Immersive Virtual Reality, a participatory-enhancing tool for collaborative spatial planning and design?

Roy Boertien

S3217531

Master Thesis

Msc Society, Sustainability and Planning

Faculty of Spatial Sciences

University of Groningen

9th of July 2021

Supervisor: Gerd Weitkamp

Colophon

Name:	Roy Boertien
Student number:	S3217531
Document:	Master Thesis
Programme:	Msc Society, Sustainability and Planning
Faculty:	Faculty of Spatial Sciences
University:	University of Groningen
Email:	r.e.boertien@student.rug.nl
Supervisor:	Gerd Weitkamp
Email:	s.g.weitkamp@rug.nl
2nd assessor:	Farzaneh Bahrami
Email:	f.bahrami@rug.nl

Title:	Immersive Virtual Reality, a tool for collaborative spatial planning and design?
Word count:	22.450 (including tables and figures)
Date:	9th of July
Place:	Groningen
Version:	Final

Abstract

The emergence of collaborative spatial planning and design initiated a shift in spatial planning and design theory and practice which focussed on the inclusion of stakeholders. Within this context, a new array of tools and practical implementation of tools has evolved. Participants are invited to not only be informed about spatial plans and designs, but they have the ability and craftsmanship to express their thoughts and ideas with the help of so-called participatory-enhancing tools. Through a conceptual lens of design, this research examined the effects of Immersive Virtual Reality on the collaborative spatial planning and design process analysing stakeholder engagement, spatial planning and designing and the process of co-creation. One group of designers and one group of non-designers have been observed while using IVR for the design task of making the Zernike Campus, the Netherlands more vibrant. The results of stakeholder engagement show that tool instructions on paper are ignored, communicative and designer roles are prominently present, inclusive and exclusive participatory moments shift during the design session, communication can hamper and decrease after time and elements of hardware, software and data have encouraged and constrained the design process. The results of spatial planning and design illustrate that IVR assisted in the creation of generative design visions but faced pre-programmed difficulties during the moments of refinement and creative moments. In the case of the process of co-creation, results indicate that IVR encouraged an individual design process with collective-induced moments of discussion. The main conclusion is that Immersive Virtual Reality has the potential to be a participatory-enhancing tool, but spatial planners and designers need to be aware of self-initiated consequences during implementation which may prevent this from happening.

Preface

Innovation is a movement which has triggered my attention for the past years due to its unpredictable nature and challenges that lie ahead. In this context, Immersive Virtual Reality captured my interest in defining how stakeholders can become better involved in collaborative spatial planning and design with the help of this tool. As with many innovative technologies, I think that such tools face the challenge to move from technocratic use towards collective use. During my early working career at Student-Labs I experienced this already and posed myself often the question how to simplify the use (Immersive) Virtual Reality. With this research I hoped to gain more in-depth insights into what the opportunities and limitations of this tool are in order to assess whether Immersive Virtual Reality is a participatory-enhancing tool. In advance, I would like to thank my supervisor Gerd Weitkamp for the useful and enriching meetings we had and the privilege I had to use the VR-lab of the Centre of Advanced Studies in Urban Science and Design (CASUS).

Table of content

List of figures

List of tables

List of abbreviations

IVE	Immersive Virtual Environment
IVR	Immersive Virtual Reality
VR	Virtual Reality

1. Introduction

1.1 Spatial planning and spatial design

In the past decades, much attention in spatial planning[1] theory and practice has been given to the concept of collaborative planning which can be defined as: *''an interactive process of consensus building and implementation using stakeholder and public involvement.''* (Margarum, 2002, p237). Harris (2002) defines collaborative planning as: *''An element in a longer-term programme of research and theoretical development focused upon a concern with the democratic management and control of urban and regional environments and the design of less oppressive planning mechanisms.''* (p22). Collaborative planning is seen as one of the strategic instruments to capture the renewed thinking in planning theory and practice that emerged during the first five years of the 1990s (Goodspeed, 2016). This renewed thinking is conceptualised as the communicative turn.

The core foundation of the communicative turn is that former political systems and its mechanisms failed to incorporate the contemporary interests that people and places have (Healey, 1996). The historical roots for this development lay in the work of Habermas and Giddens (Healey, 2003). Both Habermas and Giddens rejected the belief that quantitative-driven economic and technological conceptualizations of reality are able to completely grasp reality. The strive of communicative planning was to move beyond this technical-oriented line of thinking and shift towards the inclusion and understanding of social relationships that shape our reality simultaneously, in order to make better and well-informed decisions (Innes, 1998). This changed the role of spatial planners as well. Instead of drafting plans based on top-down and seemingly expert judgement, communicative approaches prescribed that planners should create plans from a bottom-up perspective (Healey, 1996; Innes, 1998). The bottom-up perspective includes that the planner should become fully aware of the environmental consequences of a planning intervention by asking for what and whom one is planning (Sandercock, 2004). Moreover, this involves the necessary participation of planners in an inclusive and open planning process with all the stakeholders. The term stakeholder is referring to any individual or group that affects or is affected by the outcomes of the process (Freeman, 1984). According to Thorpe (2017), such situated participatory roles are not new and have already a long history in planning. However, these roles have remained rather communicative than truly participatory. Planners have presented their ideas and used the input of the stakeholders to modify their plans without actually involving the stakeholders in the production process (Forester, 1989; Watson, 2014; Thorpe, 2017). The pitfalls of such a communicative approach have been alienation of stakeholders before, during and after the planning process, hampering collective support for a plan, power imbalanced moments of discussion and restrictive opportunities for creativity and communal interference during the planning process (Tewdwr-Jones & Allmendinger, 1998; Brand & Graffikin, 2007). The positive outcome is that people are at least in the position to become involved in the planning process and therefore can have a say in the planning discussions.

[1] Hereafter referred to as solely planning instead of spatial planning. In some cases the word spatial planning is still used for emphasis.

On the contrary of the communicative approach, the aforementioned and more delineated collaborative planning approach strives for true participation of stakeholders. The planner is a facilitator who does not dominate the planning process, is receptive to the ideas of all stakeholders and allocates purposefully instruments that allow stakeholders to engage (Booher & Innes, 2002). The narrowed governance structure of collaborative planning looks then as follows:

> *Formal institutions of government have a role in providing a hard infrastructure of a structure of challenges, to constrain and modify dominant centres of power, and a soft infrastructure of relation-building through which sufficient consensus building and mutual learning can occur to develop social, intellectual and political capital to promote coordination and the flow of knowledge and competence among the various social relations co-existing within places. (Healey, 1997, p200).*

Similar to planning theory in the past decades, the communicative turn has impacted spatial design[2] theory as well. The ideas of segregation of functions, people and places transformed to ideas where designs are negotiated and integrated in the build environment with the goal to include differing relationships instead of separating them (Dobbins, 2009). In order to understand what relationships exist and how to bond relationships, it is essential for designers to speak with people. Hence, the claim of Forester (1989, p119) that *''designing is a deeply social process of making sense together.''*. The term coined to describe this particular design process is co-design and refers to *''an integrative perspective in which the principles of individual intellectual design activities are translated into principles for collaborative learning and decision-making [..] and combines the design skills or creative imagination and reflective judgement with communicative skills.''* (De Jonge, 2009, p199+200). Accordingly, this perspective changes the role of the spatial designer to one that needs to include all relevant societal actors because an expert-based design is likely not able to meet the normative requirements of the stakeholders when no participation has taken place (Lawson, 2005). Also for design, it is thus important to facilitate a design process instead of making constraining decisions upfront.

1.2 Participatory-enhancing tools

The brief reflection on academic thinking about planning and design shows some kind of shift in empowerment of stakeholders in planning and design processes who have not been eligible to fully express their thoughts and ideas in the past. This leads also to a change in ownership of the planning and design process from the planner to the stakeholders to the extent that participants are the sculptures of plans and designs while this previously has been the domain of the expert. A governance structure, such as the cited collaborative governance structure (see citation of Healey, 1997), allows stakeholders then to avoid conflicts and translate their interests in one shared plan also known as co-production (Ostrom, 1996). Naturally, planners and designers are still the knowledgeable persons who can say what can be realized within judicial and financial boundaries for example. Co-production processes can become quite time-consuming and extensive when data needs to be collected of large groups of people. Moreover, planners can be restricted to financial resources which can triple down to establishing planning and design processes which do not serve the needs of all stakeholders because simply the financial resources are not available. Not surprisingly, this all is contradictory to the fundamental collaborative line of thought. A focus on participatory tools could help to determine how planning and design tasks should be approached (Baker et al., 2007).

As mentioned before, the planning and design process should be constructed on the basis of stakeholders' needs. Instead of supplying participatory tools which invite stakeholders to participate

[2] Hereafter referred to as solely design instead of spatial design. In some cases the word spatial design is still used for emphasis.

in planning and design processes that enrich or justify the drafts of the experts, Bjögvinsson et al. (2012) argue for deliberately chosen participatory-enhancing tools. This refers to the practical means that help to increase craftsmanship of individuals and allow craftsmanship to occur in planning and design processes (Ehn, 1988; Stelzle et al., 2017). Therefore, participatory-enhancing tools encourage stakeholders to be creative because they have the skills to work with the tools and allow people to shape plans and designs from their individual perspective. Of course, the platform where the ideas of individuals are gathered and discussed is important and planners and designers should be aware of the occurrence of meaningless surface agreements between individuals (Brand & Graffikin, 2007). Besides, it is optimistic to think that the information of all individuals will be embedded in the final plan and design (Booher & Innes, 2002). And, as the case-study of Nienhuis et al. (2011) in Arnhem, the Netherlands revealed, 'usual suspects' in community affairs can dominate planning and design processes. However, providing the opportunity with tailored user-based tools for participation in planning and design processes may result in creative insights and innovative solutions that move beyond the initial spectrums of planners and designers (Watson, 2014; Albrechts et al., 2019). Furthermore, the ability to have a direct say in the decision-making process may enforce curiosity to become actively involved (Van der Vaart et al., 2018) and constitutes the right to determine what will happen with your build environment (Bjögvinsson et al., 2012). The creation and transformation of planning and design processes on the basis of participatory-enhancing tools is therefore relevant as it is valuable to better planning and design from a truly collaborative point of view.

1.3 The potential of Immersive Virtual Reality

A rather unexplored and potential participatory-enhancing tool which has gained attention in the practical field and academic world during the last decade is Immersive Virtual Reality (IVR). IVR is a combination of both immersive systems and Virtual Reality (figure 1). *''Immersive systems let the user totally immerse in a computer generated world with the help of a head-mounted display that supports a stereoscopic view of the scene according to the user's position and orientation. These systems may be enhanced by audio, haptic and sensory interfaces.''* (Mazuryk & Gervautz, 1999, p5) and *''VR is a computer technology that replicates an environment, whether real or imagined, and simulates the physical presence and environment of a user to allow for user interaction.''* (Jamei et al., 2017, p1). IVR is an answer to the earlier call of Sutherland (1965) and originates from an alternative way of thinking about how computers can be used to increase personal experience (Mazuryk & Gervautz, 1999).

> *''If the task of the display is to serve as a looking-glass into the mathematical wonderland constructed in computer memory, it should serve as many senses as possible. [..] The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked.'' (Sutherland, 1965, p2)*

Figure 1. Immersive Virtual Reality in action. Source: CASUS-Lab Groningen (n.d.).

Within the domain of planning and design, IVR is an interesting participatory-enhancing tool because it can enable participants to understand, modify and improve the build environment based on a personal experience (Blascovisch et al., 2002). Salter et al. (2009) researched the use of an immersive system for landscape visualisation and planning and found that participants appreciated the use of IVR for understanding the landscape, but the three hour workshops were insufficient to engage in a planning and design process. Two of the results of van Leeuwen et al. (2018) are that participants have become more actively involved in the planning and design process of a park, because distractive factors are reduced in IVR compared to high-detailed paper maps, and participants could remember more objects in IVR after the design session had taken place. According to the study of Paes et al. (2017), the implementation of IVR increases the comprehensiveness of spatial arrangements compared to desktop VR[3]. They experimented with an entrance hall of a school of architecture and design. The conclusion of the study of Pamungkas et al. (2018), wherein students had to design a room, was that IVR enforced the spatial experience in comparison with the VR-app Kubity. Zhu et al. (2020) come to the same conclusion in their comparative study (IVR and conventional graphics) on street renewal (180) based on students behaviour, but emphasise that a lack of detail of the build environment in IVR alienates participants' affiliation with the virtual environment.

These example studies show the relevance of examining IVR for spatial planning and design purposes. However, planners and designers need to be wary. Zhao et al. (2020) conclude that a desktop environment enables more spatial learning by students than an IVR based on teleportation modes. Also, designing in IVR can lead to cybersickness and nausea, because an individual's mind thinks the body is moving while a person is only moving in the IVE (Jensen & Konradsen, 2018;

[3] This is the simplest type of virtual reality application. It uses a conventional monitor to display the image (generally monoscopic) of the world. No other sensory output is supported. (Mazuryk & Gervautz, 1999, p5).

Yaremych & Persky, 2019; Zhu et al., 2020). These remarks point out that IVR, as a participatory-enhancing tool, is probably not the holy grail for everyone in every occasion. But, it may be the case that IVR can be of value to the majority of participants in a planning and design process to express themselves. Furthermore, as Wilson & Tewdwr-Jones (2019) describe, IVR can also become a subset within a set of participatory-enhanced tools that is presented for use to participants. Then, people can test IVR and choose whether to use the tool or not. In both situations, a more thorough than presented understanding of the potential effects of IVR is desired. More evidence on the implications of using IVR in planning and design can lead to more sophisticated and deliberative decision-making about where and how to implement IVR. Currently, this evidence is limited and therefore the potential of IVR underexplored (Wilson & Tewdwr-Jones, 2019; Zhu et al., 2020.

1.4 Research aim

The main aim of this research is to explore how immersive virtual reality, as a participatory-enhancing tool, can contribute to collaborative spatial planning and design processes. The practical relevance of this study is the increasing attention of planners and designers towards participatory-enhancing tools which could help them to make more informed decisions with regards to the build environment (Salter et al., 2009; Paes et al., 2017). IVR can encourage and help decision-making in spatial matters and become one of the tools in the toolbox of spatial planners and designers. The theoretical relevance of this study is that it can add to the limited (comparative) theoretical evidence on the implications of IVR as a participatory-enhancing tool (Wilson & Tewdwr-Jones, 2019; Zhu et al., 2020). Tool-based research, as this research proposes, can enrich the academic debate on participatory-enhancing tools and stimulate further discussion on the construction of collaborative spatial planning and design process from a tool perspective (Ehn, 1988).

1.5 Research questions

In line with the main research aim, the main research question and four sub-research questions of this research are formulated below.

- *What are the effects of Immersive Virtual Reality on the collaborative spatial planning and design process?*

Sub-research questions

1. How is immersive virtual reality influencing stakeholder engagement in the collaborative spatial planning and design process?
2. How are spatial outcomes developing during the collaborative spatial planning and design process while using immersive virtual reality?
3. At what stages of the collaborative spatial planning and design process can the implementation of immersive virtual reality be seen as effective?
4. What are stakeholders perceptions with regards to the use of immersive virtual reality in the collaborative spatial planning and design process?

Based on the information in this chapter, the four sub-questions above have been defined in order to provide an answer to the main research question. These sub-questions are considered to be relevant for identifying the effects of IVR on collaborative spatial planning although they are not able to uncover all the possible effects that IVR may trigger. The first question is helpful for understanding and analysing the dynamics between stakeholders' participation in the collaborative spatial planning and design process. The goal is to review the behaviour of participants and reflect on IVR as the driver of specific behaviour. The second question is purely spatial of nature and assists in objective assessment of what is actually planned and designed throughout the process. The third question is of practical and academic nature. This question is proposed in order to reflect on the collaborative spatial planning process and the potential role of IVR in this particular process.. The fourth question

dives deeper into the opinions of people and reflects upon IVR from a personal point of view. Together, these four sub questions are interesting for demystifying the effects of the participatory-enhancing tools of IVR.

1.7 Reading guide

The first chapter has introduced this research and the potential of IVR for collaborative spatial planning and design. The second chapter, the theoretical framework, elaborates on this through a conceptual lens of design and outlines other aspects related to tools for design and design in general. The third chapter explains the used exploratory methodology of this research. The fourth chapter presents the results of this research based on the criteria of stakeholder engagement, spatial planning and design and the process of co-creation. The fifth chapter continues with these results while (theoretically) reflecting on them including the perceptions of participants. The sixth chapter outlines concluding thoughts and the seventh chapter contains a reflection on the research as a whole.

2. Theoretical framework

2.1 Design as theory of concept

This study should be seen through the lens of design. The processes of spatial planning and spatial design have been fundamentally intertwined since the beginning of ancient civilisations such as the Roman empire (Forester, 1989; Thorpe, 2017). While planning tends to be a more fixed process, design is more flexible in nature. A plan can involve consensus-building for example, but the approach towards consensus-building needs to be designed. After the design process, there is then a new plan(ning). An alternative idea is to have no initial plans so the design process is more open to creative impulses that can result in a plan(ning). These examples illustrate that planning and design are mutually dependent and planners and designers can take multiple planning and design approaches depending on what is (not yet) planned and what needs to be designed. Deliberative choices on the governance structure of planning and design processes remain therefore of critical importance and should ultimately be based on the needs of its users; the stakeholders (Healey, 1997; Watson, 2014). This research attempts to unravel the process of how plans are formed during the process and what are key considerations with regards to the influence of IVR on this designing process. Hence, design theory is useful for analysing the process and understanding stakeholder engagement, spatial outcomes, stage-based effectiveness and perceptions (Björgvinsson et al., 2012). The written narrative moves from a general design perspective towards a tool perspective including a specific section about IVR.

2.2 Holistic design principles

The aforementioned interaction between planning and design underlines people's recognition to be aware of what is decided and what is open for debate. The framing of planning and design processes can therefore be challenging when the institutional framework is not clear for everyone (Lawson, 2005). Design principles offer a general guidance for that problem (Dobbins, 2009). Table 1 illustrates the design principles formulated by Forester (1989), Lawson (2005) and Dobbins (2009). The coinciding critiques with these holistic principles is that some may become purposefully endorsed and that they are too general. For instance, the principle 'reproducing identity and social relations' of Forester (1989) explicitly refers to the generation of collective information during the design process. The question is whose identity and what social relations will be reproduced. As all three authors state, it is the necessary task of the designer/expert to tailor design principles and create awareness of potential imbalances or structural inequalities that arise from the presented aspects.

The arena or location where designing takes place is herein important. This design arena should give the opportunity to start dialogues about design and allow people to explore solutions to known or unknown problems (Van Dijk & Cook, 2019). It provides the operational platform and means where people can come together, interact, design, discuss and, of course, plan. Consequently, this puts the design arena at the heart of every design process and demands deliberative thought on the framing of the design arena (Wilson & Tewdwr-Jones, 2019). Naturally, the holistic design principles can be useful for this framing.

Table 1. Design principles.

Design principles	
Principle	*Description*
Forester (1989)	
Facing ambiguity: reading context and desire	The search for a design may trigger personal feelings such as uncertainty about what is good or desired. This has to be taken into account when starting the design process
World-shaping	The recognition of how stakeholders perceive and experience the world they live in
Practical conversation and communicative action	While aiming to include stakeholders, a practical conversation allows people to understand and communicate about a design. A complex and predefined design is for instance circumstantial as it merely facilitates communication into one direction instead of a dialogue
Conversation and learning	A design process should enable conversation and mutual learning
Reproducing identity and social relations	Information derived from others is essential for the development of the design process as it is for the evolution in awareness among people
Political rationality	The persons involved in the design process are bound to the stake they have. It is important to be aware of this and perhaps elicit power relation issues for that matter
Lawson (2005)	
Morality and design	A planner operates from a certain moral or view about how the design process should be structured based on personal preference, personal experience or common practice
Decomposition versus integration	The planner should be aware of the embeddedness and consequence of the design
The future	The future is mostly considered to be uncertain, but future planning is based on prescriptive thinking
Content	Even design principles are not a blueprint for how these should be adapted. The content may vary
Client	Design tasks originate from the people who give them. Distortion of the normative end-design can therefore develop
Users	Insights into the people who are going to make use of the design is quintessential for the design to be practically used
Practical	Design thinking can stimulate out-of-the-box thinking, but planners should be aware of the materialistic constraints of their designs
Radical	Passionate planners share their sets of radical principles which make them specialists as well as constrained
Formal	The visual embodiments of designs have differed over time and concisely concentrated different kind of interactions that go beyond the formal architecture
Symbol	The personal, symbolic meaning that people have with places is important to enhance sentimental value to design

Dobbins (2009)	
Good design makes places better	Dependent on the aimed indicators, a good design achieves improvement
Design places to reflect the people who are or will be there	Design can focus on expressive design which aims at expressing values or reflective design which aims at representing existing values
Design places consciously and holistically: the whole and the parts, in constant interaction	Design often evolves by means of organic development, this includes that a design can have different effects and meanings for different purposes
Design is an essential skill	Applying the design principles in a responsible way demands that design has to be skilled in order to perform design practices
Be aware of solutionism	Design can be problem-driven or solution-driven. The danger with solution-drive design is that the solution may not be the appropriate solution for the actual problem
Design in the context of time (and motion)	Design has to be put in the context of time and motion, since a design can be viewed well at the moment it is designed while this may not be the case in twenty years from then. Therefore, other interactions may be stimulated

2.3 Co-design

The descriptions of the design principles of table 1 illustrate potential challenges for designers and stakeholders. The aforementioned perspective of co-design (see section 1.1) offers theoretical guidance on how to approach this. In co-design practices, the thinking of individual mindsets becomes leading in defining collective principles for learning and decision-making. Co-design builds on the three philosophical stands of thinking, making and acting (table 2). According to de Jonge (2009), design happens when these three are met (figure 2). Again, this stresses the relevance for collective sense-making and also highlights the task for planners and designers to find and gather different sorts of actors.

