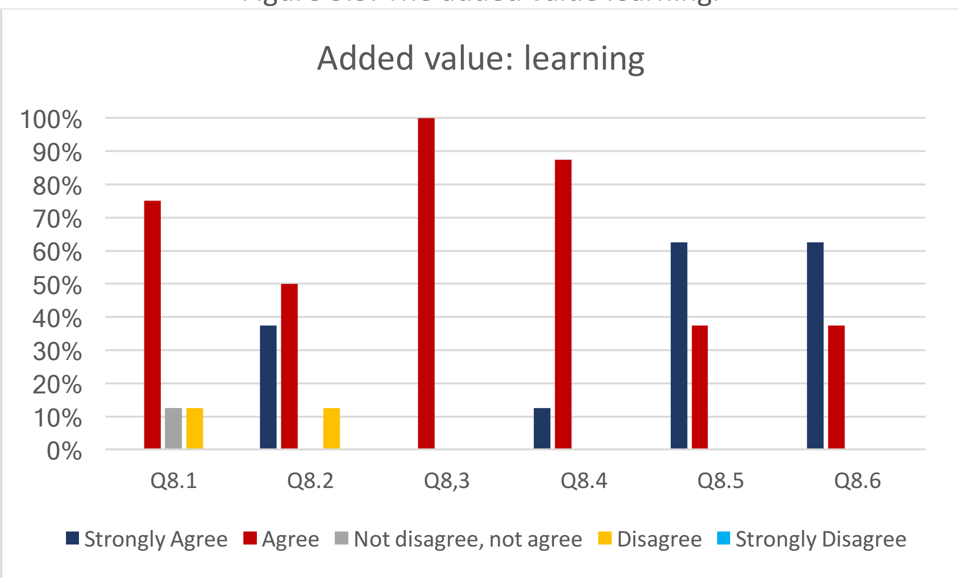
Table 5.3. Ranking of the added values of PSS for immersive VR.

Rank	Added value of VR
1	Learning about the object.
2	Better communication.
3	Better informed result.
4	Better collaboration.
5	More consensus.
6	More efficiency.
7	Learning about other stakeholders.

Regarding the added value *learning*, the participants were asked to what extent they agreed with the following statements:

Q8.1. I have a clear image of the project.
Q8.2. I have an improved image of the project after just seeing the presentation.
Q8.3. The VR environment helped to start the conversation with the others.
Q8.4. I felt motivated to participate actively.
Q8.5. I learn more about the area through VR than through a poster.
Q8.6. I learn more about the area through VR than through a physical model.

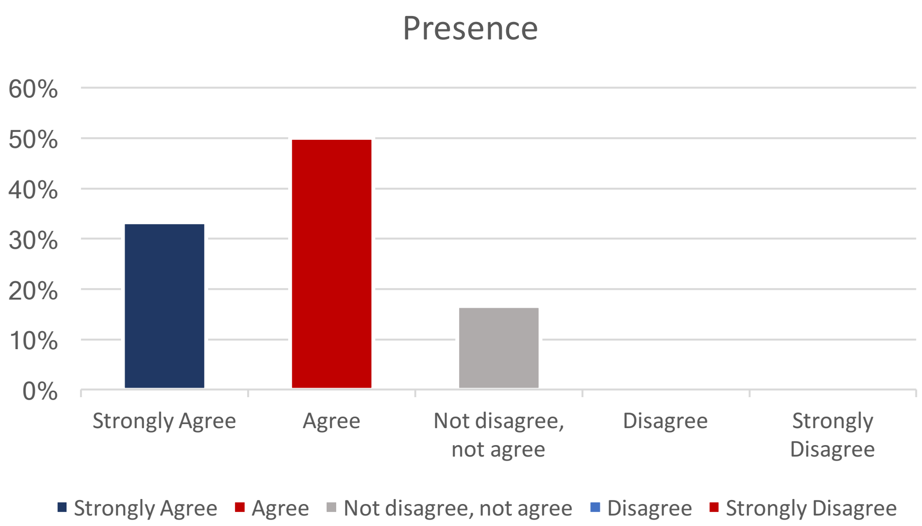
Figure 5.5. The added value learning.



Based on figure 5.5, it can be concluded that this workshop and VR, contributed to learning about the project, that it improved the knowledge about the project over just seeing the presentation and that VR also has more learning value than a poster or physical model. Furthermore, VR helps to start the conversation with others and it motivates people to participate actively.

It was indicated by seven participants that they either agreed or strongly agreed that the VR gave them a sense of presence. This is shown in figure 5.6. The feeling of presence might have contributed to the learning capabilities of VR.

Figure 5.6. Perceived presence.