Table 2. Three intellectual virtues and human capacities. Source: De Jonge (2009).

Human capacity	Thinking (Theioria)	Making (Poiesis)	Acting (praxis)
Intellectual virtue	Scientific scholarship (Episteme)	Skillfulness, craftsmanship (Techne)	Practical wisdom, prudence (Phronesis)
Rationality	Theoretical, analytical	Practical, productive	Practical, value focussed
Type of knowledge	Person- and context-independent, universal	Personal, context-dependent	Personal, context-dependent
Relevant professional domain	Science	Arts, crafts, professional practice	Ethics and Politics

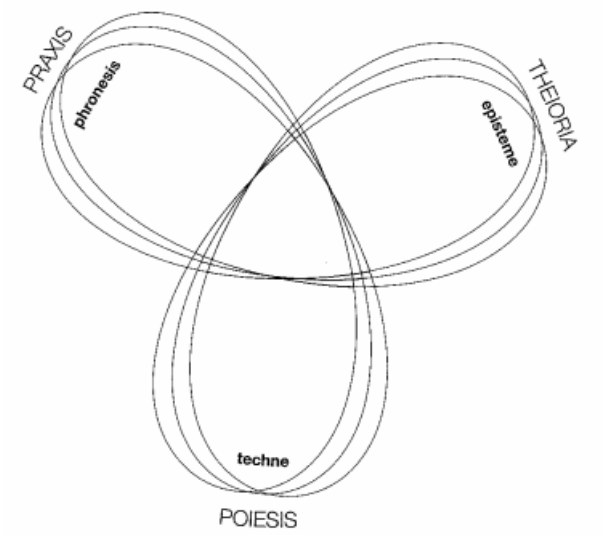


Figure 2. Designing as the meeting of intellectual virtues. Source: De Jonge (2009).

One of the challenges in co-design is to determine if a design process can be considered representative based on the actual participation of stakeholders. For instance, a co-design process can go through, hypothetically, with one academic, ten craftsmen and two planners. Nonetheless, such a setting can make it more harsh to come up with a shared agreement due to the numbers of participants and the diversity of participants. Other practical questions are: how to accommodate the different types of knowledge and what voices will be dominant or heard? A concept in design that addresses this issue is the democratization of design. *''Democratization of design [..] will allow more 'non-designers' to become involved in idea generation, development and production of products, services or processes.''* (Fleischmann, 2015, p103). According to this view, the involvement of non-experts in the design process will contribute to broader public support and may give unique perspectives on design matters. While this seems promising in an expert-led landscape, people should be wary about the negative consequences of democratization of design. The more people are involved the longer it can take to come to an agreement. Moreover, a radical increase in 'designers' can steer towards anarchy where the representation of personal or group interest becomes the goal instead of the means (Blythe et al., 2015). Furthermore, due to a lack of sense of place[4], external experts can create tension between people enforcing resistance (Griffon et al., 2011; Kuliga et al., 2015). So, it is essential that experts and non-experts are mutually learning from each other in a value-free arena (Ball et al., 2007).

In order to facilitate co-learning and co-design, tailored design approaches that accommodate in achieving the full potential of individuals capacities are necessary. Goudswaard et al. (2019) distinguish three approaches of democratization of design together shaping a prescriptive design process. (figure 3). Design by crowd is more interesting when a significant amount of people are involved or can be involved in the design process. This may contribute to broader public support when a generative design is created in order to formalize the design. On the contrary, design by crowd demands that many participants actually participate and can generate a bulk of non-representative data when certain stakeholder groups do not reply. Generative design seems most effective at the ending phases of the process, but may be relevant when pre-established concepts should be embedded in the design process. Design by play seems the key phase for this research, because it focuses on finding new designs through carrying out design activities in an accessible and playful manner. This makes that design by play can be insightful at the start for creative imagination. Nevertheless, design by play can be difficult when people do not have the right tools to express

[4] ''*the collection of meanings, beliefs, symbols, values, and feelings that individuals or groups associate with a particular locality.''* (Williams & Stewart, 1998, p19)

themselves clearly. According to Goudswaard et al. (2019), the three approaches can be implemented more or less in certain phases, but this does not necessarily have to be the case. As mentioned earlier, designing is an ongoing interactive process. The arrival at the definitive layout may for example not be finite. When the definitive layout is not supported sufficiently, it can lead to new specifications that should reassure public support the next time. The perspective of co-design is therefore interesting. It focuses on the engagement and leadership of individuals during the design process. In addition, Schön (1983) mentions that reflection-in-action is important. He argues that planners and designers often operate on the basis of their own world view and in turn constrain the creative thinking of others who adapt to that world view. During the planning and design process, reflection is seen to be necessary in order to avoid this (manipulated) tunnel thinking for both the experts as well as the non-experts. Moreover, the integration of reflection moments ensures the mediation between participants and facilitators for the purpose of consensus-oriented design (Haymaker et al., 2000). These considerations incentivized the essential development of co-creation as an important concept in relation to co-design.

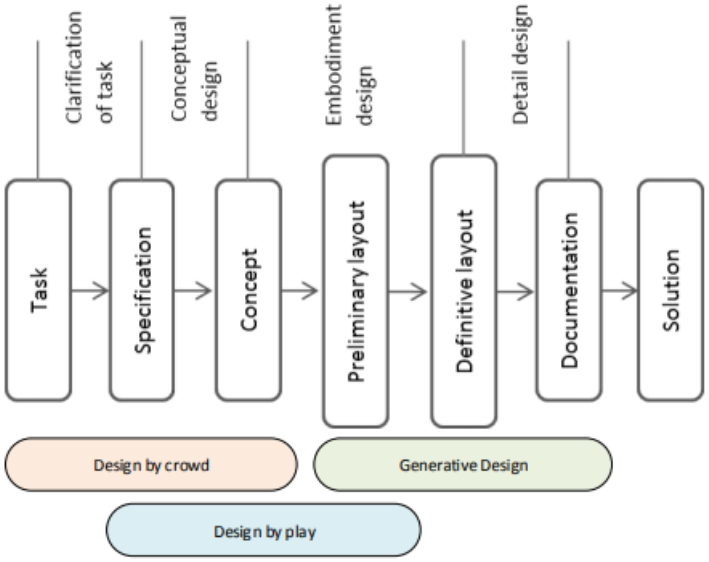


Figure 3. Three approaches to the democratisation of design set in context of the prescriptive design approach. Source: Goudswaard et al. (2019).

2.4 Co-creation

While co-design essentially focuses on the structured process wherein design occurs (table 3), the concept of co-creation is especially concerned with the collaborative and iterative creation of value during the design process (Frow et al., 2015; Puerari et al., 2018; Durall et al., 2019). The goal is to activate and share creative knowledge together (Sanders & Stappers, 2008) within the boundaries of the so-called creative enterprise, i.e. design arena (Greenhalgh et al., 2016). Co-creation can therefore be considered as some kind of creative glue that binds people in their beginning and further collaborative design efforts while leading to unpredictable and innovative outcomes. This transcendence and freedom of co-creation has often been stressed as the core advantage of co-creation (Puerari et al., 2018). Moreover, co-creation has conceptually enriched the academic debate because the scope is put on the creation of value instead of the framework wherein design occurs.

Table 3. Summary of differences between co-creation and co-design. Source: Durall et al. (2019).

	Co-creation	*Co-design*
Stakeholders' role	Creators	Information providers, creative thinkers, evaluators of ideas
Designers' role	Coordinators, developers and providers of co-creation tools	Facilitators, mediators
Opportunities	Collective creativity, knowledge exchange, and social capital	Design creativity, engagement, reflection and reflexivity, collective dialogue and negotiation
Challenges	Risk of non-reciprocal relationships in which stakeholders feel instrumentalized	Balancing tensions and creating relationships of trust

The literature review of Puerari et al. (2018) has indicated the existence of five conceptual aspects related to co-creation (table 4). These components clarify the oftentimes thin reciprocal line between co-creation and co-design. Practicalities such as the location of the design arena and the owner of that place are threats that can become a burden on the design process similar to potential practical constraints posed by the experts. A strict design environment enforces expected value creation whereas an undefined design environment may lead to unexpected outcomes. Participatory-enhancing tools may therefore be a desired way out which would locate the ownership of the design process in the hands of the stakeholders. Then, value creation can occur on the basis of needs and motivations of stakeholders irrespective of formal constraints.

Table 4. Five elements that appear in co-creation processes based on Puerari et al. (2018).

Element	*Description*
The purpose of co-creation	Co-creation can stimulate making and learning
Formal and informal co-creation	The formal set-up may influence the informal co-creation process and vice versa
The ownership of the co-creation process	The prominent engagement of specific participants may endanger the overall co-creation process
The motivations and incentives for the co-creation	Participation in co-creation process can entail costs for participations or rely on personal interests
The places/spaces of co-creation	The unique socio-spatial context of each place/space may thrive or constrain co-creation

2.5 Existing tools in collaborative spatial planning and design

The focus of this section is to provide more specific information about existing tools for collaborative spatial planning and design within a self-created criteria framework in line with the questions of this research. From a historical perspective, tools have mainly been the sculptures of planners and designers for the purposes of self-creation and presentation of plans to the wider public (Ehn, 1988; Sanoff, 1999). The intention was not to truly involve all stakeholders in the making of plans, but to inform citizens and find out whether the self-created spatial plans and designs should be adapted. Therefore, the work of Sanoff (1999) on truly participatory tools is valuable. He emphasized that deliberative and tailored choices of tools are necessary for effective and inclusive planning and design processes. In line with the definition of Pelle Ehn (see section 1.2), the used tools should enable and empower craftsmanship of stakeholders. Nakakoji (2006) adds that the empowerment of

tools can be distinguished in more efficient planning and design or wider application of specific tools in the domain of spatial planning and design. The practical consequence of this may be that diverse sets of tools are used in projects depending on the determination of which tool is the most effective for whom. Nowadays, the wide application of technology and digital tools in society and collaborative planning and design establishes that the search for what tools to use for which task is more relevant than ever and deliberate and ethical choices have to be made herein (Batty, 2018).

Criteria for tools

The three conceptual criteria used in this research logically follow out of the sub-research questions. The criteria are stakeholder engagement, spatial planning and design and process of co-creation. First of all, the collaborative line of thought suggests that participants of a design process should engage in the design process by offering them the power to express themselves (Forester, 1989). In fact, this demands that the implementation of tools should be based on the needs of the participants. Otherwise, participants are not able to express themselves. The difficulty is that the use of specific tools may exclude participants from being able to participate, which reduces the overall engagement in the design process (Dobbins, 2009). The challenge for designers is to prevent this from happening (Baker et al., 2007). As a designer, it is thus wise to be aware of the type(s) of engagement a tool supports. For example, Al-Kodmany (1999) illustrates that the showing of digital manipulated photos can be used to start discussions between participants and Wilson & Tewdwr-Jones (2019) show that a tool can be used to start an individual design process before the individual designs are plenary discussed. The goal of the design process can be leading in what tool is probably the most appropriate, but the bottom line is that all participants should engage in a manner that they can pass on their beliefs and ideas.

The second criterion is the spatial planning and design that is supported via tools. In line with the just mentioned examples, photos (see Al-Kodmany, 1999) and pen and paper (see Wilson & Tewdwr-Jones, 2019) can be used to visualise future designs for example. Again, it is important to state at first what the goal of the design process is. Detailed spatial outcomes may be more difficult to comprehend for a non-designer audience and abstract blocks miss realism to a certain extent (Lawson, 2005; Sheppard, 2005). On the other hand, detailed spatial outcomes are probably necessary in places where multiple functions need to be integrated into the build environment and abstract blocks can stimulate the interactivity with design objects because it is easy to use. The challenge is to ensure that the desired type of design outcomes interrelate with the desired type of collaborative design. Nevertheless, it is without doubt that each design tool includes a spatial component either explicit through spatial expression or implicit through dialogue (Sanoff, 1999).

As section 2.3 outlined, there can exist different approaches in a co-creation design process. As a consequence, one tool can be a better fit to one approach than the other. In order to make this statement more explicit, the aforementioned digital manipulated photos can be used for design by crowd approaches when each stakeholder has the opportunity to reflect on these photos. Moreover, stakeholders can also be invited to manipulate photos to their interests and tell their visions in such a way. Naturally, this involves a design by play approach then. It will depend on the sort of information a tool produces and how the tool is embedded in a design process whether the tool is effective (Ehn, 1988; Björgvinsson et al., 2012). The combination of individual design activities and collective discussion guides for example another design session than the other way around.

In the context of the above, differences between physical tools and digital tools are interesting because they fundamentally support different sorts of stakeholder engagement, spatial planning and design and co-creation processes. The first is grounded in reality while the second is oriented towards a digital reality. In the remainder of this section an overview will be given of the various tools co-existing with these two categories based on their effects.

Physical tools

The traditional form of participatory tools is characterized by the presence of physical materials, production in reality and physical output (Thorpe, 2017). The naming of derivative tools as physical tools seems therefore logical. These physical tools (table 5) have been awarded for their tangibility, low accessibility and comprehensiveness because most people immediately grasp how these physical tools should be used (Ehn, 1988). The positive consequence is that innovative and creative designing is not restricted to planners and designers solely. However, not all physical tools are an eligible option for everyone (Sandercock, 2004). For example, handmade 3D-models require a level of craftsmanship. Besides, only paper maps may not stimulate the generation of creative ideas while an art gallery of ideas encourages alternative thinking of participants perhaps. The power of the planners and designers to influence the planning and design process remains therefore noticeable although implicit at least (Albrechts et al., 2019). Moreover, the different tools illustrate the potential necessity for planners and designers to involve multiple tools because of their alleged purpose compared to other tools. A walk through can be a perfect first step to share thoughts and ideas about the researched environment before diving into the actual design phase for example. A disadvantage of most physical tools is that iteration within the planning and design process is resulting in a clumsy, unclear, immense or non-valid output if the used material is not replaced. hardware is not replaced by new material. On the other hand, iteration on the same material can lead to the production of insightful combinations between made planning and design efforts (Wilson & Tewdwr-Jones, 2019).

Table 5. Overview of physical tools. Based on Sanoff (1999) and Ehn (1988).

Tool name	Stakeholder participation	Spatial expression	Stage-based effectiveness
Paper maps	The only hardware material you need is paper and drawing material such as pens or markers. In essence, paper maps encourage participation because most people are able to draw with a pencil or marker. The 2D presentation of paper maps is one the hand an advantage, because most likely it recalls people's imagination of the designed area. Besides, 2D makes it easier for people to express themselves mainly by drawing. On the other hand, interpretations of the paper maps and made drawings are more difficult to imagine because they lack a third dimension	Graphic representation on a 2D paper map. The paper map is a visual representation of the designed area which is meant to immediately recognize the area. The level of detail of the map may differ which can cause unrealism or overwhelming reactions.	Paper maps can encourage individual design activities while simultaneously or subsequently brainstorm about the ideas. Moreover, they can be used to show the final concept. The tool is deemed less effective for communicating design efforts in large groups.
Charette	The charette is a proven tool where people within a group have to pass on ideas and critiques each on sticky notes in most cases. Communication happens through written words on sticky notes that are passed on in the group on high velocity. Verbal communication is only allowed after the charette has stopped.	Words or drawings on sticky notes (put together on a white board for example)	The charette enforces a cyclical process for gathering much information on short notice. The disadvantage is that thorough thinking is not possible due to the time and interactivity is limited to passing on written information.

Surveys	The supported engagement of surveys is restricted. People merely respond to the asked questions and people need to be willing to fill in a survey.	The spatial expression of surveys can be implicit. The outcomes of the filled in surveys are connected to places by words. On the contrary, drawing zones can counteract this situation.	Surveys are questionnaires which can be used to gather and analyse specific data on spatial matters. Surveys provide an opportunity to gather much information on short notice because people only need to fill in the survey. The danger with surveys is that the received information leads to misinterpretation because people do not have the opportunity to elaborate on their answer, e.g. box-ticking or yes/no questions, or the response rate is low.
Gallery	A gallery is an exposition of potential ideas or concepts where people can share their thoughts on. Engagement occurs through conversation. It is therefore important to note and remember the opinions.	The material can differ, but examples are paintings and photographs where spatial impressions are shown.	The gallery can be used to illustrate the final concepts and receive feedback on the general concept
Delphi method	Compared to surveys where drawing questions are also an option, the Delphi method is especially focussing on written ideas and concepts. Non verbal communication is included and only handwritten words are the communication mechanism. Engagement in this method is therefore limited, since people are only able to write their ideas, adhere to the most promising ideas and reach consensus.	Handwritten words	The Delphi method is an extension of the surveys. After the results from the surveys are collected, people are asked again and again in order to reach consensus on the most noted ideas. This fits with the generative design approach, but relates more to co-design.
Board games	Playing the board game is in essence the type of engagement. Users are able to discuss with each other during the game. However, the remark has to be made that the design and the rules of the board game limit engagement.	The interface and additional attributes of the game are the spatial expression instruments such as a sandbox, play materials for children, water, climbing boards, crates and instructions	Board games are interactive tools that stimulate users to think about theirs and others planning and design actions and how they influence each other. This perfectly matches the design by play approach
Handmade 3D models	Handmade 3D models help to create a dialectical sphere where people can talk about (potential) objects of the build environment. If the models are not limed on a surface, they provide great opportunity to play with the environment such as removing and replacing buildings or adding newly created buildings. The limitation is that users can only	Handmade 3D models are the physical (potential) representation of the build environment including models of buildings for example. They can be 1:1 copies of the actual environment made from Cardboard, wood blocks, styrofoam,	Handmade 3D models can be effective for design by play, establishing co-design principles or showing the final concept

	play with the models that are made.	construction paper and plastic.	
Walk-throughs	During walk-throughs, people are invited to discuss ideas on the spot. The locations of the walk through serve as the topics where they can talk about.	The spatial expression sticks to spoken words on location with probably the creative imagination of each individual.	Walk-throughs are a means to activate people to think and discuss planning and design. During walk-throughs, people are invited to discuss ideas on the spot.

Digital tools

Compared to physical tools, digital tools (table 6) have the general advantage that iteration of the planning and design process does not require the physical replacement of material and that much physical labour is simply done by mouse-clicking in most occasions (Ehn, 1988). This cost-reduction benefit is also noticeable in the amount of people that digital tools can reach. Online surveys and digital imaginary prototypes or impressions can be transferred via the internet so people do not have to transit to a specific location in order to participate in planning and design processes (Batty, 2018). Moreover, the current increase in use of technologies means that people can create their own plans and designs on their computer without the need of experts (Evans-Cowley & Hollander, 2010). The countereffect however is that this cost-reduction may facilitate that communication between the actual planners and designers and the people is decreasing while simultaneously sharpening the contrasts between the planners and designers ideas and those of the people (Lawson, 2005). Another side effect is that a new digital elite of experts is arising. This elite may outcompete the existing experts or continue to pursue the technical debate with the experts. It is questionable to what extent this is desired, but it makes the important remark that new digital tools may form a barrier for people who are not used to technologies or anxious about using them. In the most extreme cases, people do not participate because the digital tools take too much time and effort to master. The convenient answer to solve this question is that digital tools should be made as inclusive as possible. However, it is difficult to bring this into practice. The illustrated digital tools show that persons have to learn the knowhow most likely on their own when supervision and/or instructions are lacking. The almost full responsibility of participation will then be put on the people who are willing to make the effort. In addition, the illustrated variety of digital tools is a proclamation of the difficulties that may be faced knowing that application software is unique and, consequently, requires unique instructions. Even for planners and designers the application software can be troublesome when the application does match the normative expectations (Al-Kodmany, 1999). On the contrary, planners and designers are in a powerful position when they (help to) design applications and software because it allows them to modify the application to their interest. The key is to reflect on the application and verify whether the application matches the interest of the people from whom it is designed. All in all, this counts for the complete set of digital tools. The same concluding thoughts for physical tools appear for digital tools: purposeful choices need to be made about what tool to include, how and whether a mix of tools is the smarter solution.

Table 6. Overview of digital tools. Based on Al-Kodmany (1999), Ball et al. (2007), Batty (2018), Ehn (1988), Sanoff (1999) and Bjögvinsson et al. (2012).

Digital tool	**Stakeholder participation**	**Spatial expression**	**Stage-based effectiveness**	**Example**
Virtual 3D modelling	Virtual 3D models are developed on a computer and the app used to create the model. One user is invited to create 3D models with the computer. However, group engagement can occur when more persons sitting next to the model builder or see the model directly.	Virtual 3D-modelling is the online twin of handmade 3D models only more advanced, since the models are not limited to the used material and can diversify.	Virtual 3D models are viewed on devices such as a computer or a mobile phone. On the occasion that people are able to modify them, they are suitable for design by play. Otherwise, the tool can be used for informing and receiving feedback.	Sketch-Up.
3D-printing	Engagement is limited to human-computer interaction at first. However, human-human engagement is possible after the model has been printed.	3D-printing is the in-between version of physical models and virtual 3D models. 3D models are digital made and then printed out.	At the beginning, the model needs to be crafted through someone who knows how to 3D-print. After printing, it is possible to speak about the physical model. The disadvantage is that every component needs to be printed.	Felix Pro
Online survey	The online survey is filled in by a participant.	The spatial expression of online surveys can be implicit. The outcomes of the filled in online surveys are connected to places by words. On the contrary, drawing zones can counteract this situation.	Online surveys are questionnaires which can be used to gather and analyse specific data on spatial matters. Online surveys provide an opportunity to gather much information on short notice because people only need to fill in the online survey. The danger with online surveys is that the received information leads to misinterpretation because people do not have the opportunity to elaborate on their answer, e.g. box-ticking or yes/no questions, or the response rate is low.	Maptionnaire.
Video	There is very little interaction, but the impressions shown during the video can function as a trigger for discussion.	A video can show the researched area on a screen.	A video can be implemented for starting a discussion of informing participants	Movavi.

CD-ROM games	Engagement exists between the player and the game	A CD-ROM with a game that illustrates the spatial expression.	In line with design by play, CD-ROM games are individual-oriented games where people can create their own world.	SimCity.
Massive Multiplayer Online Games (MOOG)	Engagement exists between the play, possibly other players and the game.	An online game.	MOOG's are group-oriented games where multiple people can design together.	Minecraft.
Geographical Information System (GIS)	Engagement is appointed towards the user and the people who are going to see maps.	Spatial expressions are visualised through online maps.	GIS is an online information tool to view and analyse spatial data. Maps can be self-created, but also used for collective moments of discussion.	GIS.
Computer photo manipulation	Engagement is appointed towards the user and the people who are going to see photos.	Photos are created on a computer with photo manipulation software.	Computer photo manipulation is an interesting tool for finding out what people think of changes in the environment. Photos can be seen on several devices with screens.	Photoshop.
Augmented Reality (AR)	The user is engaging with AR by using his/her fingers tipping on the screen, but others who see the screen can encourage the user to make decisions.	AR shows a virtual object on a mobile phone or tablet projected in the real world where the camera is pointed.	AR is a tool for individual design activities, but can be used in group sessions where others have to carry out the same design task.	Kubity.
Immersive Virtual Reality (IVR)	Engagement happens through the VR-headset and VR-controllers, but others who see the screen can encourage the user to make decisions. Collaborative online environments can create that individuals see others actions as well.	IVR immerses a user in a virtual environment where the spatial expression is displayed.	During individual design moments, IVR stimulates design by play while it can lead to collective moments of discussion. In a collective online environment, IVR can shape dialogues directly.	Figure 1.
Mixed Reality (MR)	The user is mainly engaging with MR through the VR-headset and using his/her hands, but others who see the screen can encourage the user to make decisions. Collaborative online environments can create that individuals see others actions as well.	MR shows a virtual object on a VR-headset and projects the object in the real world where the camera is pointed.	During individual design moments, MR stimulates design by play while it can lead to collective moments of discussion. In a collective online environment, MR can shape dialogues directly.	Blocks with HoloLens.

2.6 Spatial designing within Immersive Virtual Reality

Now general design concepts, a tool-based research framework and a list of physical and digital tools have been introduced, this section continues by linking these to IVR. For each criterion, aspects are described which ought to be required for understanding the criterion.

Stakeholder engagement

The first aspect is framed as instructions. New technology such as IVR may form a burden for participants who are not familiar with using head-mounted displays and controllers (Biocca, 1992). Specifically, elderly can face more challenges than youngsters who have grown up with technological devices for instance (Morganti et al., 2009). Verbal or written instructions are then needed to perform the design task. This can entail that a designer takes a facilitative role during the design sessions explaining what participants can or should do (Wilson & Tewdwr-Jones, 2019). Probably, a mixture of design and tool instructions are necessary to ensure that participants will know what to design and how. It can be assumed that proper instructions stimulate that all participants become sooner and more actively involved.

The second aspect is role management. Radianti et al. (2020) describe that the role of a teacher differs from the role of a student which is mainly concerned with performing the task given by the teacher. This shows similarities with the relationships between the planner and the stakeholders. The planner can facilitate a design process by providing tools to people without involving himself (Booher & Innes, 2002). On the contrary, a planner can also work with people in the design process and become part of the design process in a more active, collaborative way. These discrepancies in roles are effectively enabling and constraining what people will be able to do in design and especially threatening their designed role for the process as a whole. Next to this, participants themselves can divide roles during the design process. Especially during the collaborative design sessions, participants can appoint people to a design task or communicating task. Moreover, participants can take a facilitative role and give instructions to others about the use of the tool. Similar as with the role of the designer, more threatening is the participant role where someone dictates what the others should do. This harms the conceptual thought of shaping a collective design.

Wilson & Tewdwr-Jones (2019) state that the manner in which participants interact should be based on the premise that it makes sense or is logical for participants to interact without external pressures. It will be no surprise that participants are less interacting with each other when they are designing on their own. However, this does not per se have to be harmful to the collective process when the individual design activities and thoughts are shared. In case of VR, these considered inclusionary or exclusionary practices have proven to be effective for user convenience (Lv et al., 2015) and public support (Lei et al., 2017). Here, the design arena is key for stimulating dialogues or individual design (Wu et al., 2019; Voogt et al., 2015). Riva (1999) stressed the importance of stakeholders being able to communicate in an informed way. The threshold for collaboration decreases when the perceived information is accurate and shared among people, because people are immediately able to see what someone means and can reflect upon this (Voogt et al., 2015). Lei et al. (2017) found that collaboration becomes more difficult when people are not physically at the same location. People have to give detailed explanations of what they mean instead of pointing a finger on the map. Co-learning and co-creation is more troublesome then (Ball et al., 2007; Wu et al., 2019). Nowadays technologies are capable of online screen sharing even when people are not physically near each other. This is more difficult for sharing paper maps for example, as these should involve online video-recording or verbal communication through telephone. The platform remains important in this case, so people become included in theirs and others' design process (Wu et al., 2019).

The fourth aspect is communication. The ability to speak with others is especially important for collaborative purposes in order to achieve more informed decision-making (Kuliga et al., 2015). Dialogues (including moments of evaluation and reflection) before, during and after the design process are desired, because it can reduce overlooked mistakes, change the 'business-as-usual' design thought to creative and alternative thinking (Watcharasukarn et al., 2012), strengthen a shared belief and trust in the outcomes (Forester, 1989), save time, keeps the attention of the participants (Voogt et al., 2015; Jamei et al., 2017; Lei et al., 2017) and constitutes the opportunity to have a say in the design process (Björgvinsson et al., 2012). Per tool, the type of communication can differ. Verbal communication can be encouraged using IVR for example, but the tool supports non-verbal communication through visualising design efforts in a virtual environment. This kind of passive information refers to all that can be observed in the virtual environment without performing actions (Radianti et al., 2020). The advantage of IVR is that it creates a stronger sense of presence (Heydarian et al. 2015). According to Paes et al. (2017), people are able to take larger doses of information and are able to recognise physical structures immediately. Both impact the way in which participants move their head wearing a head-mounted display and find their route in a virtual environment (Morganti et al., 2009; Napatov & Fisher-Gewirtzman, 2016). Communication, either verbal or non-verbal, can thus be steered with IVR.

Hardware, software and data is the last aspect influencing engagement. IVR is praised for the inclusion of information that affects the human senses and creates a sense of presence (Matthews et al., 2017). The head-mounted display makes participants feel immersed in a virtual environment where they are elucidated from the physical reality. The type of IVR-hardware varies, but figures 1 and 4 present two examples of how participants are immersed into a virtual system. These examples immediately indicate the challenges of IVR-hardware. Due to the immersion, participants feel disconnected from their actual, physical location which makes IVR dangerous to use at locations with nearby obstacles. Moreover, most IVR-systems need a PC and the wire connected to the PC (if needed) can become entangled to the person also creating dangerous situations. Lastly, the immersion causes objects outside the person's view, such as controllers, to be difficult to see and find. These remarks point out that the use of IVR-hardware is directed into individual engagement with the tool, which makes the tool probably more intuitive to use in combination with independent learning.

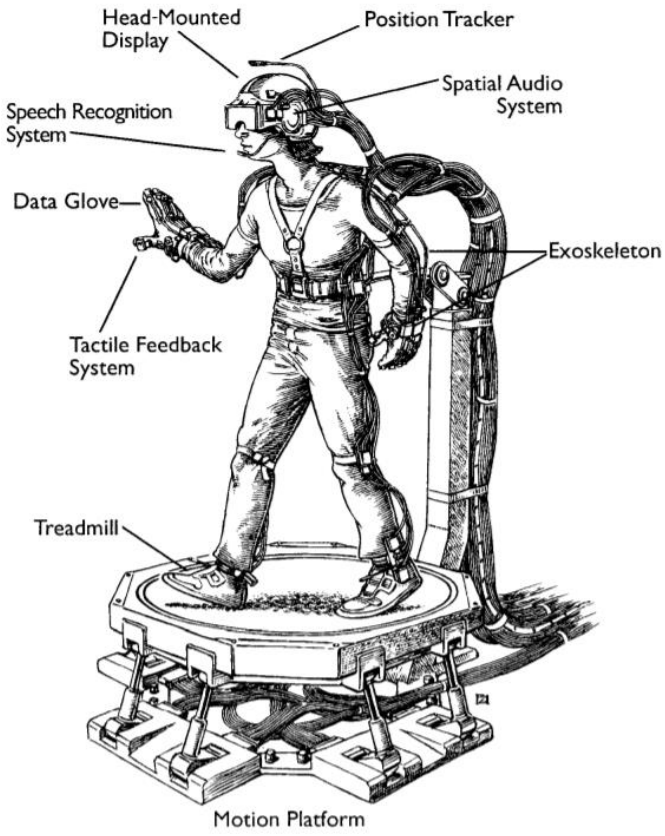


Figure 4. Immersion in IVR. Source: Biocca (1992).

The software is partially responsible for this. Sensory and substantive information needs to be programmed in the software or physically simulated on location in order to be experienced (Pitt & Naussaur, 1992). Ultimately, this includes that an individual with a head-mounted display experiences the sensory and substantive information individually at that moment. The ability to move is something an individual experiences himself and not others. In fact, the ability to move in IVR is restricted to individual physical walks or teleporting in IVR (Zhao et al., 2020). Yaremych & Persky (2019) name this as an advantage, because participants are free to explore the environment. However, this is counterintuitive to the generation of a collective experience. Lv et al. (2015) and Lei et al. (2017) note that a collective online environment enforces collective experiences and may replace a physical location where all participants are gathered. With the help of software, one online location can be programmed where participants can review each other's designs and discuss them for example. This can also encourage the development of gaming. The advantage of using software for framing the design process as a game is the added fun-factor (Radianti et al., 2020). People enjoy the design process, while perhaps not consciously and seriously feel that they are part of it. The game study of Watcharasukarn et al. (2012) showed for instance that stakeholders with contested views were able to find potential and consensus-based solutions due to their gaming experience. Moreover, the game study of Morganti et al. (2009) revealed that elderly people are less explorative-driven which is important to keep in mind for assigning the right tools to the stakeholders. Gaming can thus be interesting for designing as it is for establishing the design environment. The obvious reward for the planner and the participants is then a meaningful spatial or organisational plan. A contrasting remark is that participants can become competitors who want to pursue their vision (Radianti et al., 2020), but the most prominent risk concerned with IVR-software is that the pivotal and praised real experience is missing (Bateman et al., 2009).

Additionally, realistic data embedded in the software elucidates this concern to some extent. More realistic buildings increase the spatial experience of people which contributes to more detailed

imagination (Kuliga et al., 2015; Zhu et al., 2020). The virtual objects in IVR, such as buildings, streets or parks, are duplicates of something that is or can be reality. However, the level of detail or accuracy of the copies can greatly differ. The same is interesting for the landscape that is being communicated (Bateman et al., 2009). A flat projection is far from realistic when mountains or hills are dominating the actual landscape. It is therefore crucial to communicate realistic imaginary and also obtain detailed information from the real world to make design more recognisable (Ball et al., 2007). Realistic environments prevent misinterpretation of what is being designed and serve therefore substantive dialogues (Matthews et al., 2017). They could also trigger personal attachment to the environment, because people are familiar with the objects or place (Wilson & Tewdwr-Jones, 2019; Yaremych & Persky, 2019). This can be very insightful as a source of inspiration for stakeholders (Patterson et al., 2017). Interestingly, Napatov & Fisher-Gewirtzman (2016) found for example that landmarks were attracting the participants and became the focus points for the design process. On the other hand, too complex presentations may lose the attention of people and, therefore, their contribution to the design process (Dijkstra et al., 2003; Heydarian et al., 2015). During the design process an environment can be modified and therefore new environments are simulated. These new environments depend on the actions of participants which leads to questioning what can be designed and what not. IVR is to a certain extent constrained by this, because the possibility to change the environmental data needs to be programmed (Griffon et al., 2011; Jamei et al., 2017). A practical example is the change of weather or seasons which can be embedded in a virtual environment (Lei et al., 2017). This can enforce the design process, because people can review the success of their designs in different circumstances (Abdelhameed, 2013). Environmental data change is then a driver of design instead of a concern. All in all, environmental data, software and hardware are all linked to each other for IVR. It is important to recognise what decisions or options generated through these are affecting the design process in a fundamental way potentially through time, money or technology issues (Pitt & Naussaur, 1992; Bateman et al., 2009).

Spatial planning and design

As a consequence of how participants can engage with IVR, people can be encouraged to modify and interact with a virtual environment. This stimulates spatial learning (Wang, 2018) and addresses the fun factor that increases experiences (Jeng et al., 2017). In turn, valuable information can be received which reveals the intentions of how people construct their ideal environment and what they build (Paes et al., 2017; Thisgaard & Makransky, 2017; Makransky & Lilleholt, 2018. However, hardware, software and data should enable people to interact with objects. Without focussing too much on the technical nature of this concern, it is desired that people can properly interact with objects to express their thoughts and ideas. Otherwise, the gaming effect and the dialogue is constrained to what is programmed and perhaps not to what is needed. As the previous three paragraphs explain, the hardware, software and data is effectively influencing the interactivity with objects and, consequently, the type of spatial expression that IVR supports. Potentially limiting creative impulses, spatial expressions produced through IVR can still be valuable to earn insights in what needs to be designed. The four images on the front page still present an impression for a campus design for example. The way of visualisation is in this case 2D on a screen similar to the earlier mentioned screen-sharing method. However, participants have also the opportunity to experience other designs through moving in other virtual environments. This can be done via a collective virtual environment or through handing over the head-mounted display. According to Ceconello & Spallazzo (2008) and Zhu et al. (2020), it is essential that the needed technical expertise is reduced to the extent that participants are able to understand what spatial expressions represent. Then, spatial expressions can be used for proposing new ideas (Paes et al.., 2017; Welty and Setiawan, 2019). So, spatial expressions can be used, on the one hand, to interact with the virtual environment and, on the other hand, to confirm spatial designs. In conclusion, it is again important to stress that the type of data being transferred is crucial for how spatial expressions will be received and used by participants (Kuliga et al., 2015; Zhu et al., 2020).

Process of co-creation

The main goal of an initiated design process is to make meaningful decisions which are reviewed and deliberately selected (Wilson & Tewdwr-Jones, 2019; Radianti et al., 2020). Visualisations of designs and toolsets help to achieve this (Bateman et al., 2009; Dobbins, 2009; Abdelhameed, 2013) for the ultimate goal of increasing the quality of life (Jamei et al., 2017). The interesting remark however is that making meaningful choices is subjective to interpersonal relations that change and endure in time (Zhu et al., 2020). So, meaningful choices are bound to temporarily thinking, but strictly to the temporal thinking of those involved. This stresses again the statement of design being a continuous negotiation process (Forester, 1989). According to Dijkstra et al. (2003), final design proposals are often the result of melting different sorts of designs created by multiple tools. It is therefore perhaps no surprise that IVR can also be used in this perspective in various ways. Individuals are able to design an environment, groups are able to design individually and discuss the design outcomes collectively, groups can be able to design collectively in one collective online environment and groups are able to see the final concept. These situations are connected to the different approaches/aspects that can exist within design processes. The first relates solely to design by play and the last to generative design, but the others contain elements of co-design, design by crowd and design by play. A potential overlap between approaches can therefore be expected within one design session (Goudswaard et al., 2019). It is necessary to underline that the type of participation will determine what aspect is followed when. Design by play involves designing, co-design is establishing design rules, design by crowd is individual design in large groups and generative design is creating one final design. This multitude of possibilities increases the complexity for which stages or purposes IVR is an effective tool. The literature of this section and section 1.3 illustrates that the tool is most likely to be effective for individual or collective information transfer about spatial designing (followed by plenary discussion moments). The concern is still, what if IVR can be more than just an information tool (Wilson & Tewdwr-Jones, 2019)?

2.7 Conceptual model

Based on the introductory chapter of this research and the written narrative of this chapter, a conceptual model (figure 5) is presented in order to guide the analysis of this research and to provide clarification on what is being researched. At the moment, there is limited scientific evidence on the impacts which IVR has as a participatory-enhancing tool for collaborative spatial planning and design. Through the lens of design, this research scrutinized three criteria which are considered to be important for the use of IVR in collaborative spatial planning and design with the help of underlying requirements. Accordingly, the effects of IVR on each of these criteria became visible and statements could be made about the opportunities and limitations of IVR for collaborative spatial planning and design. The results of this research illustrate that the set of requirements can be seen from a relational perspective, but the purpose of this research has not been to make these relationships explicit. The colours in figure 5 have therefore only been used for aesthetic purposes.

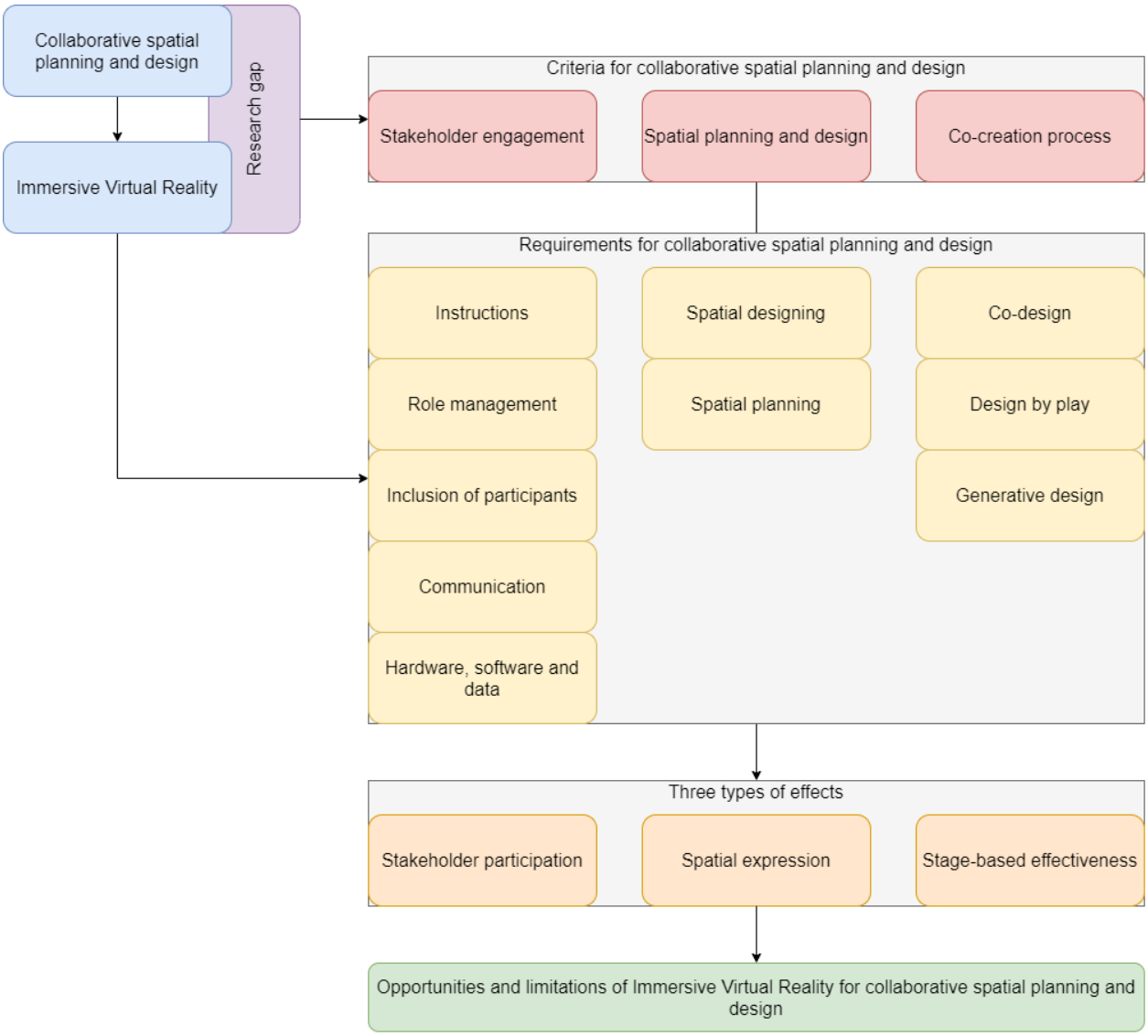


Figure 5. Conceptual model 'Scrutinizing the effects of Immersive Virtual Reality on collaborative spatial planning and design.' Source: Author.