The participants were asked why they felt a sense of presence. Most participants indicated that the possibility to look and move around, so the degrees of freedom that come with desktop VR, was essential for getting a feeling of presence in the area. Also, VR gave a feeling of proportions, which contributed to the feeling of being there.

It was agreed upon unanimously that VR gave the participants a better feeling with, and idea of the project. Someone indicated that VR enhanced enthusiasm about the project, while another mentioned the benefit of perception of proportions and if it feels right.

Two main points came up, regarding the question if something was missing in the VE. The first point was that it was not clear what was happening in the plinths of the buildings, if it were shops, offices etc. Participants wanted more detail in this regard. The second point was that the participants were missing life, people. This can be related to social presence. Social presence is thus indeed important to make the VE feel real.

Some suggestions were given to improve the workshop. Details about the context of the assignment were missing, which made it harder for the participants to make informed decisions. Furthermore, suggestions about AR, a better reachable location, and walking with multiple people at the same time in the VE were given.

The participants graded both the workshop as well as VR as a tool. The workshop was graded with an average of 7.3 and VR as a tool was graded with an average of 7.7. This indicates that the participants were generally more positive about the tool than about the workshop. What is also interesting is that the two academics, gave the lowest grades (7 & 5; 6 & 6), indicating a more reserved attitude, especially towards VR as a tool (5 & 6).

5.2.3 Conclusion

Overall, the participants were positive about the immersive approach of the workshop and about VR as a tool. The participants indicated that VR is especially beneficial in visualising spatial plans. Nevertheless, the participants were less positive about the quality of the hardware as well as the LoD. The grades given to the workshop were with an average of 7.3 a little lower than the grades given to VR as a tool (7.7) indicating that the workshop could still be improved. Furthermore, the feeling about distances and proportions and the degrees of freedom were mentioned as important features of VR. Moreover, more contextual information could improve the workshop and a clearer image of the functions in the plinths could improve the VE and thus the image of the area.

5.2.4 Group session

The group session was an important method for gaining insights into how an immersive participation workshop as a whole is experienced, as well as to gain more insights about VR as a tool. The results are described hereunder.

5.2.4.1 Immersive approach

The VR tool had an added value compared to the digital 3D model displayed without VR. The experience in VR was more about how the environment felt, which started a different conversation: less analytical. VR also really contributed to estimating heights and distances according to the participants. Furthermore, VR was found particularly useful because it gave a sense of credibility; participants had more faith in the future execution of the design.

The combination of using a 3D model where someone could fly through/over the environment with a more birds-eye perspective, with VR which has a more eye-level perspective, was really appreciated. This could also be implemented within VR; this way, the user could switch between eye-level and birds-eye. Participants indicated that the project looked smaller than expected before immersing in VR. The participants indicated that the degrees of freedom were particularly important for the experience. The fact that they were able to walk around in the environment, gave it a sense of trustworthiness.

Regarding the workshop itself, the participants indicated that they did not really know which role to take on within the workshop. Instructions and guidance should be clearer in this regard. Furthermore, it was mentioned that the location of the workshop was not ideal, and that it was a limitation that not everyone was able to be immersed in VR at the same time. On the other hand, it was mentioned that the way the VR was setup (with one VR headset and a TV where the rest could see what happened) worked well.

It was said that it resulted in a team-feeling, which was appreciated and beneficial to the group dynamics. It was questioned if this sense of team-feeling would not be lost if everyone would be immersed in VR.

5.2.4.2 Virtual environment

Regarding the VE, it was indicated that some details were missing. It was indicated that it was not clear what kind of functions were located in the plinths of the buildings: were they offices, shops or bars? Furthermore, it was mentioned that the VE's felt empty, since there were no people and traffic moving through the VE. It was said that the VE felt dead. This leaves room for improving the VE.

5.2.4.3 How to use?

When using VR as a tool for participation/communication, the 'wow-factor' can still be a potential pitfall. This could falsely increase enthusiasm. Nevertheless, these problems can be minimalised with making the VE as realistic as possible. According to the participants, VR could be a good tool to start an early conversation about an area, in a more interactive way. Designing together with stakeholders and citizens, could be a possibility to show the effect of different choices and thus explaining choices as well. This way, possible tension can be taken away from the beginning. Another suggestion was that it could be used as reviewing tool in a later stadium. This way, designing and active participation could take place before using VR, and VR could be used as a reviewing tool: is this what everyone had in mind? It was also mentioned that the size of the group was important. In this case, there were two groups of four people, which worked well. The participants were not sure if it would also work with bigger groups. Therefore, it was suggested to work with focus groups with different kinds of stakeholders with different interests, or to work with small groups of stakeholders such as developers and the municipality. Lastly, it was questioned if it would be possible for multiple persons to be immersed in VR at the same time and for them to be able to meet and interact in the VE and of this would be an effective way to use VR.

5.2.5 Conclusion

It can be concluded that there are many considerations to keep in mind when organising participation workshops and that VR can be useful as a tool for these workshops. VR was experienced as an added value, especially in combination with other forms of communication, since the conversation became different than with the other forms of communication; the conversation became more about how the built environment was experienced and thus less analytical. Furthermore, the increased perception of distance, height and depth was really valued. This way proportions and size became clearer. This gave more feeling to the design, making it easier to experience the design. Lastly, two suggestions were made in how to use VR during a participation workshop: firstly, it was suggested that VR would work well in a later stadium of the participation process, using it as a tool to review the final design. Secondly, it was suggested to use VR in an earlier stadium, in a more interactive way. This way the design changes could be made in real time, which could really make it a co-creation workshop. An overview of the most important findings of experiment II can be found in table 5.4.

Table.5.4. Overview of important findings from experiment II regarding immersive VR.

Immersive VR	
Pros	**Cons**
High communicative value	Hardware not sufficient
User friendly	Not always responding accordingly
Teleportation is a suitable interaction method	Not enough level of detail
Learning about the object	Not suitable for large groups
Better communication	
Better informed result	
Gained knowledge over just presentation	
Works better than posters and models	
Motivates to participate	
Gave a sense of credibility to the design	
Enthuses	

5.3 Comparison of the experiments

Comparing the first experiment with the second experiment is interesting, since different forms of VR were used and because the setting was different. Within experiment I, citizens were informed about a redevelopment project of the municipality and mobile VR was used, whereas experiment II was with professionals and was more interactive, using desktop VR. The professionals in the second experiment indicated that having the degrees of freedom to move around within the VE was particularly important and an added value, because this contributed to a natural feeling and to the sense of trustworthiness of the design. The trustworthiness was experienced less in the first experiment, due to a lack of detail and some errors such as a tram, which went in the wrong direction. The birds-eye perspective might have contributed to this as well. Nevertheless, in both experiments the outcome was that generally people found VR an added value: in de first experiment mostly for gaining knowledge about the project and for creating enthusiasm, whereas the more interactive immersive approach of the second experiment also functioned as a conversation starter in a more subjective way, it enthused and motivated people to participate actively. Also, the perception of distances and height was an important added value of VR in the second experiment, whereas in experiment I the proportions felt off, probably due to the difference in perspective (bird-eye versus eye-level) and quality of the VE. Nevertheless, using mobile VR was more appropriate for the larger group and thus more appropriate for just communicating the plans to a broad audience, in this case citizens, whereas the immersive approach of the second experiment was more interactive and more suitable for starting an in-depth conversation with a small group.

6 Conclusion

The research question of this thesis was as follows:

<u>How can immersive virtual reality add value to participatory planning?</u>

To answer this research question, it was divided into six sub questions. Before an answer to the main research question can be given, it is necessary to answer the sub questions. All sub questions are answered individually below.

What is participatory planning?

No specific guidelines for participations processes are set within the municipality of Amsterdam, and therefore the processes differ from project to project. The form of participatory planning depends on the context of the project, the project team, the resources. It can range from intensive participation with PSS or through extensive platforms such as 'OpenStadsdeel' and 'TransformCity', to simple informative gatherings. Sometimes participation is not even part of the project.

Bottlenecks exist within participation processes. Participants do not always speak the same language as the professionals, which makes it harder to communicate, but also to be motivated. Also, communication methods such as maps or GIS systems require a level of proficiency, sometimes lacked by participants. This can result in elite-capture. Furthermore, participation processes often take a lot of time (for both the municipality as the participants) and other resources.

What is important within participation processes, is to keep the 'user' in mind. The customer journey stands at the basis of the knowledge about how a certain user wants to be approached and what kind of information he or she needs; it is important to use the right communication method. Expectation management is also very important: participants can get the idea that a design might be final even though it is not, especially if the design looks very real. This can be a bottleneck when using VR for participation.

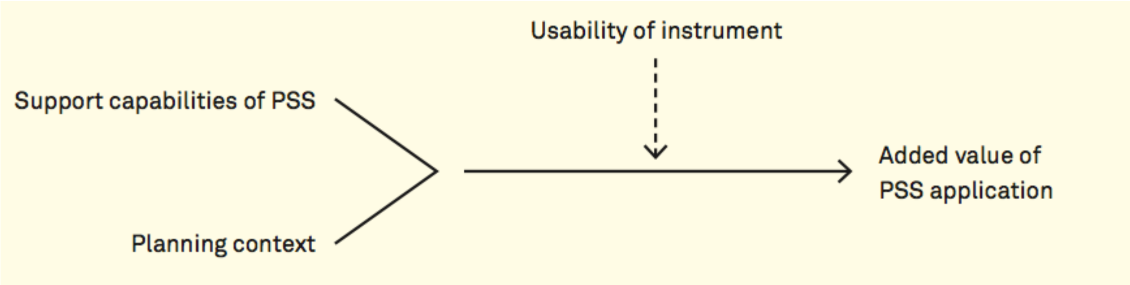
What is immersive virtual reality?