3. Methodology

In continuation of the presented conceptual model, this chapter explains the methodology of this research. The first section generally explains the research design of this research followed by the research area in section two, the design task in section three, the data collection methods and analysis in sections four and five and the sixth section outlines the ethical concerns regarding this research.

3.1 Exploratory research design

This research applied a qualitative research design with the aim to gain detailed information on multiple theory-deducted aspects that are considered relevant for assessing the potential of IVR as a participatory-enhancing tool for collaborative spatial planning and design. Qualitative methods are known for the in-depth knowledge a researcher can acquire and therefore particularly interesting for studies that aim to explore subjects which have concisely been investigated (Strauss & Corbin, 1990). Here, the limited practical and academic knowledge on the implementation of IVR in collaborative spatial planning and design serves as the window of opportunity for finding out key results. Moreover, a qualitative method is more preferred for in-depth data collection on perceptions that people have. This type of method allows people to make distinctive comments while quantitative methods are guided and blinded through their self-created content (Punch, 2014).

More specifically, this study is concerned with the qualitative approach of ethnography. According to Herbert (2000), *''Ethnography explores the tissue of everyday life to reveal the processes and meanings which undergird social action, and which enable order to be reproduced and sometimes challenged.''* (p551). Atkinson et al. (2000) note that *''Ethnography is rooted in the first-hand experience of the research setting, and ethnography is committed to interpreting the point of view of those under study.''* (p43). These defining elements show that ethnography may be difficult to grasp and analyse, because the research can be conducted in a wide variety of observational and participatory research settings where the researcher has little control. Ultimately, this is seen as one of the advantages for this type of approach. Due to the inherent uncertainty in scrutinizing human actions and behaviour, more specific and perhaps unpredicted knowledge can be acquired on how people act and react under pre-set conditions or in daily operations. In addition, Hammersley & Atkinson (1983) point out that this can be either used for theory development or theory validation depending on what is being researched. In the case of this research, it is a combination of both. From the perspective of spatial planning and design, theory development is key for unlocking a potential role for IVR. From the more technical-driven perspective of IVR, already some knowledge has been outlined in the previous chapter. The main focus will nevertheless be on theory development as the research aim and research questions suggest. The use of ethnography is seen as particularly interesting for this research as its primary objective is to demystify specific notions on the actions and behaviours of people for instance during a design session using IVR. Additionally, the side effects of ethnography are that it is difficult to make generic valuable claims and overall representative statements because the statements only count for what and who is being observed at a specific moment (Herbert, 2000).

3.2 Research settings

Before the data collection strategies are explained, this section introduces the research settings first. The research area of this study has been the Zernike Campus in Groningen, the Netherlands (figure 6). The Zernike campus can be considered a home to businesses, Hanze University of Applied Sciences and the University of Groningen. It is an interesting research area for its dynamic environment. The great number of students, scientists and employees create a mixed environment that is intensively used during daytime and in-between holidays. In the evening and during holidays, the campus is predominantly used for leisure and recreational activities besides ongoing educational

activities. However, the amount of leisure and recreational activities is much lower than all the activities during daytime. This contributes to the situation that there exist huge shifts between daytime and night and (non-)holiday periods in terms of visitors, noise and traffic. Besides, the top-down modernistic character of the campus helped to establish a place where people have to go instead of want to go (De Groot et al., 2015; Van de Gevel, 2018). Soares et al. (2020) note that post-war desired segregation between places and functions of place on the Zernike Campus currently leads to an overlooked potential for e.g. students to interact, meet and creatively engage with each other. The study of de Groot et al. (2015) showed that 72% of the students (n=385) did not use the public spaces on the Zernike Campus as a place to meet and 71% did not use the public spaces for recreational activities. The study of van de Gevel (2018) revealed that international master students only visited educational places and facilities because they have to be there. In closing, Soares et al. (2020) opt for a mixture and integration of land-uses and facilities based on the user perceptions in order to enhance creative encounters to occur more frequently. Their results illustrate the specific and place-based proximity in which people meet nowadays. Earlier, the physical composition design of Okra (2016) complied with these statements and reviewed the necessity to make the Zernike Campus more vibrant. Their conclusion was to create, on the one hand, activities and places to meet and, on the other hand, places where nature is dominant. A review on the Healthy Ageing Campus design of Campus Groningen (2021) shows this line of thinking reflected in space. The interesting remark however is that new ideas and constructions are located on the edges of the campus whereas the core remains mainly similar to old physical structures. What if people now had the ability to change the core and self-create their desired campus? For instance Roggema (2021) suggests that nature should become the explaining factor for the physical layout of the Zernike Campus. In order to move away from conventional and functional thinking, there is a task for the users and spatial planners and designers of the Zernike campus to create a more vibrant Zernike campus (Soares et al. 2020).

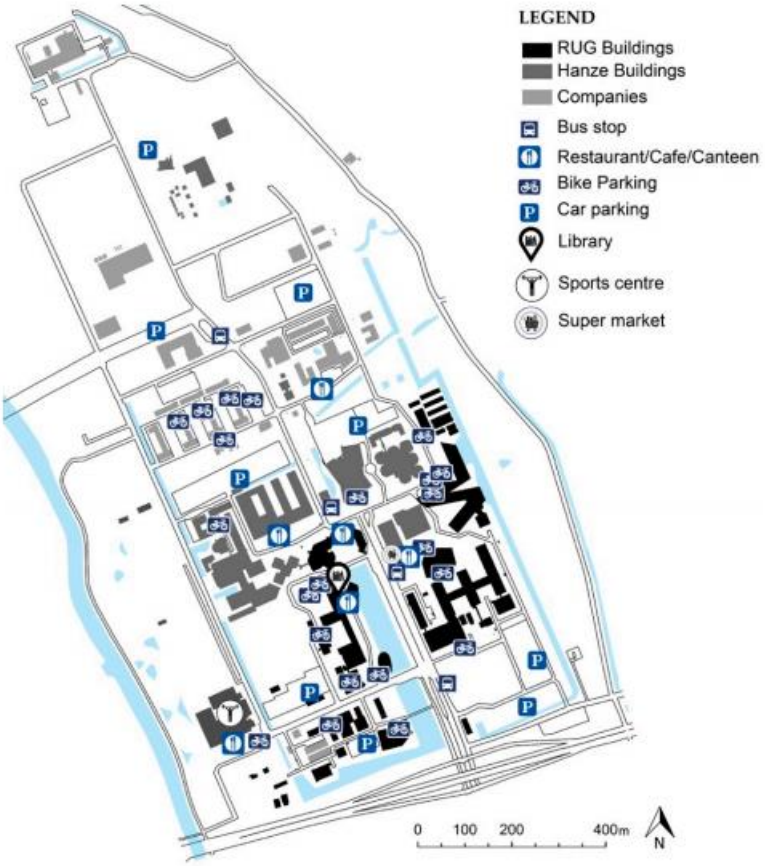


Figure 3. Zernike Campus land use.

Figure 6. Map Zernike Campus. Source: Soares et al. (2020).

Participants characteristics

Four participants have been asked to join one session and two sessions have been held of each about two hours (two times 45 minutes with a break in between). Due to the constraints related to the COVID19-virus, the groups of study have only been students. This is not representative for all the stakeholder who normally should be involved such as the businesses and the municipality of Groningen (Healey, 1997). The expectation would then be that the research setting mirrors an actual design session and participants would act accordingly (Wicker, 1985). This is considered essential for finding realistic and valuable outcomes for this research (Pickard, 2013). The nuance and selection of participants for this study is different. The two groups are selected on their (absence of) past design experience. One group consists of four members who do not had experience with designing and the opposite is true for the other group[5]. A general characteristic has been that they did not all use IVR earlier. According to Dobbins (2009), persons who have engaged in design activities are more aware, confident and capable of dealing with the design matter and design tools while inexperienced designers may be more hesitant or afraid to engage with the design task and tool. On the contrary, inexperienced designers are not confined to past design thinking which can encourage creative and unpredictable impulses. Moreover, in line with the collaborative line of thinking, the separation of both groups was interesting for assessing the velocity in which IVR was mastered by expert versus non-expert participants. The participants of the designer group did not know each other or solely by name, share a study at the Faculty of Spatial Sciences and are in the final year of a bachelor

[5] The designer group consisted of three members, because one participant had to withdraw from the experiment due to illness.

programme or master programme. The non-designer group was divided into two blocks of two participants who know each other through living together. The locations of their faculties are dispersed across the Zernike campus and participants were also in their final year of a bachelor programme or master programme. The age of participants in both groups varied from 21 to 24 and they all live in the city of Groningen.

3.3 Design task

The group of students have been asked to make the current Zernike Campus more vibrant. In addition, after 45 minutes an additional assignment was given. This assignment included the same task, but the researcher had removed all the buildings within the virtual model. This in order to enhance creative and unique design solutions which break with the conventional physical structure of the Zernike Campus. Participants could only use the tool Immersive Virtual Reality in order to explicitly measure the effects of IVR on the collaborative process. The digital library of the CASUS-lab of the University of Groningen has offered the virtual model of the Zernike Campus (i.e. Mercator City) which is used to conduct this research. Within this model participants were able to individually modify the virtual environment by removing, replacing, re-scaling or allocating on-campus or standardized buildings (e.g. houses and offices), on-campus greenery, road infrastructure, on-campus transportation modes and digital human beings. They were also able to purposefully place pointers in the environment for highlighting specific locations. Participants have been using the Oculus Rift headset including controllers so they could make changes, move to different heights and have the ability to teleport themselves throughout the model. Beforehand instructions (Appendix 1) have been given to participants with the goal to make themselves physically familiar with the material and the design task within five minutes. The time limit of five minutes has been chosen in order to observe practical obstacles during the early phases of the design process. It was deemed to be important not to mention words such as integration and creative places, because participants are asked to design based on their perceptions. It was hypothesized that participants would come up with these ideas themselves.

3.4 Data collection methods

In line with the qualitative approach of ethnography, data has been collected in the following two ways: observations and focus groups. The combination of both is seen as an effective manner to let people reflect on the process afterwards while the researcher is interested in the potential divide between thoughts and actions (Hammersley & Atkinson, 1983). With the help of screen recordings, video recordings and audio recording, the participants during this study have been monitored during the design sessions and during the focus groups at another moment afterwards.

3.4.1. Observations

The observations for this study took place in the spring of 2021 during the COVID19-pandemic at the CASUS-lab of the University of Groningen. The COVID19-pandemic has had a serious impact on the data collection and therefore needs some elaboration with regards to data collection and research setting. Figure 7 presents the setting of this research. Due to the COVID19 measurements, it has not been allowed for participants to be near each other within a distance of 1,5 meter and they were obliged to show a negative corona-test. The research setting itself has been disinfected up front and after the research. The pitfalls of this research setting are that people are not able to discuss design matters near each other and express themselves in the ‘research area’ of someone else. However, the allocation of one central design area with a large screen which can be managed by one participant is an attempt to create a collective design arena visible for all. Moreover, participants were allowed to swap locations when they disinfected their workspace. The design sessions were video and audio recorded. Two cameras watched the lab, four screen recorders the design process on the computers and one mobile device was tracking the audio. These video and audio tapings are

used for the data collection of individual and group behaviour and spatial outcomes. The researcher has taken a semi-participant role during the entire research session and limited its influence to solving technical issues and communicating the program of the design session. This is considered preferred in order to reduce interference in the design and evaluation process (Pickard, 2013).

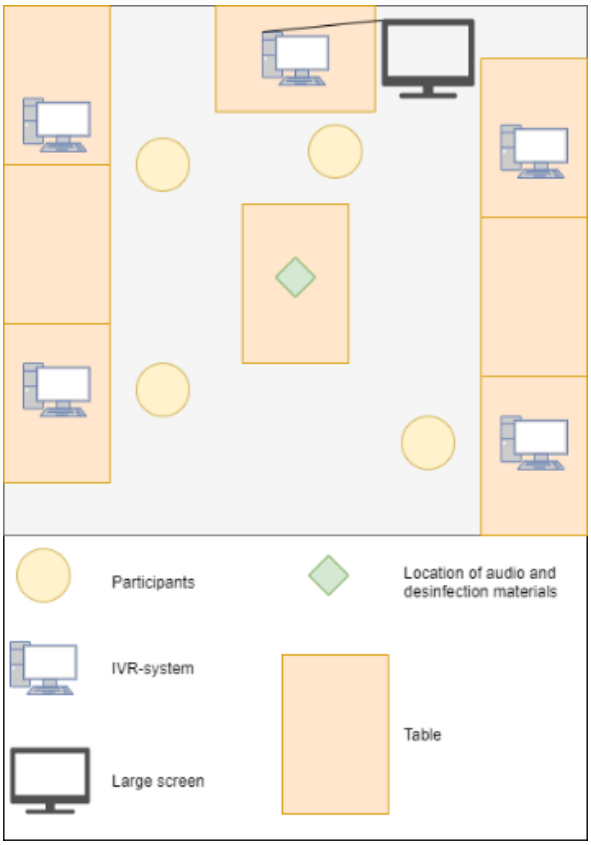


Figure 7. Design arena (schematic). Source: Author.

In addition, the specific type of observational study format has been the multiple-group cohort design. *''The multigroup cohort design is a prospective (i.e. longitudal) study in which two (or more) groups are identified at the initial assessment (Time 1) and followed over time to examine outcomes of interest.''* (Kazdin, 2003a, p175). Naturally, the start and the end of the design session have been the beginning and end moments of the observations and the outcomes of interest focus on the concepts outlined in the conceptual model. The key strengths and weaknesses of the chosen cohort design are listed in table 7. The most interesting benefit of using the multi-group cohort design is that the same aspect can be measured in sequence within the defined time frame. This contributes to the understanding of a sole aspect during the design process as it allows for stage-based evaluation. A weakness can then be that it takes much time and effort to gather and analyse data. Fortunately, the set-up of the observations is reducing these effects which will be explained in the following section. The most striking weakness, and applicable to this study, is that the outcomes miss validity due to the research design (Pickard, 2013). Firstly, the interface of and options within the virtual model of Mercator City are not representative for all the IVR tools that exist and Mercator City is one digital representation of the Zernike Campus. The findings of this research should therefore be taken with caution. Secondly, the selection of participants is thus not a true representation of at least the different stakeholders on the Zernike Campus. Thirdly, the chosen design time puts restrictions on what can be designed within the timeframe and demands participants to make deliberate choices.

Table 7. Strengths and weaknesses of cohort designs. Source: Kazdin (2003a).

Strengths	**Weaknesses**
They can firmly establish the timeline (antecedent of some outcome of interest).	Prospective studies can take considerable time to complete, and answers to critical questions (e.g. effect of asbestos and smoking on health, effect of physical or emotional abuse on youths) may be delayed.
Measurement of the antecedents cannot be biased by the outcomes (e.g. being depressed now cannot influence past recall of events early in life – those events were assessed before being depressed).	Studies conducted over time can be costly in terms of personnel and resources. Retaining cases in a longitude study often requires full-time efforts of the researchers.
Multiple methods and assessments at different points in time can be used to assess the predictors to chart the course or progression from the antecedent to the outcome.	Attrition or loss of participants over time can bias the sample.
All of the permutations can be studied in relation to the antecedent (occurred or did not occur at Time 1) and outcome (participants did show or did not show the outcome at Time 2).	Cohort effects may serve as the moderator, that is, it is impossible that the findings are because the sample was assessed at a particular point in time.
They are good for generating and testing theories about risk, protective and causal factors and mediators and moderators.	The outcome of interest (who becomes depressed, engages in later criminal behaviour, commits suicide) may have a relatively low base rate. Statistical power and sample sizes become issues in evaluating the outcome.

3.4.2. Focus groups

After the data collection moments of the observational study were finished, participants were asked to join online focus group sessions in Google Meet at a later moment with the same members they have worked with during the design session. The goal of the focus groups was to reflect in-depth on the design process and, as a consequence, find out what the perceptions of the participants are. Based on the holistic design principles of section 2.2, four statements have been formulated below where participants could react. The statements have been asked in sequential order.

1. I could express my ideas and identity with Immersive Virtual Reality
2. I can make good designs with Immersive Virtual Reality
3. Immersive Virtual Reality stimulated dialogues, learning and knowledge-sharing
4. Immersive Virtual Reality created power imbalances between participants

According to Punch (2014), this structured manner of focus groups offers great opportunities to, on the one hand, filter and, on the other hand, collect valuable data. Especially the collective discussion, which this research has allowed to occur, assists in collective sense-making about how the design process went and what enabling or constraining factors became noticeable. The researcher took a facilitating role in the discussions and only responded to ask for more clarifications. In doing so, the discussions became an untouched narrative spoken by the participants and this coincides with the explorative nature that ethnography attempts to embrace. The supplementation of focus groups after the design session also allowed the researcher to reflect on the actual and perceived reality.

3.5 Data analysis methods

In case of the observations, the screen recordings, video recordings and audio recordings have been analysed on the basis of a codebook (Appendix 2) which has been set in advance (deductive) and elaborated during the research (inductive). The interpretation of the codes and used data is also defined in this codebook. The audio has been transcribed using Atlas.ti software. Table 8 illustrates the briefing sheets which have been used to note what happened at what time during the observations. It was particularly interesting to find out what steps will be taken at what moment in practice and how this relates to the deducted theoretical concepts because design is an iterative, interactive and co-learning process (Design-Based Research Collective, 2003; Roggema, 2016; Goudswaard et al., 2019). Naturally, the exclusion of aspects can be considered a critique on the data collection because perhaps critical information is left out. However, the purpose of the literature-review has been to review aspects which are essential for this research. A potential void should not become a barrier for finding interesting results (Joseph, 2004) and a lack of information should not prevent research on unexplored interventions because we can learn while doing research (Design-Based Research Collective, 2003; Kennedy-Clark, 2013). The results have been presented in the format of timelines in which it is clearly visible at what moment what activity did or did not take place. Blocks of five minutes have been chosen to identify the most prominent code or combination of codes and this timeframe proved to be sufficiently detailed. It is important to highlight that the shown aspects in chapter 4 are the result of observations of multiple individuals contributing to the naming of an aspect unless stated otherwise.

Similar to the audio tapings of the design session, the audio recording of the focus groups have been analysed using Atlast.ti software as well. The aforementioned codebook has been used to label the transcribed discussion. The comments have been grouped on the basis of the used concepts and integrated into the aspects of stakeholder engagement, spatial planning and design and the process of co-creation. Participants have been anonymised depending on their naming preference. In case of the discussion, the perceptions are withdrawn in order to strengthen the stakeholder view for theoretical discussion and answering the specific sub-research questions.

Table 8. Example briefing sheet.

Variable: stakeholder participation		
Aspect: instructions		
Time	Observations (perform design task/not perform design task	Audio
00-05		
05-10		
10-15		
15-20		
20-25		
25-30		
30-35		
35-40		
40-45		
The same time frames have been used after the additional assignment		

3.6 Ethical considerations

''Ethical issues include multiple responsibilities to participants (e.g., their rights and protections) and adherence to the professional standards of one's discipline (e.g., ethical codes).'' (Kazdin, 2003b, p4). In this research, participants have been asked upfront to join the research sessions and were informed about the setting, the audio and video recordings for the data collection and further ethical considerations with regards to confidentiality. At the beginning of the research session, participants have been informed about the research through an information sheet (Appendix 3) and they officially agreed on this by signing an applicant form (appendix 4) which they have received up front. During the research sessions, participants were allowed to leave the research setting at any moment and could also deny further participation in this research. The data has been handled in confidence what in this case entails that only the researcher had access to the data. After the research was finished, the audio and video recordings were deleted. It is allowed to publish this research online and participants have been informed on this potential event.

From a more substantive perspective, Sheppard (2005) has aligned six ethical considerations regarding the display and visualisation of virtual models such as the one used in this research. Not surprisingly, most of these considerations have been addressed in the literature-review but they remain important to highlight. First, the extent to which the visualisation matches the expectations. Second, the representation of the actual in the virtual. Third, the visual clarity of the visualisation. Fourth, the manner in which visualisation engages people. Fifth, the accountability of the visualisation (how did the creation process go and who made the visualisation). Sixth, the level of physical or online access people have to the visualisation. Especially during the focus groups, participants could raise their concerns on these ethical considerations.

4. Results

This chapter outlines the results of the conducted research. The following three sections describe, in line with the conceptual model, the results with regards to stakeholder engagement, spatial planning and design and co-creation processes. Figures have been made to visualise the design process in order to understand what exactly occurs at what specific time. The blocks represent each five minutes. The extra assignment is given at 45 minutes and the design session stopped at 90 minutes. Unfortunately, the design session of the non-designer group had to stop earlier due to closure of the faculty building where the VR-lab is located.

4.1 Stakeholder engagement

The concept of stakeholder participation consisted of the aspects instructions, role management, engagement, communication and hardware and software in this research. The results on these aspects are discussed in more detail below.

Instructions

Figure 8 shows the extent to which participants have been following the design instructions and tool instructions. They had five minutes to read the instruction document upfront, but it seems natural that participants have a look on what is expected and how to use IVR shortly after the beginning. The interesting finding is that all participants except one did have a look at the instruction paper after the first five minutes. One participant explained the reason for this:

> *''It takes quite some effort to put your VR-headset on and when you have it on, you are not going to take it off to look at the instruction paper. Moreover, it would be smarter to display the instructions in IVR instead of outside the VR-headset.''*
> *(Tom)*

Another interesting result is that the designer group did spend less time on familiarizing with the tool. The non-designer group was clearly focussing on exploration first before they performed the design. Both groups shared the performance of the design task and not using the tool instructions in the remainder of the design process. Five examples of these situations can be seen in figure 10.

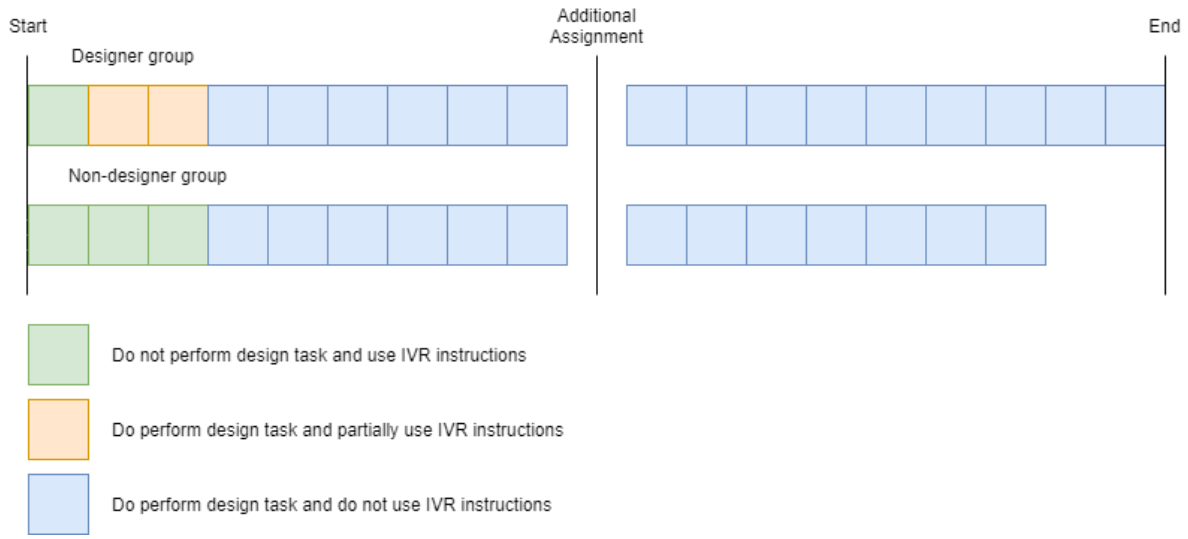


Figure 8. Results of the aspect instructions.

Role management

In general, figure 9 illustrates that the designer and communicator roles are the dominant roles within the design process. Due to technical errors, an individual was deemed crowd and on occasion an individual took a facilitative role. The interesting result is that all participants have been designing and communicating. The variety of roles which participants took during the design sessions is more narrow for the designer group than for the non-designer group (figure 9). During the design session of the designer groups only the role of communicator or designer became visible and hearable. During the other session, participants were communicator, designer, facilitator and sometimes even crowd (figure 10[6]). The designer group appeared to be more individualistic in exercising while the non-designer group started collectively through facilitating that colleague-designers could start as well. The remark is however that after some time, specifically after the assignment had been given, also the designer and communicator roles remained. Interestingly, it could not be noticed that a person took an expert role and dominated the design discourse in both design sessions.

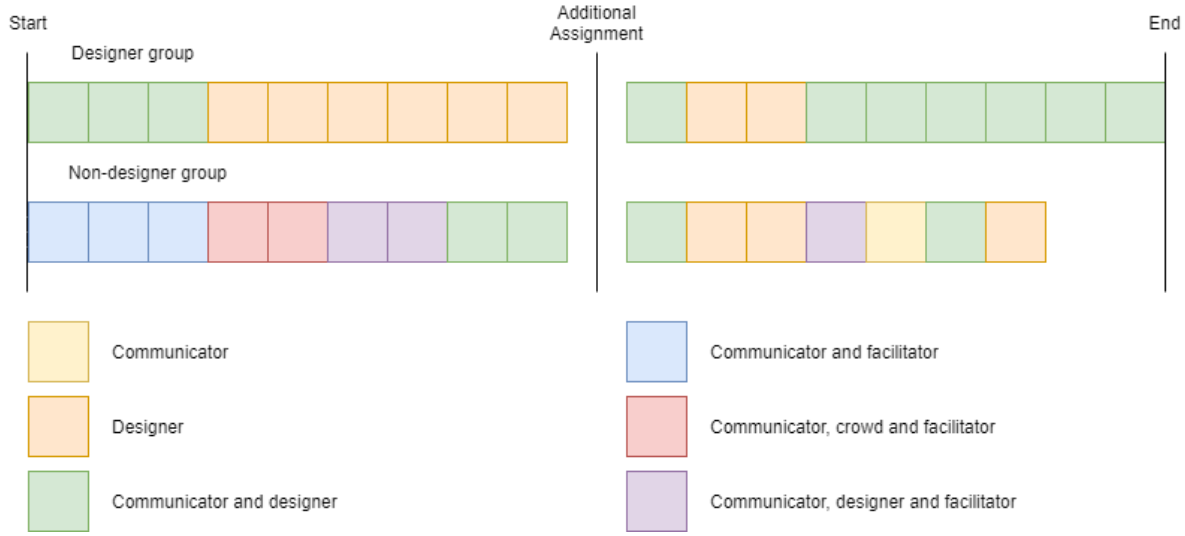


Figure 9. Results of the aspect role management.

[6] Description of the images can be found on the next page.


A
B
C
D
E

Figure 10. Examples of group dynamics visualised. In case of role management: A= communicator, B= designer, C= communicator, D= communicator and designer and E= communicator, crowd and facilitator. In case of inclusion of participants: A= Inclusion, B= Verbal inclusion and visible exclusion, C= Inclusion, D=Inclusion and partial exclusion and E=inclusion and literal exclusion.

Inclusion of participants

Innovative technologies such as IVR can cease stakeholder participation because of their newness and higher levels of unpredictability. Fortunately, the set-up of the design session did not prevent participants from creating new designs and they enjoyed the exercise. During the focus groups they mentioned the following reasons for causing (potentially) power imbalances, and consequently inclusion or exclusion: tool expertise, designing expertise, way of providing instructions, overruling (due to disrupted design processes caused by technical failure), time, differing stakeholders and intergenerational concerns. Most of the concerns have been experienced, but the last two are speculated. The audio-tapings in combination with the video-recordings illustrated some remarkable situations regarding the inclusion of participants during the design sessions. Figure 11 shows the wide variety in inclusionary and exclusionary practices that shifted sometimes from block to block. Both groups named what has been found in the literature already that IVR can stimulate an individual design process. Participants explain that design dialogues appeared at the beginning of the design session next to practical discussions on how to work with the tool. After time passed, the participants became immersed in their own model and communicated less.

The designer group verbally included every participant, but remained visually segregated (figure 10B). Almost the entire design session, participants wear the IVR-headset and communicate by voice about their ideas. Rarely, an individual took off the IVR-headset. This caused for instance the situation cited below. Surprisingly, the designer group started together after the extra assignment was given. However, they put on their IVR-headset soon after the start. On the contrary, the non-designer group planned multiple collective meetings where they discussed and viewed their perspectives with the help of their screens (figure 10C) or not (figure 10A). In order to make things more comprehensible, they technically split into two groups but collectively discussed everything after some time. This has caused that not always everyone was included during the design process or due to technical failure (figure 10E). The fifteen minutes exclusion in the non-designer group is the result of purely individual designing.

''Should we remove these football fields? They use much space.'' (Gijs)

''I just added six of them.'' (Alex)

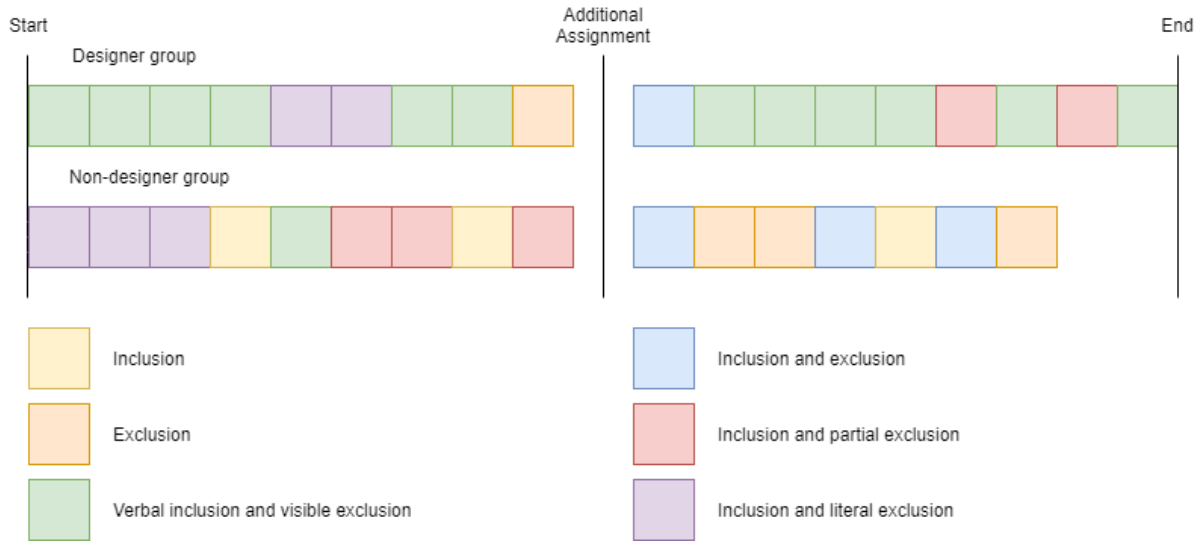


Figure 11. Results of the aspect inclusion of participants.

Communication

In terms of communication, the three categories in figure 12 are noticed. Verbal communication is the most commonly used type of communication, non-verbal communication second and no communication third. It is promising that IVR did not stop communication due to its immersive component. In general, communication appears to be difficult sometimes and decreasing as a matter of fact. The use of the IVR-headset provided that participants were not completely able to communicate their thoughts to each other which resulted in unanswered questions and unclarity (using words as here and there). Besides, participants have been communicating to themselves on a regular basis when they did find out a new option or were impressed by the visual content (such as discovering the moving water). Participants acknowledged that IVR did not stimulate dialogues, co-learning and knowledge-transfer that much during these specific design sessions, but it has the potential to do so. As a solution to the increasing individual endeavours, participants propose an online collective workspace where they can see each other and each other designs could surpass this issue to some extent. One participant also added that the possibility to write basic words could help to clarify what someone means in case a certain feature is not included in the application.

More specifically, the designer group communicated during the entire design session constantly with each other although wearing a head-mounted display (figure 10B). At the beginning of the session, one person shared his screen and communicated therefore in a non-verbal manner. This happened again at a later moment. Their ordinary verbal communication mainly involved practical issues related to tools and collective organisation, design matters (what is beneficial or not for a vibrant campus) or reference points in the model such as building names[7]. The first occurred mainly before the additional assignment and the others during the entire design session.

The non-designer group communicated in various ways. Mostly in a verbal manner and otherwise non-verbal during their plenary moments of screen-sharing (see figure 10C). Their verbal communication consisted of practical questions and discussions about the design tasks. They also used references[8] similar to the designer group and the practical questions are asked mainly during the first part of the design session. This specific group also encountered some moments when they did not communicate at all. In fact, they have been silent for fourteen minutes from 00:50:00 till 01:04:00. In combination with the fact that the participants were using IVR, this indicates that participants were totally immersed in the virtual model. These higher levels of immersion return in the coded transcript in the form of less communication before and after the additional assignment. In the designer group the amount of sentences dropped from three sentences per minute to one sentence per minute in general while the non-designer group experienced the same starting at four per minute to one sentence per minute. An exception for the non-designer group is the central discussion moment between the minutes 20 and 25. They spoke about four sentences per minute here.

[7] The designer group referred chronologically to the buildings Mercator, Foodcourt, Bernouilliborg, Duisenberg, ACLO, Hanze, Nijenborgh, AH to GO, Linnaeusborg, the Egg, Smitsborg, Feringa building, Aletta Jacobshol, Economic tower and Kapteynborg.

[8] The non-designer group referred to the buildings Linnaeusborg, Feringa building, Duisenberg, the swimming pool, Aletta Jacobshal, Mercator, Kapteynborg, ACLO, Hanze and Jaagpad.

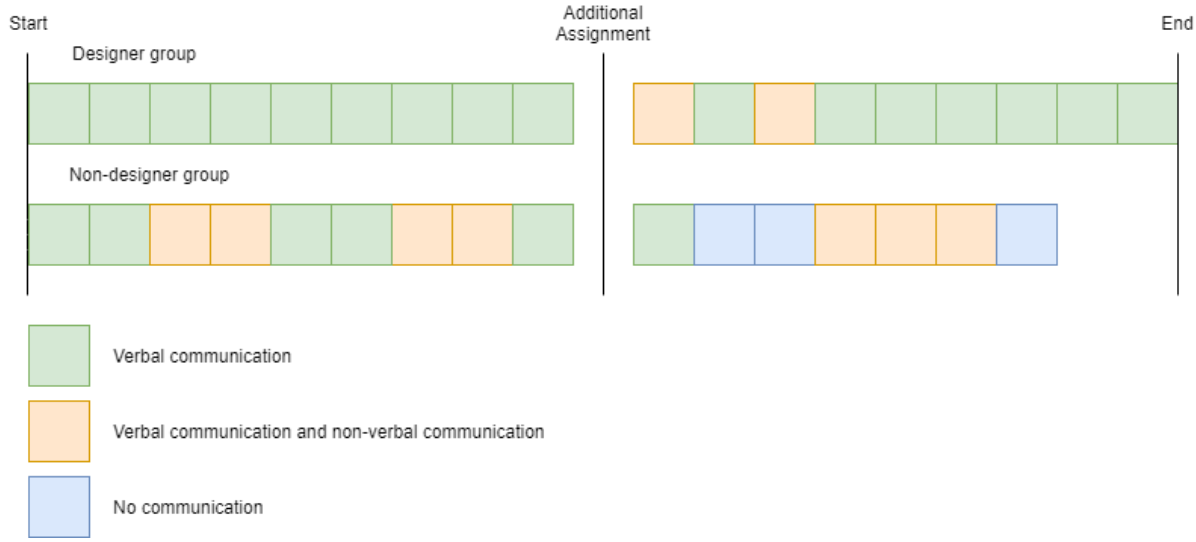


Figure 12. Results of the aspect communication.

Hardware, software and data

From the perspective of hardware, software and data, IVR is used for the two purposes of craftsmanship and transferring information. During both design sessions, participants have been either informing each other or using the tool for designing constantly (figure 13). At the moments when they did not use IVR, they were literally excluded from the design process or discussing the design matter collectively. General issues that appeared regarding the hardware, software and data are:

''It is a bit difficult to discuss things because everyone has his own working file.'' (Nils)

''I have the feeling that I am collapsing a bit and it feels like lawn-mowing with the cable in front of me.'' (Alex)

''I am unable to pick a different colour for the squares'' (Max)

Nevertheless, the hardware, software and data also created positive and remarkable notions:

''The Zernike Campus looks beautiful from the sky.'' (Hannah)

''Cool, the water is actually moving.'' (Gijs)

''Let's move the Duisenberg building immediately.'' (Alex)

''Designing with plain maps takes super long. IVR fastens this process and enables you to express your ideas sooner. For instance, putting the Duisenberg building above water takes a long time to sketch and clarify to the audience. With IVR, it is clear within no-time.'' (Patrick)

Surprisingly, the large screen visible for everyone has not been used for the purpose of information sharing. It appears everyone was dedicated to their workplace even though they were allowed to switch between locations when they disinfected their workspace. The orange blocks illustrate this as well. Participants did use IVR more independently for craftsmanship purposes from time to time. This is the result of an increase in craftsmanship as will be later illustrated in this chapter. Another interesting observation has been that participants mainly designed from above. Consequently, they did not experience the impact of their design on ground-level, which is in fact one of the assumed key advantages of using IVR. A last critical remark is that the software and data sometimes cause

confusion. One participant accidentally rotated a building and thought that the Duisenberg building was removed.

In the case of the designer group, the combination between craftsmanship and information becomes very visible (figure 13). Participants have been talking to each other about design matters in IVR. In the case of the non-designer group, the same adds up. However, they used IVR in a different way regarding information transfer than the other group. The designer group still used IVR while the non-designer group illustrated the information through voice and individual screen-sharing. These collective moments are visible in red.

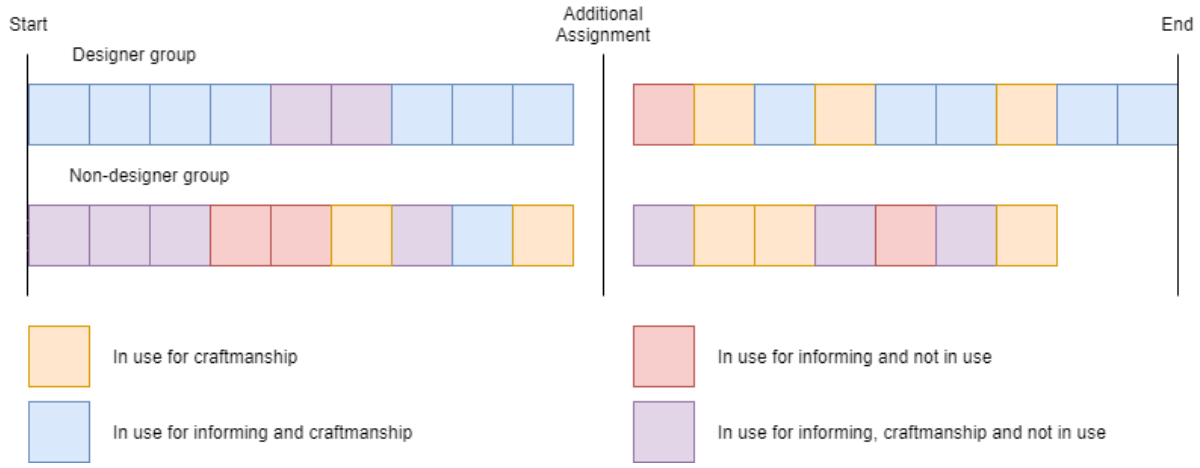


Figure 13. Results of the aspect hardware and software.

Stakeholder engagement
The design sessions have activated stakeholders to participate in a design matter to their interest. The results show that tool instructions on paper are ignored, communicative and designer roles are prominently present, inclusive and exclusive moments shift during the design session, communication can hamper and decrease after time and elements of hardware, software and data have encouraged and constrained the design process. Therefore, the general outcomes are that IVR is a tool for individual designers and does enhance participation to the extent of information and knowledge transfer. The reflective point of attention is that the used model of Mercator City only allowed designing independently on one computer and not in a digital collectively-used environment.

4.2 Spatial planning and design

In this section, the results of the aspects of spatial designing and spatial planning are presented. Impressions of the design solutions are added in order to emphasise what is meant.

Spatial designing (in terms of interactivity with objects)
After some time passed, the results in figure 14 suggest an increase in interactivity with objects. It is interesting to notice that the removal of objects occurred before the additional assignment. During the first part of the session, the existing structure of the Zernike Campus was still in place so new plans needed space. As the following paragraph will illustrate, this did not cause major building removal for example. Small-scale plots were used for testing or new objects were allocated within the existing structure. Therefore, the allocation of objects continued during the first part. The additional assignment only stimulated this development for both groups. Overall, the no interactivity moments are caused by technical failure or central discussion moments.