Shortly, immersive VR is a VE that can be experienced in an immersive fashion (generally on eye-level). Different forms of immersive VR exist. In this thesis, the main focus was on immersion induced by HMD (VR goggles). Even within this form of VR, a distinction has to be made between mobile VR and desktop VR. Mobile VR uses hardware with limited capabilities and therefore has limitations in its experience. The degrees of freedom are limited, and the quality of the VE is generally not as high as with desktop VR**.** With desktop VR, the user is bound and attached to a powerful computer. Immersive VR is the only medium that can induce presence, which can benefit learning processes.

How can the added value of immersive virtual reality as a PSS for participatory planning be conceptualised?

It can be concluded that there are many different added values for PSS (Pelzer, 2015), but that not all added values are as relevant, in case of immersive VR. PSS are generally analytic systems, which is not the case for VR. Nevertheless, the conceptualisation of the added value of PSS by Pelzer (2015) shown in figure 6.1, also works for VR as PSS for participatory planning.

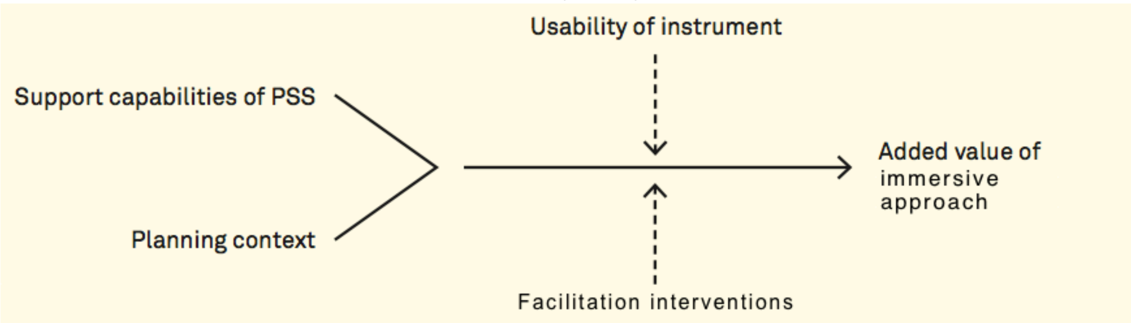
Figure 6.1. Schematic depiction of the main factors related to the added value immersive VR as PSS.



Pelzer (2015).

Nevertheless, regarding participatory workshops, it was argued that usability of the instrument is not the only factor influencing the added value of PSS. As was argued by Pelzer et al. (2015), the interventions done within the workshop also influence the outcome. Therefore, these interventions can be added to the original conceptualisation of the added value of PSS. Figure 6.2 shows the conceptualisation of the added value of an immersive approach.

Figure 6.2. Schematic depiction of the main factors related to the added value of immersive VR as PSS for participation workshops based on Pelzer (2015) and Pelzer et.al. (2015).



The strength of immersive VR as tool for participations processes is the high communicative value. Informing and communication are the main support capabilities of immersive VR as a PSS for participatory planning. This makes learning about the object an important added value of immersive VR. As mentioned, visual information is easier to process than the written word, especially for non-professionals (Al-Kodmany, 2002).

The learning affordances by Dalgarno & Lee (2010) created more depth into the added value *learning about the object*. The learning affordances match the found added values of immersive VR. A renewed framework for added values of VR as a tool that came forth from this research is shown in table 6.1. The same categorisation used by Pelzer (2015) is used: *individual level, group level* and the *outcome level.*

Table 6.1. Renewed framework for the added values of immersive VR based on findings.

Added Value	Description of the added value
Individual level	
Learning about the object	- Enhanced spatial knowledge representation of the explored domain. - Facilitation of experiential learning tasks that would be impractical or impossible to undertake in the real world. - Improved transfer of knowledge and skills to real situations through contextualisation of learning. - Natural perception of the environment, experiencing the environment. - Sense of proportions (height and distance).
Motivation and engagement	Increased intrinsic motivation and engagement.
Enthusiasm	Increased enthusiasm.
Credibility	Increased sense of credibility of a design.
Group Level	
Collaboration	Interaction and cooperation among the stakeholders involved.
Collaborative learning	Richer and/or more effective collaborative learning.
Communication	Sharing information and knowledge among the stakeholders involved.
Outcome	
Better informed plans or decisions	A decision or outcome is based on better information and/or a better consideration of the information. - Scenario building can result in better-informed plans or decisions. - VR can provide spatial insights that can prevent errors.