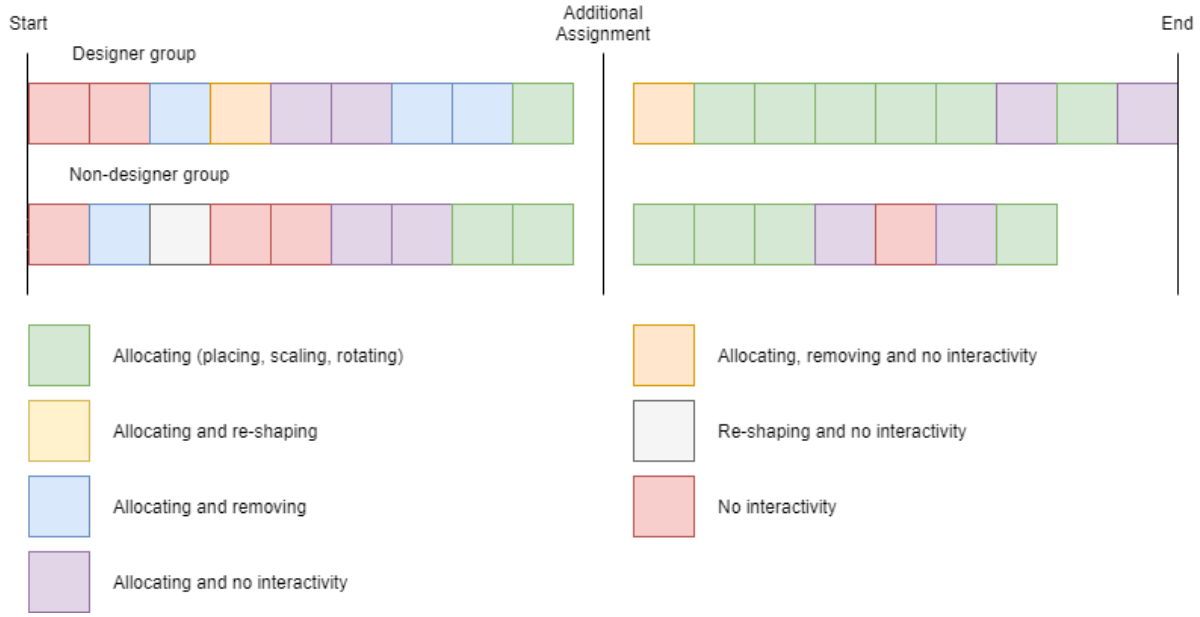


Figure 14. Results of the aspect spatial design (in terms of interactivity with objects).

Spatial designing and spatial planning

The first statement of the focus group was concerned with the extent to which participants were able to express their thoughts and ideas with IVR. The participants agreed that the used model limited design opportunities because of the limited inventory and no possibility to add new objects. On the other hand, the participants acknowledged that the model can be useful for the creation of generative designs (within the set time limit[9]). Participants shared that they were able to pinpoint or visualise what their intentions were. In answer to the returning question 'what should be added to the model?', participants replied with more basic amenities (e.g. supermarkets and restaurants), more objects from outside the existing campus area and self-created objects. On the statement whether good designs can be made with IVR, participants reacted hesitantly. They put forward that it will depend on either the intentions of the individual what to express and the purpose for which person's IVR serves as a tool. Again, they stressed the advantage of showcasing impressions and that the level of refinement can cause issues for design specialists and local communities. Generally, the results of spatial designing and spatial planning vary greatly between individuals and therefore the choice has been made to illustrate the design process with impressions (figure 15[10]).

After the additional assignment was given, spatial planning and spatial designing increased. It cannot be stated that the line of thought did change, but the absence of the buildings stimulated that participants more easily allocated objects in the remaining gaps in the landscape. Naturally, this can be a result of an increase in craftsmanship of using IVR. Two out-of-the-box examples, defined as spatial plans that are not based on existing physical structures, are counted (i.e. the large Linnaeusborg above the water and the Manhattan-like living across campus, see figure 15C and figure 15B). Other spatial plans and spatial designing derived from existing structures or the newly existing boulevard on the Zernike Campus (figure 15D and figure 15E). An interesting remark is however that the additional assignment seemingly stimulated that existing faculty buildings were appointed to new locations. The observations illustrate location-swapping and this only occurred with buildings where the aesthetics are considered higher according to the participants (e.g. Bernoulliborg, Linnaeusborg, Feringabuilding). On the contrary, the empty places outside the campus have not been used as construction sites. Since the business areas were not included in the model and the participants did not mention anything about these areas, it can be suggested that the

[9] This has been mentioned during the focus group session of the non-designer group.
[10] Descriptions of the images can be found on the next page.

participants have been mainly invoked to matters of personal interest. On the other hand, they have been designing at a lot of different places across the Zernike Campus including areas where they do not need to come per se[11]. This may indicate that people are not specifically bound to their known destinations. The end proposals show to some extent that the participants opt for a more inclusive design where different kinds of people are able to meet, live or commute. They stressed that the central bus lane is forming a barrier and the building plan causes segregation between Hanze students and university students as well as ad hoc university students. However, a critical view from the researcher on the proposal of the designer group notices spatial segregation in a new form. The designer group acknowledged this concern during their session, but emphasised the multi-use of buildings in practice. The non-designer group developed this understanding as well and mentioned that the present building structures do only allow spatial segregation. In turn, they mentioned arguments for multi-use and integrative building design. This re-addresses the notion of inclusive design for a vibrant Zernike Campus.

Within the designer group, individuals placed a few buildings, greenery and some scenery (e.g. benches, people, a square, a jungle gym and bus stops) during the first thirty-five minutes. Moreover, they removed buildings and greenery at the locations where they allocated new objects afterwards. The non-designer group focussed more on infrastructure and greenery objects. At the beginning, the individuals allocated, scaled, rotated or re-placed buildings from the existing scene and the inventory. After their collective discussion moment (block 10-15), the participants were allocating new infrastructure, greenery and scenery and removing infrastructure. The primary reason for this situation is that they agreed on removing the central bus lane for a vibrant boulevard. The non-designer group continued with this line of thinking and all individuals concentrated on new small-scale concepts around the former central bus lane. In general, the observations show that squares with on top people, greenery, small-sized buildings and scenery such as benches were created. The observations of the designer group revealed that this group also complied to a more small-scale approach (see figure 15A). They removed the Nijenborgh building and the central bus lane. In their efforts, they mainly concentrated on the area around the Nijenborgh including a new square, new infrastructure and other scenery. Interestingly, both groups indicated that the central bus lane should be removed. The solution they proposed was a concentric road around the Zernike Campus with stops either in the north or south or at predefined bus stops close to the faculty buildings.

During the second part of the design sessions (after the additional assignment) the participants within the designer group have been working mostly independent from each other. At the beginning, they were collectively agreeing that the Linnaeusborg building should become the eye-catcher and the central bus lane should be removed (see figure 15B). Then, they focussed each on different parts of the Zernike Campus. Ultimately, this caused different conceptions of how to make the Zernike Campus vibrant. One participant was concerned with the creation of parks and infrastructure all around the campus, the other with the allocation of buildings and the last participant did a bit of both while also creating a bus station. In the end, this resulted in a proposal where all concepts were so to speak integrated. However, they did not actually put all the ideas into one model and they were not aware of the creations of other participants. The non-designer group continued with their boulevard idea during the second part of the design session. They opted for an approach where each individual designed his ideas first and planned a collective moment afterwards (see figure 15D and figure 15E for end proposals). Although this shares similarities with the designer group, all participants of the non-designer group used more or less the same objects (squares, benches, people, jungle gyms, fountains and small-sized buildings representing cafés and restaurants). In general, they did not allocate massive constructions but rather kept the boulevard cosy and visually attractive. Some participants did allocate one or two bigger buildings near the end of the design session, but this was mainly driven by the idea that the Zernike Campus needed more buildings than

[11] This statement is based on the connection between stakeholders and their faculty buildings or sports centre.

they had allocated so far. Similar to the designer group, the non-designer group also did not integrate all the ideas into one model.

Spatial design

The combination of results on the interactivity with objects and the user-generated content amplifies the earlier mentioned calls of an increase in craftsmanship resulting in more communicating and designing roles. Besides, this section illustrated that participants became more actively involved in designing during the design sessions. It is interesting to see that small-scale exploratory spatial designing shifted to the combination of holistic and refined spatial planning and design. In this respect, IVR assisted in the creation of generative design visions but faced pre-programmed difficulties during the moments of refinement and creative moments. The citation below captures these frustrating moments of participants.

‘‘You are clearly limited to the pre-set objects of the inventory.’’ (Alex)

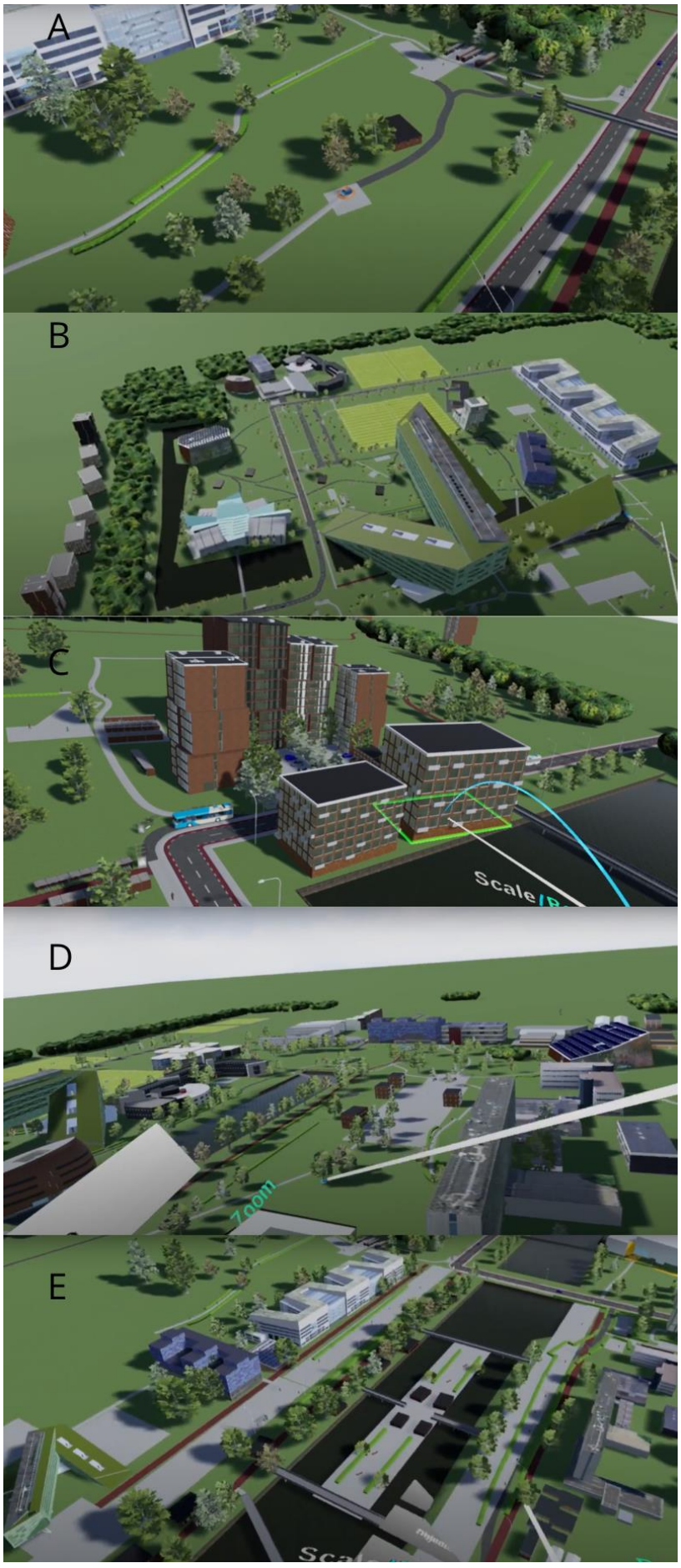

A
B
C
D
E
zoom

Figure 15. Visuals of design proposals. A= small-scale development, B= Linnaeusborg as eye-catcher, C= Manhattan-style housing, D= on-shore boulevard and E= off-shore boulevard.

4.3 Process of co-creation

Figure 16 shows the design sessions from the perspective of the co-creation process. Each group has taken a different approach for finalizing the assignment, but design by play and/or co-design appear on a frequent and continuous basis after the beginning. The no-design phase occurred in both groups right at the start and took an extra ten minutes for the non-designer group. After the no-design phase, co-design principles re-established the collective design matter. The observations show that this resulted in two directions before the additional assignment was given. The designer group discussed designer matters, while still designing by play, and the non-designer group organised individual design by play before they collectively discussed the design matter. Interestingly, both groups formed generative designs for the Zernike Campus within the first five minutes after the additional assignment was given. The designer group removed the central bus lane and located a large Linnaeusborg partially above the water. The non-designer group also removed the central bus lane, but thought of creating a boulevard with shops and café's around the water. With these generative designs in mind, the groups took again different ways of organisation. Surprisingly, the designer group ignored collective discussion moments after ten minutes and focussed on individual design by play. The non-designer group continued shifting between collective design moments and individual design moments. In the end, it turns out that the perceived generative design idea of the boulevard was actually a design principle in accordance with co-design. The moments of design by play have been individual for both groups since they did not simultaneously look at other screens while one person was designing.

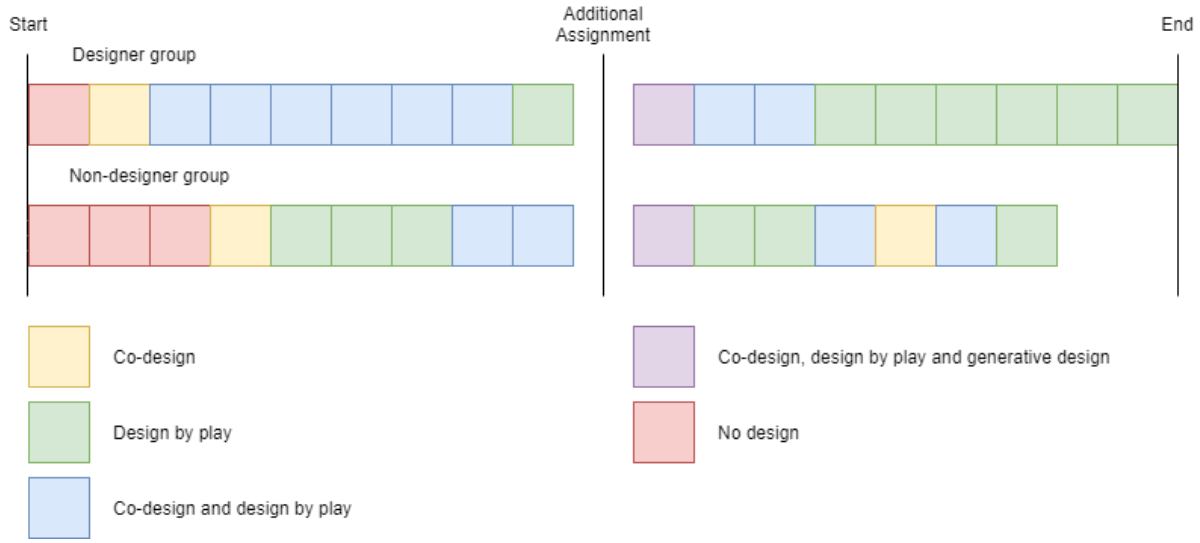


Figure 16. Results of the aspects co-design, design by play and generative design.

Co-design

The advantage of co-design is that people can define principles where the collective has to adapt to. The citation below perfectly addresses the usefulness for establishing design principles, but IVR stimulated other conversations simultaneously. While designing by play or at least sight-seeing in IVR, participants have been verbally communicating plenty of ideas on how to make the Zernike Campus more vibrant (table 9). The non-designer group communicated slightly more thoughts than the designer group. This can be the consequence of their boulevard concept. Ideas related to infrastructure and mobility appear slightly more in the designer group.

''I study on the Zernike Campus for three years now and I have never been to this side (Mercator/Duisenberg side) of the water.'' (Max)

Table 9. Ideas of the designer and non-designer groups.

Ideas designer group	**Ideas non-designer group**
Existing or general buildings, road, cycling, pedestrian infrastructure, bus stations, public transport hub, cycle parking, parking lots, transport modes, shared bicycles/steps/scooters, parks, people, wooden tables, jungle gyms, greenery, trash cans, benches, bridges, wadi's, fountains, sporting fields and student-housing.	Existing or general buildings, road, cycling, pedestrian infrastructure, bus stations, cycle parking, transport modes, parks, people, wooden tables, jungle gyms, greenery, trash cans, benches, bridges, wadi's, fountains, sporting fields, student-housing, boulevard, cafés and restaurants, nature, theatre, car-restricted area, nodes, squares, supermarkets.

Design by play and generative design

The co-design moments formed the basis of idea exploration in the first place in combination with design by play approaches. Further on, participants became also aware of the unrealistic or creative opportunities which design by play offers. From the perspective of stakeholder engagement, the non-designer group used IVR for showcasing the individually made designs. From the perspective of spatial design, the inventory and existing structure of the Zernike Campus strengthened the feeling that participants were able to modify the environment partially to their desires. This led to interesting situations (see citations below). Nevertheless, the pre-set inventory did constrain sophisticated spatial designing to a certain extent. The used model of Mercator City became useful for concept creation. The generative design considerations were for example the removal of the central bus lane and the placement of a large Linnaeusborg. A coherent generative concept has not been delivered.

''I am going to allocate the biggest tree know in Groningen.'' (Gijs)

''I think you are able to make some kind of bridge of Linnaeusborg where people can go through and walk-over.'' (Nils)

''This guy is larger than the Duisenberg building. What is the undo button?'' (Tom)

Co-creation design process

In a professional setting, the design process would probably have been pre-scripted through the person responsible for the given design tasks. This research illustrated that participants themselves are also capable of shaping the design process and actually took different approaches. In fact, this led to different spatial outcomes. The participants of the designer group had all their own subject and/or zone while the non-designer group created different concepts for the same area. Ultimately, IVR encouraged an individual design process within the collective design process.

The participants were generally speaking positive about their designing experiences with IVR (see also the last citation in section 4.1). Nonetheless, they have been asked to critically reflect on the tool and did so consequently. Participants think IVR can fasten designing processes and clarify spatial outcomes, but are doubtful regarding the usable objects. They are also critical about the collective process, which did become an individual one and raise concerns with regards to potential threats to stakeholder engagement. It thus remains important to embed IVR deliberatively in collective spatial planning and design processes.

5. Discussion

In this chapter, the results of this research are used to reflect on the theory presented in the introduction chapter and the theoretical framework. This study started with the normative quest to involve stakeholders into the collaborative spatial planning and design process by means of participatory-enhancing tools. The potential of IVR was underexplored and the results of this research contribute to better understanding of the effects of using IVR. The following sections will dive deeper into the reflections on these understandings.

5.1 Stakeholder engagement

The main criterion of stakeholder engagement consisted of five specific aspects that were used to find out the appearing group dynamics and to what extent stakeholders are participating using IVR. At first, it is important to clarify that the adopted research setting created that spatial designing was more embedded in this research. The two times 45 minutes turned out to be not sufficient in establishing collectively-agreed spatial plans, but proven to be interesting for observation of the individual spatial design process. Although all individuals developed spatial designs, collective moments of discussion focussed more on informing each other than similar spatial plans. Therefore, the results of this research indicate that IVR contributed to an individual design process rather than a collective one. However, the opposite may become true depending on the research setting. After time passed, individuals became more focussed on and stayed in their individual design environment. As a matter of fact, participants did discuss various ideas or shared their thoughts collectively at certain moments. This idea of crafting your idea first and then bringing it on the table can become an important part of the collective spatial planning and design process (Al-Kodmany, 1999). Hence, the results of this research do not automatically mean that IVR influenced stakeholder participation in a negative manner. The results only explain different sorts of stakeholder participation and the difficulties which IVR faces. After all, final design proposals will in practice probably be a mixture of designs, so individual designing can still enrich the design session (Forester, 1989; Dijkstra et al., 2003).

The newness of tools such as IVR have the potential to constrain designing to occur (Biocca, 1992) and the outcomes of this research confirm this for the first part of the design session. Participants were trying to work with IVR while the answers to their problems were written on the instruction paper. This ironic situation leads to questioning the way in which the instructions have been presented. Naturally, the non-active role of the research can be appointed as explanation (Wilson & Tewdwr-Jones, 2019). On the other hand, participants stated that the immersion and head-mounted display caused them to ignore the instruction papers. From a practical stand, solutions can be found in both directions. The facilitator of the design session can physically show and explain how to work with IVR and the instructions can be displayed virtually while wearing the head-mounted display. It is important to recognize that both can lead to different design processes. The first can help in social bonding between participants when done in group workshops while the second stimulates individual learning. It will depend on the intentions of the design sessions what is more favourable (Wilson & Tewdwr-Jones, 2019). For instance, is a session organised to become familiar with IVR or to actually design?

In case of role management, the structure of the design session can facilitate who takes what role. The minimal role of the researcher in this study was to help the participants only when they faced program errors, positioned themselves in physically dangerous situations or needed clarity on the design task. Therefore, it was interesting to find out whether stakeholders would divide roles and responsibilities. Democratic moments of mutual discussion between individuals form an occasion for this (Harris, 2002) similar to becoming a professional IVR-expert (Biocca, 1992). The two roles of communicator and designer occurred mostly during this research, but this does not mean that this will be the case for every design session where IVR is used. Surprisingly, not a person took an expert

role telling others what should happen or how they can approach the design and IVR matter the best. This pinpoints that all individuals shared more or less the same thoughts on nurturing the design sessions. Communication and designing seemed the most important objectives.