It has to be noted that an increased sense of credibility of a design was only experienced with desktop VR: the degrees of freedom of desktop VR contributed to a sense of credibility of the design. It can be concluded that the added value of immersive VR can be found its communicative strength. Learning about the object in a natural way is an important added value of immersive VR. It enables the user to experience the environment in a natural way. This contributes to learning about the object, in an experiential way. It can take away language and professionalism barriers which often exist within participation processes. This way, VR can assist planning professionals to gather and process lay-knowledge. This is important since it is up to the planner to engage with the different kinds of knowledge.

What are the benefits and limitations of immersive virtual reality in general?
Different benefits and limitations can be distinguished when using immersive VR as a PSS. This is dependent on which form of immersive VR is used. Mobile VR has limitations in processing power, degrees of freedom and overall quality, but is cheaper and easier accessible. Desktop VR is still somewhat expensive, you are still attached to a computer, but the overall quality and degrees of freedom are better. Nevertheless, both can be

seen as powerful communication methods, and can be used for different purposes. Overall benefits and limitations of immersive VR can be found in table 6.2.

Table 6.2. Overall benefits and limitations of immersive VR.

Immersive VR	
Benefits	**Limitations**
High communicative value.	Takes resources to create VE of high quality.
Eye-level perspective.	Still somewhat expensive.
Natural perception of the environment	Logistic issues (computer and headsets)

How can an immersive approach add value to participatory planning?
Using an immersive approach within participation processes, can add value in multiple ways. Firstly, immersive VR is a good method to visualise spatial plans to stakeholders. When using an eye-level perspective, a more natural way of perceiving the built environment can be experienced. Using an immersive approach in a participation workshop can help to start the conversation about the environment. It facilitates the subjective conversation, it becomes more about the experience, how something feels; VR facilitates the conversation about the (un)built environment and thus enhances the communication between stakeholders. It makes it easier for lay-people to explain and express their opinions in their own language, which makes it easier for the planning professional to translate and asses these knowledge claims. The conversation is less analytical than when using traditional visualisation methods and can help to overcome commonly encountered (professional) language barriers. This makes it particularly powerful to combine traditional tools with immersive VR: combining the analytic with the subjective. The more subjective conversation can, in its turn, also benefit the analytic conversation. The conversation can take away the subjectivity of certain statements, because they can be explained and explored through the objectivity of the VE. Lastly, VR can motivate participants to actively engage in participation and results in a sense of team-feeling. An overview of the specific added values of an immersive approach can be viewed in table 6.3.

Table 6.3. Specific added values of an immersive approach.

Added values of an immersive approach	Description of the added values
Communication	Better communication amongst participants, due to the fact that participants can use their own language.
Conversation starter	An immersive approach can start a conversation about the built environment.
Subjectivity of the conversation	An immersive approach can facilitate a conversation on a subjective level instead of analytical.
Motivation	An immersive approach motivates participants to engage in conversation and participate actively.
Team feeling	An immersive approach contributes to a sense of team-feeling.

What is the potential of immersive technologies within participatory planning?
With technology improving rapidly, more and more possibilities will continue to open up for VR. Mobile VR will most likely become more like current desktop VR and interaction methods will become more accurate and more sophisticated. Furthermore, predictions were made by multiple experts that VR will probably merge in some way with AR, combining the best of both technologies. This would create possibilities to switch between VR and AR, depending on the features needed for a particular task. This way you could interact with the built environment on location using AR, but also shut off from the real world using VR. Furthermore, in time, it could be the case that more and more people have devices suited for VR, which can eliminate distance all together. People could enter a VE from their homes through the internet and participate by exploring and interacting with the VE and with other participants. This way we could come one step further to the long-predicted future of Mee and: *"… distance will lose its enchantment by being abolished altogether."* (Mee, 1898; found in Slater & Wilbur, 1997, p. 11). Furthermore, it was argued in this thesis, that analysing was not a support capability of immersive VR. Nevertheless, it would be a plausible scenario that in the near future, complex analyses about for instance congestion and crowd-control will become more common in VR. VR can, in that case also add extra value, because user can experience the crowdedness of a certain area and express their feelings about it. This way, analysing, could become a support capability of immersive VR, which can lead to better informed outcomes.

Overall, participatory planning is complex. There is no one way in which participation processes are executed. Immersive VR should therefore function as a tool in an extensive toolbox of different PSS and visualisation methods. In the end, it all comes down to tailor-made solutions. Nevertheless, it is important to create a tailor-made solution based on the project and audience, and not based on the technology. Every technology has its own benefits and limitations making it highly important to match the technology to a certain project and not the other way around. To quote Steve Jobs in 1997: *"You've got to start with the customer experience and move backwards to the technology. You can't start with the technology and try to figure out where you're gonna try to sell it."* (YouTube, 2017). This quote perfectly illustrates a commonly made mistake with using exciting new technologies such as VR in professional settings and illustrates how to overcome this mistake. In case of VR, it should not be about using VR because it is an exciting new technology, but about using VR because it adds value to the planning process.

Furthermore, it is a different conversation that is held with VR. The conversation is about how the environment is experienced. Participants can express their opinions in a more natural way, which makes it easier and makes it also less of a barrier to participate actively. VR can function as a translator between professionals and non-professionals and lift language barriers. According to Rydin (2007), it is up to the planner to handle the different forms of knowledge that can be found. Facilitating the conversation between professionals and non-professionals can help the planner to interpret lay-knowledge and can assist non-professionals in explaining their lay-knowledge.

Something that has to be noted regarding VR within participatory planning is that the LoD of the VE is very important. Since VR is about the experience, and the realness of VR is one of its most important attributes, the LoD should be a high a possible. It was found that textures on buildings help to estimate distances and proportions, making BLOM's LoD 4 a minimum. Moreover, it can be argued there is a difference between mobile VR and desktop VR and that mobile VR is only suitable for visualising spatial plans, and thus only for the most basic form of participation, whereas the immersive approach with desktop VR is suitable for more interactive forms of participation such as co-creation, since the participant can walk and really explore the VE. Also, since having a participation workshop with an immersive approach, such as the one that was done for the second experiment is only suitable for small groups, it can be expected that an immersive approach is also suitable for sessions between different kinds of professionals such as planners, architects, developers, politicians and participations experts. This way the group size can be kept to a minimum and problems regarding jargon can be kept to a minimum.

In the end, the power of VR is the natural experience that you can get. The user can view an (un)built environment as if they were there, on site. This closes the gap between the analytical analyses that can be done beforehand, and the more subjective conversation about the environment, hence enriching the overall preparations that can be done beforehand. Looking back at the definition of added value of a PSS: *"a positive improvement of planning practice, in comparison to a situation where this particular tool is not used"*, it can be concluded that immersive VR can, in case of participatory planning, be seen as a positive improvement in comparison to a situation where the tool is not used.

What will the future look like? No one knows exactly. But future innovations within the field of VR, can help VR to become even more suitable for participatory planning.

7 Discussion

This chapter exists of three parts, a methodological reflection, a conceptual reflection and academic recommendations.

7.1 Methodological reflection

Many complications were encountered whilst writing this thesis. It was planned to conduct one experiment with a real-life case with the actual participants of that case. This would have increased the realness of the setting and thus the validity compared to an experiment with professionals. Nevertheless, combining an experiment with informing citizens with an experiment with professionals was a good combination in the end to gather the needed data. Due to the fact that the initial planned experiment could not be realised, the whole planning of the thesis was delayed. This resulted in conducting the second experiment during the summer period which, consequently, resulted in the absence of many potential participants.

Regarding the experiments, since the sample size is very small, generalisations cannot be made. Nevertheless, it can still give an indication about the added value of immersive VR, which can steer future research. It must be emphasised that in case of the first experiment, there was a flaw in the order the experiment was set up; a presentation about the project was given in between harming the validity of these outcomes. Furthermore, the second experiment was quite hard to organise with little resources. Also, it took more time to setup the system than expected, which was not practical. Therefore, in the end, only one VR setup could be used. Additionally, since the author's experience with the VR system was also limited, there was a small problem with the VR which could not be fixed: sometimes the screen was flickering. The lack of experience in organising participation workshops also resulted in basic problems such as not enough guidelines for the project. Furthermore, participant observation in the first experiment turned out to be harder than assumed beforehand. This was because it was not clearly communicated with the rest of the team and, moreover, since photos had to be made to document parts of the process, it was hard to remain unnoticed. Additionally, all the participants were much older than the author which might have given away the authors role.

Furthermore, the group session could have been a little longer, but since we were already ten minutes over time, at that point it had to be cut off. Also, regarding the questionnaire, there was some confusion at some point about how to rank the added values of question 7. Nevertheless, since the confusion arose during the session, the problem could be solved during the workshop. Still, the question was not answered in the correct way in two of the questionnaires, so it was asked to the participants to re-answer this question by e-mail. This resulted in one extra answer bringing the total n of question 7 to seven.

Since the context is always important when analysing PSS workshops, it was a good suggestion by Peter Pelzer to not only look at immersive VR as a tool, but also to the immersive approach of the workshop as a whole. Consequently, added values which were specific to the approach such as: enhanced motivation, subjective conversation and a sense of team-feeling were found, and could be separated from the added values specific to immersive VR as a tool.