The inclusion of individuals with the design process is one the necessary conditions for co-design practices (see section 2.3, De Jonge, 2009). The individual design endeavours led however to two different kinds of engagement. In general, there have been moments of collective discussions and moments of collective silence. These are deemed necessary for polishing individual ideas and collective ideas (Wilson & Tewdwr-Jones, 2019) and facilitate reflection-in-action (Schön, 1983). The iteration between individual and collective thinking is not new in design thinking (Sanders & Stappers, 2008), but the results of this research illustrate that the increase in craftsmanship over time diminished the feedback component of the collective moments. Participants became focussed on their individual design and lost the connection to other designs. This resulted in merely informing other participants by voice or via screen-sharing what misses the goal of collaborative processes (Bjögvinsson et al., 2012). The essential discussion point here is when should people engage with each other and when not. The decrease in collaboration can be seen as a phase where collaborative engagement is slipping away (Voogt et al., 2015) or the lack of mutual communication (Van Dijk & Cooke, 2019). The counterargument is however that the intention not to intervene can stimulate an interesting creative individual process thereafter plenary feedback can be given (De Jonge, 2009). This is illustrated in this research by means of the different conceptions of the boulevard for instance. No engagement then becomes a proxy for individuals to vote for their thoughts.

Because participants have been working in separate environments, the urgency to review each other's work and communicate has been there. The designer group discussed design matters while wearing the head-mounted display which ultimately decreased the accuracy and realised individual designing (Voogt et al., 2015). The non-designer group communicated in various ways what led to the conceptual thought of a boulevard. However, verbal communication dropped for more than half. These considerations stress the point that the implementation of IVR can experience difficulties in establishing dialogues or the transfer of information verbal and/or non-verbal. Again, the issue at hand is the purpose for meaningful communication (and engagement) (Wilson & Twdwr-Jones, 2019). When the absence of communication is preventing the making of collective decisions, it can be considered that IVR is negatively impacting the collective process and should therefore do more for shaping dialogues. The other side is that individual designing can bring peace and rest to the participants because they do not have to communicate all the time. All in all, the purpose of communication differed in this research but the decrease in verbal communication touches potentially on a challenge for IVR.

The aspect hardware, software and data proved to be of critical importance when doing tool-based research. Firstly, IVR activated that participants became designers of their Zernike Campus. Secondly, participants felt actually present in their design environment. Thirdly, the convenience of using the IVR-model was high according to the participants. Fourthly, the visualisations or virtual modelling of IVR underpinned constructive discussion moments and information-sharing. Finally, the lack of experience with IVR did not create major power imbalances after two times 45 minutes. On the contrary, the limited inventory restricted design opportunities for individuals to add (self-created) content. Moreover, a shared digital platform constrained online observations of other design proposals and screen-sharing provided limited opportunity to personally experience and reflect on other designs. Furthermore, measurement of allocated buildings in order to be realistic was troublesome. Finally, the present immersive component of IVR contributed to individual design processes whereas a collectively-agreed spatial design was the ultimate goal. The combination of these incentives and pitfalls with regards to the hardware and software addresses that IVR is not per se beneficial for collaborative spatial planning and design. A perhaps surprising consequence is however that stakeholder participation did not stop except some participants who have been literally

excluded. In addition, the nuance is that IVR shifted the forms of stakeholder participation. Participants have been either communicating about IVR or design matters or effectively designing. Naturally, one individual will be sooner experienced with the hardware and software than the other, but this apparently did not influence collective designing in the most literal definition.

5.2 Spatial planning and design

The first and the second part of the design session touched upon either the interactivity with objects as the creation of spatial plans. The video-recordings showed that this process developed from experimentation towards large-scale plots. It is perhaps not a surprise that participants experimented with the objects and the technological possibilities before they created content that matched their interests (Radianti et al., 2020). The existing environment of the Zernike provided the opportunity to play, re-design and become aware of the research area. After the additional assignment had been given, it seemed that the allocation of buildings and new vibrant areas dominated the process. In other words, their incentives changed to use IVR (Puerari et al., 2018). Participants build more and more large-scale developments. Interestingly, the more visually appealing buildings returned in this new campus often in new locations. It can be assumed that the clearance of the existing building structure stimulated that participants have been re-shaping the campus. The theoretical reflection on this observation is that aesthetics and (free to design) places matter. The actions of participants are shaped through what catches their attention, it seems. This suggests that design is a subjective process wherein participants become attached to certain visible particles of the design process and ignore others (Van Leeuwen et al., 2018). The removal of buildings shaped in that sense that new buildings should be placed instead of designing the infrastructure first for example. Next to this, a strong conceptual lens such as a boulevard delineated the design process and the spatial plans. A critical review in the context of section 5.1 learns nonetheless that spatial design and spatial planning did not per se serve a collective goal. The participants have been active with exploring IVR for individual purposes. This poses the question what the benefits of these individual spatial plans and designs are. The duration of the experiments do not allow such a question to be answered, but the disintegration of content can be seen as problematic from a participatory view as from a professional point of view (Dobbins, 2009).

5.3 Process of co-creation

The key notion of prescriptive design processes is that the prescription logically orders the different steps of the design processes. The iteration of design steps can make that the assumed sequence can be interrupted (Goudswaard et al., 2019), but this research illustrated that a tool can divine the design process as well. From the start onwards, participants have been working with IVR. Generative design appeared on the side and co-design and co-creation emerged during almost all blocks. The used hardware, software and data helped participants to express their visions, but did not contribute to collectively-agreed designs. Therefore, IVR can be an appropriate tool for design by play phases or serve as input for moments of co-design, design by crowd and generative design. In addition, this research showed that participants can work independently with IVR which can be valuable to these specific approaches when all stakeholders conform to this. From this perspective, IVR can be part of a wider collaborative planning and design process (Wilson & Tewdwr-Jones, 2019) but the necessary condition is that IVR or a combination of tools including IVR not prevent stakeholders from participating (Al-Kodmany, 1999). Hence, it is essential to make the tool easily accessible for its users and constitute reflection and feedback moments (Ceconello & Spallazzo, 2008; Zhu et al., 2020). According to the participants, the duration of the experiments of this research was too short, similar to the three hour workshops of Salter et al. (2009). The assumption can therefore be made that time is an important factor in determining the length of the design sessions but may endanger the willingness to participate on the other hand. The design arena of this research provides in that sense an interesting observation that participants remained involved in the design task. Actively involving

stakeholders can therefore be considered not only essential for generating spatial design but simultaneously entangling stakeholders to the (prescribed) design process.

5.4 Perceptions

The participants have been in general positive on the implementation of IVR because it allowed them to modify the environment easily and express their thoughts and ideas to a certain extent. The nature of digital tools such as IVR substantively explains that its applied use needs to be programmed (Griffon et al., 2011; Jamei et al., 2017). The reproduction of ideas and identity is consequently connected to what the manufacturers included. The perception of participants regarding the limited options of the used IVR-system is therefore valid and illustrates the usefulness of IVR for the transfer of generic design visions. The more depressing thought is that IVR relies on the expertise of its manufacturers to become more inclusive to non-inventory objects. In order to not become an expert tool, it is relevant to underline that IVR can become more effective and realistic when participants can add their own creations or existing objects from a database. As the results suggest, only then can good designs be made with IVR instead of solely inspiring designs. The essence of this matter is that participants are able to reflect their ideas 1:1 and make better informed decisions as a consequence (Innes, 1998; Dobbins, 2009). At the start, an invitational and political-free design arena for all people with a stake is the basis from which useful designs can emerge (Ball et al., 2007). In the end, the truly collaborative underpinnings ensure that stakeholders will perceive this similar to the participants of this research.

6. Concluding thoughts

This research aimed to explore the potential of IVR as a participatory-enhancing tool for collaborative spatial planning and design. The findings of this study suggest that IVR can function as a participatory-enhancing tool as a result of achieved individual craftsmanship, but this mainly depends on the co-design setting. In answering the first secondary question, the used IVR-system diminished group dynamics in terms of communication and the inclusion of participants and translated the co-creation design process to an individual design process. When active, stakeholders were either communicating design or IVR related sentences or actually designing. IVR instructions have been (completely) ignored. Related to the second secondary question, the setting of this research formed the basis for individual craftsmanship and design to occur while the collective goal remained in the background. Spatial outcomes developed from small-scale development towards small-scale and large-scale developments where arranged design rules played an important role in establishing spatial designs. Ultimately, the participants designed different conceptions of their collectively-agreed conceptual lenses or co-designed rules in other words. Participants acknowledged that they felt more immersed into their own virtual environment after time passed and their ability to use IVR increased. They state that these developments encouraged individual design solutions and discussions on these solutions, but made it difficult to come up with one collective design. The outcomes of this research therefore suggest that the used IVR-system is most effective for (individual) design by play efforts while it has the potential to become involved in other stages of co-creation design process. In line with these concluding thoughts, the following research directions are recommended:

- Extensive research on the implications of using IVR in phases of spatial planning and design processes where collective decisions need to be made with a differing nature (e.g. differences in spatial planning and design matter or number of stakeholders).
- Scrutinizing the effects of paper instructions, digital instructions and facilitator instructions in relation to different stakeholder groups.
- Examination of the potential to add self-created content or content from a web-based library to the used IVR inventory by individuals and collectives.
- Investigation of the effects of IVR in an online collective design environment where participants are able to communicate.
- Impact assessments on the feasibility of design proposals made in IVR in general.
- The creation of an IVR-system purely based on the input of a potential stakeholder group
- Tracking and quantifying observational data through artificial intelligence in order to identify patterns in group dynamics and spatial design.

7. Reflection

The introductory chapter already stated that IVR is probably not the holy grail as a participatory-enhancing tool for collaborative spatial planning and design, but this study revealed that IVR can be an interesting and convenient tool to enhance stakeholder participation although individually. The necessary reflection is that the used research setting and the used hardware and software contributed to this statement. The research setting nurtured that individuals were mostly working in their own digital environment and definitely needed more help than the given on-paper instructions at the beginning of the design session. The non-facilitating role of the researcher is deemed not desired and would have helped the actual design process to start earlier (Booher & Innes, 2002; Wilson & Tewdwr-Jones, 2019). However, the behaviour of participants showed that they made individual efforts to become familiar with the tool. After they learned how to use IVR, the modification of the Zernike Campus increased. Nevertheless, the design possibilities offered through the used Mercator City application is seen as restrictive to the design process. General and existing scenery could be allocated, but the participants missed the opportunity to self-create content. On the other hand, the time window of two times 45 minutes was sufficient to establish generic visions according to the participants. For practitioners, it remains thus important to review the intentions why IVR should be used and what are the stakeholders which need to be involved. For instance, IVR can be used solely for informing stakeholders and allows them to react to proposals. The concern with this situation is that planning and design are still not truly collaborative. Allowing them to design an environment and discuss the design can be. This makes the role of spatial planners and designers crucial for further development and implementation of IVR. As IVR is new and innovative, spatial planners and designers need to be wary of not translating IVR in an expert tool while it can be a participatory-enhancing tool.

References

Abdelhameed, W., A. (2013). Virtual Reality Use in Architectural Design Studios: A case of studying structure and construction. *Procedia Computer Science*, 25, 220-230.

Al-Kodmany, K. (1999). Using visualization techniques for enhancing public participation in planning and design: Process, implementation, and evaluation. *Landscape and Urban Planning,* 45(1), 37-45.

Albrechts, L., Barbanente, A., & Monno, V. (2019). From stage-managed planning towards a more imaginative and inclusive strategic spatial planning. *Environment and Planning C: Politics and Space*, 37(8), 1489-1506.

Atkinson, P., Coffey, A., Delamont, S., Lofland, J., & Lofland, L. (2000). *Handbook of ethnography*. London: Sage.

Baker, M., Coaffee, J., & Sherriff, G. (2007). Achieving successful participation in the new UK spatial planning system. *Planning, Practice & Research*, 22(1), 79-93.

Ball, J., Capanni, N., & Watt, S. (2007). Virtual reality for mutual understanding in landscape planning. *International Journal of Social Sciences,* 2(2), 78-88.

Bateman, I. J., Day, B. H., Jones, A. P., & Jude, S. (2009). Reducing gain–loss asymmetry: a virtual reality choice experiment valuing land use change. *Journal of environmental economics and management*, 58(1), 106-118.

Batty, M. (2018). *Inventing Smart Cities*. Massachusetts: MIT Press.

Biocca, F. (1992). Virtual Reality Technology: A Tutorial. *Journal of Communication,* 42 (4), 23-72.

Björgvinsson, E., Ehn, P., & Hillgren, P. A. (2010). Participatory design and "democratizing innovation". In *Proceedings of the 11th Biennial participatory design conference* (pp. 41-50).

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive Virtual Environment Technology as a Methodological Tool for Social Psychology. *Psychological Inquiry*, 13 (2), 103-124.

Blythe, J., Silver, J., Evans, L., Armitage, D., Bennett, N. J., Moore, M. L., ... & Brown, K. (2018). The dark side of transformation: latent risks in contemporary sustainability discourse. *Antipode*, 50(5), 1206-1223.

Booher, D. E., & Innes, J. E. (2002). Network power in collaborative planning. *Journal of Planning Education and Research*, 21(3), 221-236.

Brand, R., & Gaffikin, F. (2007). Collaborative planning in an uncollaborative world. *Planning Theory*, 6(3), 282-313.

Campus Groningen (2021). *Locatie Healthy Ageing Campus*. Retrieved on 16 May 2021 from https://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjcr5O-5OXwAhVUPuwKHWzRAfYQFjAFegQIBhAD&url=https%3A%2F%2Fcampus.groningen.nl%2Fuploads%2Ffckconnector%2Fe9430d86-7745-5384-af42-

c412e4712a61%2F3169551651%2FBouwkaart%2520CG%2520-23032021%2520hr.pdf&usg=AOvVaw1P-zguxlPN3x0YGKtUKCaG.

CASUS VR-lab (n.d.). *Image from the CASUS VR-lab library.*

Ceconello, M., & Spallazzo, D. (2008). Virtual reality for enhanced urban design. In Proceedings of 5th INTUITION, *International Conference Virtual Reality in Industry and Society: From Research to Application*. 6-8 Ottobre 2008. Torino.

De Groot, J., Kwak, J. F., & Oosterveld, W. (2015). Zernike Campus Groningen: Onderweg naar leefbaarheid en een stimulerende leeromgeving. *Bachelor Thesis*. Retrieved on 16 May 2021 from Scriptie Zernike Campus Groningen W. Oosterveld_J. de Groot_J. Kwak.pdf (hanze.nl).

De Jonge, J. (2009). Landscape architecture between politics and science: an integrative perspective on landscape planning and design in the network society. *PhD thesis*. Wageningen University.

Design-Based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational researcher*, 32(1), 5-8.

Dijkstra, J., Van Leeuwen, J., & Timmermans, H. (2003). Evaluating design alternatives using conjoint experiments in virtual reality. *Environment and Planning B: Planning and Design*, 30(3), 357-367.

Dobbins, M. (2009). *Urban Design and People*. New Jersey: John Wiley & Sons, Inc.

Durall, E., Bauters, M., Hietala, I., Leinonen, T. & Kapros, E. (2019). Co-creation and co-design in technology enhanced learning: Innovating science learning outside the classroom. *Interaction Design and Architecture(s) Journal,* 42, 202-226.

Ehn, P. (1988). Work-oriented design of computer artifacts*. Doctoral dissertation*, Arbetslivscentrum.

Evans-Cowley J., & Hollander J. (2010). The new generation of public participation: Internet-based participation tools. *Planning, Practice & Research*, 25(3), 397-408.

Fleischmann, K. (2015). The democratisation of design and design learning–how do we educate the next–generation designer. *International Journal of Arts & Sciences*, 8, 101-108.

Forester, J. (1989). *Planning in the face of power*. Berkeley: University of California Press.

Freeman, R. E. (1984). *Strategic management: A stakeholder approach.* Boston: Pitman.

Frow, P., Nenonen, S., Payne, A. & Storbacka, K. (2015). Managing co-creation design: A strategic approach to innovation. *British Journal of Management*, 26 (3), 463-483.

Goodspeed, R. (2016). The Death and Life of Collaborative Planning Theory. *Urban Planning*, 1(4), 1-5.

Goudswaard, M., Forbes, H., Kent, L., Snider, C., & Hicks, B. (2019). Different approaches to democratise design-are they equal?. In *Proceedings of the Design Society: International Conference on Engineering Design*, 1 (1), pp. 119-128. Cambridge University Press.

Greenhalgh, T., Jackson, C., Shaw, S. & Janamian, T. (2016). Achieving research impact through co-creation in community-based health services: literature review and case study. *The Milbank Quarterly*, 94 (2), 392-429.

Griffon, S., Nespoulous, A., Cheylan, J. P., Marty, P., & Auclair, D. (2011). Virtual reality for cultural landscape visualization. *Virtual Reality*, *15*(4), 279-294.

Hammersley, M., & Atkinson, P. (1983). *Ethnography: Principles in practice*. New York and London: Routledge.

Harris, N. (2002). Collaborative Planning: From Theoretical Foundations to Practice Forms. In Allmendinger, P. & Tewdwr-Jones, M. (Eds.), Collaborative planning. Planning futures: New directions for planning theory, pp. 21-43. Routledge: London and New York.

Haymaker, J., Keel, P., Ackermann, E. & Porter, W. (2000). Filter mediated design: generating coherence in design. *Design Studies*, 21, 205-220.

Healey, P. (1996). The communicative turn in planning theory and its implications for spatial strategy formation. *Environment and Planning B: Planning and design*, 23(2), 217-234.

Healey, P. (1997). *Collaborative Planning – Shaping Places in Fragmented Societies*. Houndmills and London: Macmillan.

Healey, P. (2003). Collaborative Planning in Perspective. *Planning Theory,* 2(2), 101-123.

Herbert, S. (2000). For ethnography. *Progress in human geography*, 24(4), 550-568.

Heydarian, A., Carneiro, J. P., Gerber, D., Becerik-Gerber, B., Hayes, T., & Wood, W. (2015). Immersive virtual environments versus physical built environments: A benchmarking study for building design and user-built environment explorations. *Automation in Construction*, *54*, 116-126.

Innes, J. E. (1998). Information in Communicative Planning. *Journal of the American Planning Association*, 64 (1), 52-63.

Jamei, E., Mortimer, M., Seyedmahmoudian, M., Horan, B. & Stojcevski, A. (2017). Investigating the role of Virtual Reality in Planning for Sustainable Smart Cities. *Sustainability,* 9 (11).

Jeng, M., Pai, F. & Yeh, T. (2017). The Virtual Reality Leisure Activities Experience on Elderly People. *Applied Research Quality Life*, 12 (1), 49-65.

Jensen, L. & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, 23, 1515-1529.

Joseph, D. (2004). The practice of design-based research: Uncovering the interplay between design, research, and the real-world context. *Educational psychologist*, 39(4), 235-242.

Kazdin, A., E. (2003a). Experimental and observational designs: An overview. In A. E. Kazdin (Ed.), Methodological issues & strategies in clinical research (pp 155–180). *American Psychological Association*.

Kazdin, A. E. (2003b). Methodology: What it is and why it is so important. In A. E. Kazdin (Ed.), Methodological issues & strategies in clinical research (pp 5–22). *American Psychological Association*.

Kennedy-Clark, S. (2013). Research by Design: Design-Based Research and the Higher Degree Research student. *Journal of Learning Design*, 6(2), 26-32.

Kuliga, S. F., Thrash, T., Dalton, R. C. & Hölscher, C. (2015). Virtual reality as an empirical research tool — Exploring user experience in a real building and a corresponding virtual model. *Computers, Environment and Urban Systems*, 54, 363-375.

Lawson, B. (2005). *How designers think: the design process demystified*. Fourth Edition. London: Architectural Press.

Lei, Z., Shimizu, Sh., Ota, N., Ito, Y. & Zhang, Y (2016). Construction of Urban Design Support System using Cloud Computing Type Virtual Reality and Case Study. *International Review for Spatial Planning and Sustainable Development,* 5 (1), 15-28.

Lv, Z., Yin, T., Zhang, X., Song, H. & Chen, G. (2016). Virtual Reality Smart City Based on WEBVRGIS. *IEEE Internet of Things Journal*, 3 (6), 1015-1024.

Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development*, 66(5), 1141-1164.

Margarum, R. D. (2002). Collaborative Planning Building Consensus and Building a Distinct Model for Practice. *Journal of Planning Education and Research*, 21, 237-253.

Matthews, Y., Scarpa, R., & Marsh, D. (2017). Using virtual environments to improve the realism of choice experiments: A case study about coastal erosion management. *Journal of Environmental Economics and Management*, 81, 193-208.

Mazuryk, T. & Gervautz, M. (1999). Virtual Reality History, Applications, Technology and Future. *Online paper*. Retrieved on 12 October 2020 from https://www.cg.tuwien.ac.at/research/publications/1996/mazuryk-1996-VRH/TR-186-2-96-06Paper.pdf.