7.2 Conceptual reflection

PSS are generally analytic systems. This is not the case for VR. VR speaks a universal language: the language of vision. It does not facilitate the analytic conversation, but the subjective conversation. Nevertheless, the conceptualisation of PSS by Pelzer (2015) worked also for the purpose of this research. Learning about the object was one of the most important added values of immersive VR as tool for participatory planning. The learning affordances by Dalgarno & Lee (2010) matched the added values found in this research and were found useful in the process.

Presence is still a more complex concept when it comes to immersive VR. Presence contributes to the experience and it is expected to contribute to learning processes. Nevertheless, how it contributes and to what extent it contributes to learning, remains unknown. Further research should evaluate presence more closely, maybe even to a more neuro-scientific level.

Furthermore, the immersive approach resulted in a team-feeling. The benefits of a team-feeling within participation processes remains unclear. It also remains unclear if the outcome is enhanced through using VR. It was indicated by the participants of the second experiment that VR contributed to a better-informed result and also consensus was achieved to a certain extent, but the question remains: is the outcome improved by using VR?

7.3 Academic recommendations

Since this research was highly experiential, I would recommend evaluating the outcomes and improve and repeat this research. This research was mostly qualitative and because the n of the questionnaires was low, future research should focus to increase the sample size. This can give more insight into what group sizes are suitable for VR; this research has indicated that desktop VR is not suitable for larger groups, but it remains unknown how large a group has to be before it stops being suitable. Furthermore, regarding small groups, insights in the benefits of a team-feeling amongst participants and its added value is an interesting subject. Furthermore, I would recommend analysing a real participation process, to increase the validity. It would also be interesting to focus on how VR could be used in a remote way. It could be integrated in a platform, for instance, and used for visualising spatial plans to a broader audience. Another interesting research would be to examine how VR could be used with collaborative design. It can be researched if VR is useful for a broad spectrum of different professionals such as planners, politicians and architects. As mentioned, a recommendation is to gain more insights in the actual added value it brings regarding the outcomes of processes: does the outcome improve when you use VR? Furthermore, it still remains unclear what the added value of presence exactly is, how and how much it contributes to learning. This can be an interesting and interdisciplinary research topic. Lastly, developments in the field of VR should be closely examined, since it was indicated that the quality of the hardware was not good enough.

8 Recommendations for participatory planning[8]

As already mentioned in the conclusion of this thesis, there is not one size that fits all. Participation is too complex and differs too much from project to project to be able to give some kind of one size fits all solution. Nevertheless, some important recommendations can be made on how, when and what kind of VR to use for participation purposes. Regarding the communication of plans to a broad audience, mobile VR has logistic advantages over desktop VR. Nevertheless, it lacks the interactivity that you would get with an immersive approach with desktop VR. An immersive approach in a participation workshop is suitable as a conversation starter and desktop VR is particularly suited to facilitate a conversation on a more subjective level: how does it feel?

Getting back to the tailor-made solutions, it is important to think of VR as a tool in your toolbox. If you need a powerful visualisation method where it is important to not only think on an analytical level, but also on a more subjective level (e.g. how does the environment feel) and where the perception of height and distance are important, VR can be very suitable to use. Nevertheless, to think back to the quote of Steve Jobs, it is more important to use the tool that fits the audience, than to just use the tool because it is cool. For example, younger people will most likely be more used to and interested in using all different kinds of technology, which make it easier for them to understand everything quickly, and make them enthusiastic about participating. I reckon that, if properly used, immersive VR can be both cool as well as a tool!

[8] Beslisboom VR in participatie na de Nederlandse samenvatting, aan het eind van deze thesis.

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Samenvatting

Deze thesis beoogt een beter inzicht te geven in immersive virtual reality (VR) in participatieve planningsprocessen. VR heeft de afgelopen jaren grote ontwikkelingen doorgemaakt. Nieuwe VR-headsets zoals de HTC Vive en Oculus Rift zijn beschikbaar voor consumenten en bieden nieuwe mogelijkheden voor het visualiseren van ruimtelijke ontwikkelingen. In het verleden is er al onderzoek gedaan naar immersive VR, maar sinds de kwaliteit van VR in de afgelopen jaren aanzienlijk is verbeterd, is de meeste literatuur verouderd. Bovendien is de toegevoegde waarde van immersive VR binnen participatieve planning in de literatuur nog niet goed in kaart gebracht. Daarom is onderzoek nodig om de mogelijkheden van immersive VR in de hedendaagse participatieve planning te onderzoeken.

Een belangrijk kenmerk van immersive VR is de immersie. Immersie betekent dat de gebruiker wordt afgesloten van de echte wereld. Een meeslepende ervaring van hoge kwaliteit moet resulteren in een gevoel van aanwezigheid, een gevoel van plaats, die de leermogelijkheden van de gebruiker in VR moet vergroten: de gebruiker kan de omgeving ervaren.

Participatieve planning is sinds de jaren zestig in de belangstelling komen te staan en wordt gezien als een positief middel voor ruimtelijke planning. Desalniettemin zijn er diverse knelpunten bij participatie. Een manier om een aantal knelpunten in de participatieve planning te overkomen is door middel van planningsinstrumenten. Geografische informatiesystemen (GIS) zijn bijvoorbeeld bekende instrumenten voor planners om plannen te communiceren. Ook Planning Support Systems (PSS) zijn hulpmiddelen die kunnen worden gebruikt om te helpen bij planningsvraagstukken, vaak door middel van analytische analyses. Over het algemeen vereisen PSS en GIS echter een hoog niveau van bekwaamheid, wat niet altijd door alle participanten wordt beheerst.

Op het gebied van PSS kunnen zeven verschillende toegevoegde waarden worden onderscheiden: *leren over het object*, *leren over andere stakeholders*, *samenwerking*, *communicatie*, *consensus*, *efficiëntie* en *beter geïnformeerde plannen of beslissingen*. Wat betreft 3D virtuele omgevingen, kunnen vijf verschillende leermogelijkheden worden genoemd: *ruimtelijke kennisrepresentatie*, *ervaringsleren*, *engagement*, *contextueel leren* en *samenwerkend leren*. Deze toegevoegde waarden zijn gebruikt als kader voor dit onderzoek naar de toegevoegde waarde van VR.

Voor dit onderzoek zijn gemengde onderzoeksmethoden gebruikt. Ten eerste zijn interviews afgenomen met deskundigen. Ten tweede is een experiment met mobiele VR uitgevoerd. Dit experiment omvatte een informatieve bijeenkomst met een VR-tour over de herontwikkeling van' Weteringcircuit'. Ten derde werd er nog een experiment uitgevoerd met desktop VR. In dit experiment werden experts gevraagd hun mening te geven over drie verschillende ontwerpen van het ontwikkelingsgebied' Sloterdijk I-zuid', in het westen van Amsterdam, om deze te bespreken en consensus te bereiken over het beste ontwerp. De deskundigen werden gevraagd naar hun mening over het VR als instrument voor participatieprocessen en over de workshop in het algemeen.

Uit de interviews is gebleken dat de participatieprocessen van project tot project verschillen en sterk afhankelijk zijn van het projectteam en de beschikbare middelen. Verder is ontdekt dat verwachtingsmanagement, de customer-journey en een passende vorm van communicatie belangrijk zijn binnen de participatieprocessen. Daarnaast moet binnen VR een onderscheid gemaakt worden tussen mobiele VR en desktop VR. Mobiele VR heeft een lagere rekenkracht, minder vrijheidsgraden, maar is toegankelijker en goedkoper dan desktop VR. Met desktop VR is de kwaliteit van de hardware beter, maar je bent daardoor gebonden aan een krachtige computer.

De resultaten van dit onderzoek wijzen uit dat VR binnen participatieve planning meerdere toegevoegde waarden kan hebben. Het helpt om kennis over het object op te doen en laat de gebruiker op een ervaringsgerichte manier leren. Hierdoor is het gemakkelijker om hoogtes en afstanden in te schatten en doordat de gebruikers van VR de omgeving kunnen ervaren, is het voor hen gemakkelijker om zich op een natuurlijke manier te uiten. Dit motiveert hen ook om actief deel te nemen en het VR verhoogt het enthousiasme. Bovendien zijn scenario-building, foutpreventie en simulaties toegevoegde waarden van VR.

In het algemeen is VR een krachtig instrument om ruimtelijke plannen te visualiseren. Het laat de gebruiker de omgeving op een natuurlijke manier ervaren. Binnen participatieprocessen kan hierdoor het gesprek over de omgeving op een subjectief niveau gehouden worden en dit versterken. Dit biedt mogelijkheden om taal- en professionalismebarrières weg te nemen en leken- en ervaringskennis te ontdekken. VR moet daarom worden gezien als een serieuze kandidaat voor het visualiseren van complexere ruimtelijke plannen. Het is echter nog onzeker wat VR kan bijdragen aan de uitkomst van dergelijke processen en het blijft onduidelijk hoe presence het proces ten goede komt. Dit moet verder onderzoek in de toekomst uitwijzen.

Beslisboom

Deze beslisboom, gemaakt voor de gemeente Amsterdam, kan helpen bij de afweging of VR moet gebruikt worden voor een participatieproces en of hiervoor mobile of desktop VR gebruikt kan worden.