Morganti, F., Marrakchi, S., Urban, P. P., Iannoccari, G. A., & Riva, G. (2009). A virtual reality based tool for the assessment of “survey to route” spatial organization ability in elderly population: preliminary data. *Cognitive processing*, 10(2), 257-259.

Nakakoji, K. (2006). Meanings of tools, support, and uses for creative design processes. In *International design research symposium*, 6, pp. 156-165.

Napatov, A. & Fisher-Gewirtzman (2016). Visibility of Urban Activities and Pedestrian Routes: An Experiment in a Virtual Environment. *Computers, Environment and Urban Systems*, 58 (1), 60-70.

Nienhuis, I., van Dijk, T. & de Roo, G. (2011). Let's Collaborate! But Who's Really Collaborating? Individual Interests as a Leitmotiv for Urban Renewal and Regeneration Strategies. *Planning Theory & Practice*, 12(1), 95-109.

Okra (2016). *Zernike Groningen – Structuurontwerp Tussengebied*. Retrieved on 16 May 2021 from https://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjVxInn-ebwAhWJlxQKHSeSCzYQFjABegQIAxAD&url=https%3A%2F%2Fcampus.groningen.nl%2Fuploads%2Ffckconnector%2Fd99688aa-1d48-5c77-b066-c1bbf7bc58e1%2F3163403914%2F2016%252003%252031%2520-%252015-120_Groningen%2520Zernike%2520Tussengebied_folder.compressed.pdf&usg=AOvVaw1_divRDhiCdDSL5GqusjiS.

Ostrom, E. (1996). Crossing the great divide: Coproduction, synergy, and development. *World Development*, 24, 1073-1087.

Paes, D., Arantes, E., & Irizarry, J. (2017). Immersive environment for improving the understanding of architectural 3D models: Comparing user spatial perception between immersive and traditional virtual reality systems. *Automation in Construction,* 84, 292-303.

Pamungkas, L. S., Meytasari, C., & Trieddiantoro, H. (2018). Virtual Reality As A Spatial Experience For Architecture Design: A Study of Effectiveness for Architecture Students. *SHS Web of Conferences,* 41 (2).

Pitt, D. G., & Nassauer, J. I. (1992). Virtual Reality Systems and research on the perception, simulation and presentation of environmental change. *Landscape and Urban Planning*, 21 (4), 269-271.

Patterson, Z., Darbani, J. M., Rezaei, A., Zacharias, J., & Yazdizadeh, A. (2017). Comparing text-only and virtual reality discrete choice experiments of neighbourhood choice. *Landscape and Urban Planning*, 157, 63-74.

Pickard, A. J. (2013). *Research methods in information*. London: Facet publishing.

Puerari, E., de Koning, J. I. J. C., von Wirth, T., Karré, P. M., Mulder, I. J., & Loorbach, D. A. (2018). Co-Creation Dynamics in Urban Living Labs. *Sustainability,* 10.

Punch, K. F. (2014). *Introduction to Social Research: Quantitative & Qualitative Approaches*. London: Sage.

Radianti, J., Majchrzak, T. A., Fromm, J., Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: design elements, lesson learned, and research agenda. *Computers and Education*, 148.

Riva, G. (1999). Virtual reality as communication tool: a socio-cognitive analysis. *Presence Teleoperators & Virtual Environments*, 8 (4), 462-468.

Roggema R. (2016). Research by Design: Proposition for a Methodological Approach. *Urban Science*, 1(1).

Roggema, R. (2021). From Nature-Based to Nature-Driven: Landscape First for the Design of Moeder Zernike in Groningen. *Sustainability*, 13(4), 2368.

Salter, J. D., Campbell, C., Journeay, M. & Sheppard, S. R. J. (2009). The digital workshop: Exploring the use of interactive and immersive visualisation tools in participatory planning. *Journal of Environmental Management*, 90 (6), 2090-2101.

Sandercock, L. (2004). Towards a Planning Imagination for the 21st Century. *Journal of the American Planning Association*, 70(2), 133-141.

Sanders, E. B-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design, *Co-Design*, 4 (1), 5-18.

Sanoff, H. (1999). *Community participation methods in design and planning*. John Wiley & Sons.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books.

Sheppard, S. R. J. (2005). Validity, reliability, and ethics in visualization. In: Bishop, I., Lange, E. (Eds.), *Visualization in Landscape and Environmental Planning*. Taylor and Francis, London, (Chapter 5), pp. 79–97.

Soares, I., Yamu, C., & Weitkamp, G. (2020). The Relationship between the Spatial Configuration and the Fourth Sustainable Dimension Creativity in University Campuses: The Case Study of Zernike Campus, Groningen, The Netherlands. *Sustainability*, 12(21), 9263.

Stelzle, B., Jannack, A., & Noennig, J. R. (2017). Co-design and co-decision: Decision making on collaborative design platforms. *Procedia computer science*, 112, 2435-2444.

Strauss, A., L., & Corbin, J. (1990). *Basics of Qualitative Research*. Thousand Oaks: SAGE Publications.

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

Tewdwr-Jones, M. & Allmendinger, P. (1998). Deconstructing Communicative Planning: A Critique of Habermasian Collaborative Planning. *Environment and Planning A*, 30, 1975-1989.

Thisgaard, M., & Makransky, G. (2017). Virtual learning simulations in high school: Effects on cognitive and non-cognitive outcomes and implications on the development of STEM academic and career choice. *Frontiers in psychology*, *8*, 805.

Thorpe, A. (2017). Rethinking Participation, Rethinking Planning. *Planning Theory & Practice*, 18(4), 566-582.

Van de Gevel, A. J. M. (2018). *(On) verbondenheid met de stad Groningen*. *Bachelor Thesis*. Retrieved on 16 May 2021 from Scriptie-Anke_van_de_Gevel-def_1.pdf (rug.nl).

Van der Vaart, G., Van Hoven, B., Huigen, P.P.P. (2018). Creative and Arts-Based Research Methods in Academic Research; Lessons from a Participatory Research Project in the Netherlands. *Forum Qualitative Social Research*, 19 (2), Art. 19., 28 p.

Van Dijk, T., & Cook, M. (2019). Design Dialogues as a Specific Mode of Communication – About the Ongoing Exploration of Solution Space. *Design Discourse on Culture and Society,* 5.

Van Leeuwen, J. P., Hermans, K., Jylhä, A., Quanjer, A. J., & Nijman, H. (2018). Effectiveness of virtual reality in participatory urban planning: A case study. In *Proceedings of the 4th Media Architecture Biennale Conference* (pp. 128-136).

Voogt, J., Laferriere, T., Breuleux, A., Itow, R. C., Hickey, D. T., & McKenney, S. (2015). Collaborative design as a form of professional development. *Instructional science*, 43(2), 259-282.

Wang, X. (2018). Virtual reality of 3D digital factory based on coastal environment. *Journal of Coastal Research*, 83 (1), 507–512.

Watcharasukarn, M., Page, S., & Krumdieck, S. (2012). Virtual reality simulation game approach to investigate transport adaptive capacity for peak oil planning. *Transportation Research Part A: Policy and Practice*, 46(2), 348-367.

Watson, V. (2014). Co-production and collaboration in planning - The difference. *Planning Theory & Practice*, 15(1), 62-76.

Welty, C., & Setiawan, A. (2019). *Digital Immersion− case studies in virtual reality*. In SHS Web of Conferences (Vol. 64, p. 01007). EDP Sciences.

Wicker, A., W. (1985). Getting out of our conceptual ruts: Strategies for expanding conceptual frameworks. *American Psychologist*, 40(10), 1094-1103.

Williams, D. R., & Stewart, S. I. (1998). Sense of Place: An Elusive Concept That is Finding a Home in Ecosystem Management. *Journal of Forestry*, 96 (5), 18-23.

Wilson, A., & Tewdwr-Jones, M. (2019). Let's draw and talk about urban change: Deploying digital technology to encourage citizen participation in urban planning. *Environment and Planning B: Urban Analytics and City Science*, 0 (0), 1-17.

Wu, T., Wu, F., Liang, C., Li, Y., Tseng, C. & Kang, S. (2019). A virtual reality tool for training in global engineering. *Information Society*, 18 (2), 243-255.

Yaremych, H. E., & Persky, S. (2019). Tracing Physical Behaviour in Virtual Reality: A Narrative Review of Applications to Social Psychology. *Journal of Experimental Psychology*, 85.

Zhao J., Sensibaugh, T., Bodenheimer, B., McNamara, T. P., Nazareth, A., Newcombe, N., Minear, M. & Klippel, A. (2020). Desktop versus immersive virtual environments: effects on spatial learning. *Spatial Cognition & Computation*, 1-36.

Zhu, W., Guo, S. & Zhao, J. (2020). Planning participants' preferential differences under immersive virtual reality and conventional representations: An experiment of street renewal. *Environment and Planning B: Urban Analytics and City Science*, 0(0), 1–15.

Appendix 1 'Instruction paper'

Design instructions

Introduction
Welcome to the design session for the master thesis research: Immersive Virtual Reality, a participatory-enhancing tool for collaborative spatial planning and design? Hereby, I would like to thank you in advance for participating in the design session and, subsequently, the focus group session. On this page you will find information regarding the design task and on the page at the back you will find information on how to use the tool Immersive Virtual Reality. Good luck!

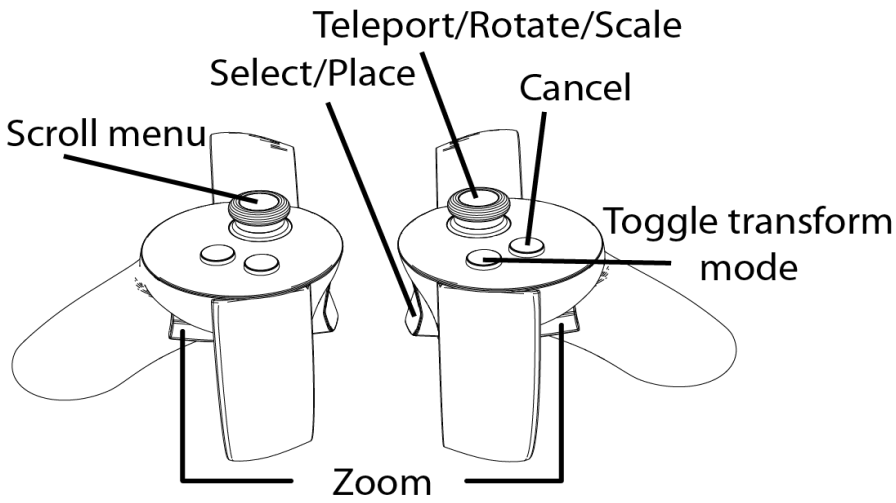
Design task
As one of the stakeholders of the Zernike Campus, you are invited to re-design the physical environment of the Zernike Campus to your liking. The goal is to create a more vibrant campus with your colleague designers where people want to be instead of, functionally, have to be. The virtual model of Mercatory City allows to remove, replace, re-scale or allocate on-campus or standardized:

- Buildings (e.g. houses and offices)
- Greenery and nature-based objects
- Pedestrian, cyclists and road infrastructure
- Transportation modes
- Digital human beings
- Pointers in the environment for highlighting specific locations (pointers need to be explained what they represent)

These objects can be found in the catalogues within the application. Your group has one and a half hours to finish your vibrant design proposal on one of the computers. An additional assignment will be given after 45 minutes. Always keep 1,5meter distance between your colleagues due to the ongoing presence of the COVID19-virus within our society. Have fun and start designing (after you read the tool instructions)!

Tool instructions

All the interaction is done using the Oculus Touch controllers. The right hand controller is used to select and manipulate objects while the left hand controller is used to display a menu.



Selecting
This is done by pushing the **Select** button (right trigger). You can use this button to select objects or click on menu entries.

When you select an object the user interface on the left hand controller will change to show additional options for the selected object.

To deselect and object press the **Cancel** (right **A**-button) button.

Teleporting
Moving around is done by teleportation. To teleport first **press** the **Teleport** stick (right thumb stick). You will see a blue arc pointing out of the controller. When you release the thumb stick you will be teleported to the other end of this arc. You can also move the thumb stick to control which way you will point when you are done teleporting.

Zooming
To zoom in/out hold down **Zoom** buttons on both controllers. Then move your hands together to zoom out or further apart to zoom in.

Manipulating objects
When you have an object selected you can rotate or scale this object by moving the right thumb stick. Depending on the transform mode the object will rotate or scale. There are labels placed over the controllers that show the current transform mode. You can change this mode by pressing the **B**-button on the right controller.

You can also move an object, this is done by pressing the **Select** button and holding it for a half a second. Keep holding the button till you are satisfied with the new position and then release the button.

Building roads
There are two types of roads. One-lane roads and two-lane roads. One-lane roads have three types: car, bicycle and pedestrian. Two-lane roads are normal car roads but with an option to add a bicycle or pedestrian lane to the right or right of them.

Roads consist of road segments that are attached to intersections. One-lane and two-lane roads have their own special intersections that they can be attached to. A two-lane intersection or a roundabout will adapt to the roads that are attached to it automatically.

To build a road segment select a road type and use the right trigger button to place the starting point of the road. You can then keep pressing the right trigger button to place subsequent points and the road will follow those points. When you are finished placing a road press the **Cancel** button.

You can also attach the end points to an intersection.

Placing objects
You can place buildings or other objects by selecting them from the menu and placing them on the ground. The different object are grouped by different categories: buildings, foliage, people, transportation and objects.

Placing notes
You can also place a note. Notes have colours that can be changed by selecting the note and then selecting the colour from the menu on your left hand controller.

Appendix 2 'Codebook'

Variable	Aspect	Code
Stakeholder engagement	Instructions	Perform design task (d) *Observed through screen recordings, video recordings and/or audio recordings.*
		Use VR instructions (d) *Observed through video recordings.*
		Not perform design task (d) *Observed through screen recordings, video recordings and/or audio recordings.*
		Not using VR instructions *Observed through video recordings.*
	Role management	Communicator (d) *Person who communicates with regards to the design task. Observed through screen recordings, video recordings and/or audio recordings.*
		Facilitator (d) *Person who helps other participants with IVR. Observed through video recordings and/or audio recordings.*
		Expert (d) *Person who determines what others should do and how without involving them in the decision-making process. Observed through video recordings and/or audio recordings.*
		Designer (d) *Person who is solely designing in IVR. Observed through screen recordings, video recordings and/or audio recordings.*
		Crowd (d) *Person who is not involved in the design process at all. Observed through video recordings and/or audio recordings.*
	Inclusion of participants	Inclusion (d) *Observed through video recordings and/or audio recordings.*
		Exclusion (d) *Observed through video recordings and/or audio recordings.*
		Literal exclusion (i) *Exclusion due to technical issues. Observed through video recordings and/or audio recordings.*
		Partial exclusion (i) *A part of the group communicates independently from the other part. Observed through video recordings and/or audio recordings.*

	Communication	Non-verbal communication (d) *Communication between participants using IVR to illustrate what is meant. Observed through video recordings and/or audio recordings.*
		Verbal communication (d) *Communication between participants through speaking. Observed through video recordings and/or audio recordings.*
		No communication (i) *No communication between participants. Observed through video recordings and/or audio recordings.*
	Hardware, software and data	Not in use (d) *Observed through video recordings and/or audio recordings.*
		In use for informing (d) *Observed through video recordings and/or audio recordings.*
		In use for craftsmanship (d) *Observed through video recordings and/or audio recordings.*
Spatial planning and design	Spatial designing (in terms of interactivity with objects/gaming)	Allocating objects (d) *Observed through screen recordings and/or audio recordings.*
		Scaling objects (d) *Observed through screen recordings and/or audio recordings.*
		Rotating objects (d) *Observed through screen recordings and/or audio recordings.*
		Removing objects (d) *Observed through screen recordings and/or audio recordings.*
		Replacing objects (i) *Observed through screen recordings and/or audio recordings.*
		No interactivity (i) *Observed through screen recordings, video recordings and/or audio recordings.*
	Spatial designing and spatial planning	Buildings (d) *Observed through screen recordings, video recordings and/or audio recordings.*
		Infrastructure (d) *Observed through screen recordings.*
		Greenery (d) *Observed through screen recordings.*
		Transportation modes (d) *Observed through screen recordings.*
		People (d) *Observed through screen recordings.*

		Markers (d) *Observed through screen recordings and/or audio recordings.*
Co-creation design process	Co-design	Formulating design principles (d) *Observed through screen recordings and/or audio recordings.*
	Design by play	The creation of designs while using IVR (d) *Observed through screen recordings, video recordings and/or audio recordings.*
	Generative design	Definitive concept creation (d) *Observed through screen recordings and/or audio recordings.*
Stakeholder perceptions	Reproduction of ideas and identity *Statement 1: I could express my ideas and identity with Immersive Virtual Reality.* *Statement 2: I can make good designs with Immersive Virtual Reality.*	Statement 1: Discussed as to the extent to which participants were able to transfer their thoughts and ideas into IVR. *Gathered through audio recordings.* Statement 2: Discussed as the extent to which participants think designs can be made perfect to the interests of the participants. *Gathered through audio recordings.*
	Conversation and learning *Statement: Immersive Virtual Reality stimulated dialogues, learning and knowledge-sharing.*	Codes of the aspect communication. *Gathered through audio recordings.*
	Political rational behaviour and ambiguity. *Statement: Immersive Virtual Reality created power imbalances between participants.*	Listing the mentioned power imbalances. *Gathered through audio recordings.*

Appendix 3 'Information sheet'

Information sheet – Research Ethics Committee (REC)

for master thesis:

Title: Immersive Virtual Reality, a participatory-enhancing tool for collaborative spatial planning and design?

Thank you very much for taking the time to consider getting involved in my research project.

The emergence of collaborative spatial planning and design initiated a shift in spatial planning and design theory and practice which focussed on the inclusion of stakeholders. Participants are invited to not only be informed about spatial plans and designs, but they have the ability and craftsmanship to express their thoughts and ideas with the help of so-called participatory-enhancing tools. Through a conceptual lens of design, this research examined the effects of Immersive Virtual Reality as a participatory-enhancing tool on the collaborative spatial planning and design process.

Confidentiality and participant rights:

- The design session will be video-recorded and audio-recorded and notes will be taken after the design session.
- The focus groups will be video-recorded and audio-recorded and notes will be taken after the focus group sessions.
- You have the right to ask to have the recording turned off whenever you decide and you may also stop at any time.
- If you wish so you will be sent a copy of the focus group notes, and you will have the opportunity to make corrections or request the erasure of any materials you do not wish to be used.
- The information you provide will be kept confidential in a locked facility or in a password protected file on my computer for up to five years upon completion of my research.

The main use of the information you provide will help me towards my master thesis, which upon completion will publicly be available on the Internet. The data may also be used for articles, book chapters, published and unpublished work and presentations. Unless you have given explicit permission to do so, personal names or any other information which would serve to identify you as an informant will not be included in this research or in any future publication or reports resulting from this project. As a participant you have the right to:

- Decline to participate
- Decline to react on any particular statement
- Ask for the audio-recorder to be turned off at any time
- End participating at any time
- Ask any questions about the study at any time during participation
- Ask for the erasure of any materials you do not wish to be used in any reports of this study

Once again I thank you for taking the time to find out more about my research. I am at your disposal for any questions you might have. You can also contact my supervisors at the address below. Yours sincerely,

Researcher contact details : Roy Boertien r.e.boertien@student.rug.nl	Main Supervisor contact details: Gerd Weitkamp s.g.weitkmap@rug.nl

Appendix 4 'Agreement to participate form'

Agreement to participate - Research Ethics Committee (REC)
in research project:
Title: Immersive Virtual Reality, a participatory-enhancing tool for collaborative spatial planning and design?

The purpose of the research is to find out how immersive virtual reality, as a participatory-enhancing tool, can contribute to collaborative spatial planning and design processes.

I have read and I understand the information sheet of this present research project.
I have had the opportunity to discuss this study. I am satisfied with the answers I have been given.
I understand that taking part in this study is voluntary and that I have the right to withdraw from the study up to three weeks after the design sessions
I understand that taking part in this study is voluntary and that I have the right to withdraw from the study up to three weeks after the focus groups, and to decline to answer any individual questions in the study.
I understand that my participation in this study is confidential. Without my prior consent, no material, which could identify me will be used in any reports generated from this study.
I understand that this data may also be used in articles, book chapters, published and unpublished work and presentations.
I understand that all information I provide will be kept confidentially either in a locked facility or as a password protected encrypted file on a password protected computer.

Please circle YES or NO to each of the following:

I consent to the design sessions and focus groups being audio-recorded YES / NO

I wish to remain anonymous for this research YES / NO

If YES
My first name can be used for this research YES / NO

OR
A pseudonym of my own choosing can be used in this research YES / NO

"I agree to participate in the design sessions and focus groups and acknowledge receipt of a copy of this consent form and the research project information sheet."

Signature of participant:_____Date: _____

"I agree to abide by the conditions set out in the information sheet and I ensure no harm will be done to any participant during this research."

Signature of researcher: _____Date: _____

Please fill in the following information. It will only be used in case you want to be sent a copy of the focus group notes so that you have the opportunity to make corrections.

Address:
Email: