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Virtual Reality and Public Participation in Evaluation of Landscape Planting Design

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Preface

The aim of this thesis is to investigate if virtual reality headsets (VR) is viable in evaluation of digital landscapes in public participation processes in Norway. This study could help landscape architects evaluate the effectiveness and usefulness of VR as a new tool for the public evaluation of different planting designs.

The thesis was submitted as a partial requirement for the degree of Master in Landscape Architecture at the Norwegian University of Life Sciences (NMBU) during the spring of 2022.

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Abstract

The use of digital visualization in public participation processes have been suggested as a way to overcome known barriers to participation in planning processes and public participation. While the latest developments with virtual reality headsets (VR) have been popularized since the mid 2010's, its use in planning and amongst landscape architects remains low, even though its use has been thought to be advantageous within certain aspects. This study explores the viability of VR in public participation processes regarding evaluation of landscape designs by participants.

To evaluate the effects of VR in public participation processes, the study combines a case study site with a research experiment, comprising of a quantitative survey and a qualitative group interview. Here, the experiment utilized a control and experimental group to evaluate the effects of VR on landscape preferences. The study also explores changes in landscape preference when vegetation density change. The experiment was designed as to simulate a public meeting, as this is a traditional way to present a project in current public participation processes.

Results reveal that participants thought that VR was an effective tool for evaluating landscapes, where subjects particularly highlight that their experience was enjoyable and that the size and scale of the case study was better with VR than with traditional media. Feedback could also show that evaluation of compact spaces was better with the use of VR. However, participants also experienced technical problems and discomfort with the use of VR during the experiment.

Findings also show the participants had an overall preference for medium dense vegetation. While this was statistically significant for the study, previous studies warn that students and professionals with spatial competence, as was tested in this study, might score differently than the rest of the population. Results should therefore be assessed with care.

A recommendation from the study is that the use of VR in public participation would be beneficial in small-scale events where proposed designs have high spatial complexity and where understanding of size and scale of vegetation is crucial for participants.

Further studies should assess these findings by using a larger group of participants without spatial competence, and should address the use of VR in public participation for real projects.

Sammendrag

Bruk av digital visualisering i offentlige medvirkningsprosesser har blitt foreslått som en måte å overvinne kjente barrierer for deltakelse i planprosesser og medvirkning. Mens den siste utviklingen av virtual reality briller (VR) har blitt populært siden midten av 2010-tallet, er bruken av VR i planlegging og blant landskapsarkitekter fortsatt lav, selv om bruken har vært antatt å være fordelaktig innenfor visse aspekter. Denne studien utforsker brukbarhenten til VR i medvirkningsprosesser angående evaluering av landskapsdesign blant deltakere.

For å evaluere effekten av VR i medvirkningsprosesser, kombinerer studien et casestudie med et forskningseksperiment, som består av en kvantitativ spørreundersøkelse og et kvalitativt gruppeintervju. Her bruker eksperimentet både kontroll- og eksperimentelle grupper for å evaluere effekten av VR for landskapspreferanser. Studien utforsker også endringer i landskapspreferanser når vegetasjonstetthet endres. Eksperimentet ble designet for å simulere et folkemøte, da dette er en tradisjonell måte å presentere et prosjekt på i vanlige medvirkningsprosesser.

Resultatene viser at deltakerne mente at VR var et effektivt verktøy for å evaluere landskap, der forsøkspersonene fremhevet spesielt at deres opplevelse var trivlig, og at opplevelsen av størrelse og skala ved casestudiet var bedre med VR enn med tradisjonelle medier. Enkelte tilbakemeldinger tydet også på at evaluering av kompakte rom var enklere med VR. Enkelte deltakere opplevde imidlertid også tekniske problemer og ubehag ved bruk av VR-briller under forsøket.

Forskningsfunnene viser også at deltakerne hadde en generell preferanse for middels tett vegetasjon. Selv om dette var statistisk signifikant for studien, advarer tidligere studier om at studenter og fagpersoner med romlig kompetanse, som ble testet i denne studien, kan skåre annerledes enn den resterende befolkningen. Resultatene bør derfor vurderes med forsiktighet.

En anbefaling fra studien er at bruk av VR i medvirkningsprosesser vil være gunstig i ved mindre arrangementer der foreslåtte designforslag har høy romlig kompleksitet, og der hvor forståelse av størrelse og skala av vegetasjon er avgjørende for deltakerne.

Videre studier bør vurdere disse funnene ved å bruke en større gruppe deltakere uten romlig kompetanse, og bør ta for seg bruken av VR i medvirkningsprosesser for reelle prosjekter.

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1 | Introduction

Purpose

Modern urban planning in Norway requires citizens to be informed about new plan proposals and allow citizens to comment on decisions from authorities and developers in hope to influence them. For this to become reality, citizens need a multitude of arenas to meet and influence planning decisions. While there is a minimum requirement for public participation (Knudtson, 2015), where public meetings are very common (Nyseth & Ringholm, 2018a), several more creative types of public participation are already in use, and new forms for participation develops constantly (Nyseth & Ringholm, 2018b).

To investigate these new forms for public participation, this study will look further into the use of virtual reality headsets (VR) in public participation processes. It will further evaluate its use in relation to evaluation of different vegetation design proposals. Previous studies point out the advantages of VR in relation to an increased spatial understanding for size and scale (Schott & Marshall, 2021), and possibly an enhanced understanding of context. If the use of VR is seen as advantageous in public participation processes, the tool might be useful to include in development processes of public parks or green spaces in residential neighbourhoods as an example.

Public participation has been a legal requirement in planning practice since its introduction to the Norwegian Planning and Building Act of 1985 (PBA). Its role is to ensure that all affected parties have the opportunity to comment and review planning proposals before a plan becomes adopted (Kommunal- og moderniseringsdepartementet, 2018). Its introduction have had some positive effects in planning, like early conflict resolution and a way to secure quality in urban planning (Nyseth & Ringholm, 2018a). However, its adoption and use in planning processes has also been argued as far from adequate and ineffective (Andersen & Skrede, 2021; Nyseth & Ringholm, 2018a; Ringholm et al., 2018), and numerous barriers could hinder good implementation (Skaaland & Pitera, 2021). Münster et al. (2017) summarize four main barriers for public participation: few users, non-representative participant selection, communication issues and process deficits. To counter this, Hanzl (2007) argues that new digital technology could provide a new communication platform that could suppress the barrier for entry for non-professionals, while Al-Kodmany (1999) concluded that digital technology could provide a common language for all participants. In more recent studies, Skaaland and Pitera (2021) finds that professional respondents now perceive that the use of 3D models, virtual reality headsets (VR), and augmented reality (AR) in planning projects increases project understanding and engagement during public participation, compared to traditional visualization methods.

However, despite the advantages that VR bring to public participation processes, the use of VR amongst professionals, especially amongst landscape architecture professionals, have been low (Li et al., 2014; Lombardo, 2018; Skaaland & Pitera, 2021).

This study further explores the use-cases and effects of VR in the evaluation of landscapes preferences during public participation processes. To provide a practical application of VR during public participation, the study focuses on the effects of landscape vegetation density in relation to public preferences. Here, participants are asked to evaluate three different vegetation density scenarios in order to evaluate if vegetation density affects landscape preferences, with the additional use of VR.

The method design utilizes a research experiment which emulate a small-scale public participation event, which combines both a quantitative survey and a qualitative group interview to look at three aspects: (1) Do participants prefer one vegetation density scenario more than other scenarios? (2) Does the use of VR alter participant preferences for different planting design scenarios? (3) Are VR a viable tool for use in public participation to evaluate landscape planting designs? Both a quantitative survey and a qualitative group interview will provide data as a foundation for the analysis and discussion later in this thesis.

Target Audience

The thesis is mainly written as an academic contribution to the field of landscape architecture. The primary target group of this thesis is therefore landscape architecture professionals, academics, and students which are interested in the use-cases and effects of VR in relation to landscape architecture.

In addition, urban planners and architects might find the results regarding the use-cases of VR in relation to public participation interesting for further research and practical use.

The thesis could also be of interest for a wider audience, especially for those interested in the use-cases of VR within their own respective fields, or for those interested in the effects of vegetation density on landscape preferences.

Technical Terms

Virtual reality headsets (VR)	Head-mounted virtual reality displays.
360-degree images	Images taken from a static point that is stitched together so that the user can pan around in all directions.
360-degree VR images	Same as above, but now able to be viewed with the use of virtual reality headsets.
Immersive VR (IVR)	A older digital technology where an image or a video is projected at a large curved wall, or a CAVE system, with or without the use of special glasses to generate a 3D effect.
Navigable VR model	A 3D model that can be viewed with virtual reality headsets which is not pre-rendered. The model can be freely explored by the user from all angles, unlike static 360-degree VR images.
CAD / 3D modelling / BIM	Common methods for producing accurate digital drawings

Software

QGIS (GIS)	For the import of geographical data, creation of maps and map analysis
Autodesk Civil 3D	For technical drafting and terrain adjustments.
Trimble SketchUp	Used for designing 3D models
Autodesk Infraworks	Rough 3D modelling software, useful for producing site surroundings
Lumion	Rendering software specialised for plants and landscaping. Also used to export 360-degree images from a model. The 360-degree images can later be imported to virtual reality headsets using special software.
3D Vista	For displaying the 360-degree VR images with virtual reality headsets.
Photoshop	Digital imagery editing

Hardware

Oculus Quest 1	Virtual reality headsets used in this study

2 | Relevance

Evaluation of a Potential Tool for Public Participation Processes

An evaluation of virtual reality headsets (VR) with regard to public participation processes could provide for a discussion for the use of visualization technologies in current planning practices in Norway. Traditional methods for communicating planning proposals by solely using maps, images and verbal description in participation processes could be described as insufficient (Albracht, 2016; Gordon et al., 2011). If the use of VR is shown to have advantages that traditional media do not have, it should be considered and explored for future use and implementation in public participation processes.

Previous studies find that audiences sometimes have difficulties reading maps and aerial photos (Bratteteig & Wagner, 2012), and using sets of images to describe spatial complexity are sometimes difficult when trying to engage an audience (Gordon et al., 2011). Gibson (1978) argues that images can to some extent communicate the sense of space; but images fail to represent how it actually feels to be in a space, and might fail to convey the complexity of it. While a video walkthrough of the site could provide participants with a higher understanding of the size and scale of the project than static images, videos could also easily overwhelm the observer with an excessive amount of information which cannot be mentally processed (Plass et al., 2009). So, if the use of VR is able to overcome some of these shortfalls, it might be viable to include it in public participation events on a wider scale than today.

Subsequent technological advances also allow participants to experience simulations of a planned site, allowing for additional exploration in project models (Bratteteig & Wagner, 2012). Simulations, such as virtual reality simulations, could allow users to freely guide themselves through the site and even manipulate its content (Plass et al., 2009). Simulations with VR could allow users to more freely engage with the site, and the technology might enhance the users sense of place and depth perception of the site (Schott & Marshall, 2021), and even provide more public engagement with the project (Skaaland & Pitera, 2021).

However, producing and showing a site with VR for a large audience could also be somewhat time consuming, so introducing it for small scale events might become more viable. The use of VR is shown to induce motion sickness, with symptoms such as nausea and dizziness for some users (Lombardo, 2018; Mouratidis & Hassan, 2020; Schott & Marshall, 2021). This might also become problematic if its use is meant to be universally available for all users. A requirement for implementation VR could be that alternative software solutions should also be available before exploring its full implementation into the planning process.

If the use of VR significantly alter participants views on presented projects, planners and architects should consider including VR when presenting new projects to the public, stakeholders, and politicians.

New Area of Research for Landscape Architecture

While the use of VR has been used and investigated in broad terms in other fields of research, investigation into the use and effects of VR within the field of landscape architecture have been sparser. As Lombardo (2018) points out, its adoption rate within the field of landscape architecture have been slow. Providing additional insight into the use cases and effects of VR for landscape architects might be valuable in consideration of its future use. If the use of VR is found to be an efficient tool for representation of landscapes in the design phase and for public participation, this study could provide the field of landscape architecture with a larger toolbox for presentation of current and future landscapes with the use of VR.

Testing Effects of Planting Design with New Technology

While the effects of planting design is a broadly covered topic in the field of landscape architecture and landscape psychology, preference studies which studies different planting designs with the use of VR in clean lab conditions have been less examined. This study utilize a case study of different vegetation densities, with the use of VR, to investigate if VR is a viable tool for quick evaluation of the effects of planting design in relation to public preferences. The study could also provide a basis for how such a method could be developed for future use.

Timing

Recent development of VR-headset technology now provides headsets with better technical specifications than before. This could enable for a smoother and better experience for the user than before, which might provide different answers when compared to previous studies. Later software development for VR, might also have made implementation easier, making it easier to use VR for design evaluation and public participation than before. Testing use-cases with more recent technology might provide different answers than previous studies, especially regarding the analysis of cost-benefit and time expenditure.

3 | Background Literature

Overview

This chapter will present background literature related to public participation and evaluation of landscape planting designs with the use of VR, which makes up the theoretical part of this study.

The first subchapter will describe the role of public participation in current planning processes in Norway. This will provide context for the viability of VR in public participation processes, and in evaluation of vegetation design proposals during public participation.

The second subchapter will provide an overview on how presentation techniques are used to present landscapes in planning proposals today. This includes both traditional and new techniques, such as with VR. This will provide a historical context for the use of VR, and its advantages and disadvantages when presenting landscapes.

The third subchapter will present how preference for landscape design have been evaluated previously in research. This will focus on vegetation design density, as it is used as an example for this study. It will also present how VR have been used in other landscape preference studies to provide points of comparison.

The fourth and final subchapter will give a more specific definition of vegetation density, which worked as a basis for the development of the three vegetation density scenarios used in this study.

This theoretical background will be further discussed in light of the results found later in this study.

Public Participation in Planning and Landscape Architechture

Public scrutiny of planning proposals is important in the Norwegian planning process, and it is legally required to be facilitated by everyone who submits a plan proposal after §5-1 in the Norwegian Planning and Building Act of 2008 (PBA) (Plan- og bygningsloven, 2008, §5-1 Medvirkning). Its role is to ensure that all affected parties have the opportunity to comment and review plan proposals before a plan becomes adopted (Kommunal- og moderniseringsdepartementet, 2018). During this process, the plan proposer shall facilitate for public participation. Public participation can be understood as citizen participation in planning, and its purpose is to bring forward new knowledge and personal views into the planning process, which might influence later planning decisions (Kommunal- og moderniseringsdepartementet, 2018; Nyseth & Ringholm, 2018, p. 317). State, regional, and municipal authorities have the right to halt or even stop planning proposals, according to PBA §5-4, while ordinary citizens do not have such right with public participation. They have the right to be informed and comment on proposals in public participation processes. Though it is possible to halt planning processes with a successful appeal, its usually possible under special circumstances, which I will not elaborate on further in this study. Citizens are usually invited to public participation to be informed about a plan proposal and invited to comment with the hope to influence the future decisions of the developers and the planning and building authorities.

The organization and type of public participation is quite flexible with regard to the Planning and Building Act, where its setup is to a substantial degree chosen by developers and authorities. The minimum requirement of the Planning and Building Act, §11-12 and §12-8, requires that affected public authorities and other stakeholders are informed that a new planning proposal is starting up, and it must be announced in at least one common newspaper read locally, and through other electronic media. When starting up with a new zoning plan proposal, landowners, lessees, and rightsholders must be notified. Knudtson (2015) comments that the PBA minimum requirement is a prerequisite for democratic participation in planning, but it does not secure any form of participation. This could also be why municipalities sometimes choose to go beyond the legal requirements (Nyseth & Ringholm, 2018), as public participation is thought to reduce conflicts and make it easier to implement adopted measures (Regjeringen, 2015). Facilitating for public participation through public meetings is usually the most common measure for broad public participation in the planning process, even though it is not legally required (Knudtson, 2015).

Nyseth and Ringholm (2018) comments that public meetings are usually characterized of being one-sided communication where public empowerment and involvement is quite low. During public meetings, the plan proposer usually presents their project to a public audience, with a short question and answer session at the end. This aligns with the categories such as “informing”, and “consultation” to some degree (see figure 1) on a model called the “Spectrum of Public Participation”, developed by the International Association for Public Participation (IAP2) (IAP2 International Federation, 2018). This model is analogous to Sherry Arnstein (1969) ladder of citizen participation in planning.

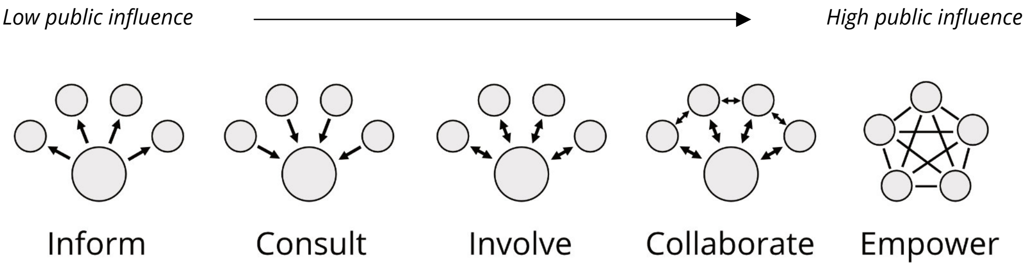


Figure 1 *- Spectrum of public engagement. The illustration is adapted from Albracht (2016).*

While public meetings is the most common type of public participation by Norwegian municipalities (Knudtson, 2015), other forms of public participation have also become more common, either through workshops, architectural competitions, city-labs, site inspections and involvement of children. However, the use of VR to inform about a new planning proposal, like in this study, might not currently be considered common in public participation processes (Skaaland & Pitera, 2021), even though its use might have clear advantages towards the sense of size and scale of the site (Schott & Marshall, 2021). The slow adoption rate of VR in the planning process could also be due to its slow adoption rate amongst landscape architecture and planning professionals (Li et al., 2014; Lombardo, 2018; Skaaland & Pitera, 2021). The use of VR could however become more common for pre-sale housing sales for developers in later planning stages (Juan et al., 2018). Common for most public participation methods that goes beyond the minimum requirements is that they are usually more suitable for conveying information, rather than the involvement of the public (Nyseth & Ringholm, 2018).

This study’s premise is that the public could evaluate planting design scenarios in public participation processes. However, presentation of different planning scenarios during public participation in smaller projects is not very common, unless an architectural competition is being held. But developing methods for evaluating planting design with VR might still be considered valuable as some municipalities, like Oslo, are beginning to focus on the planting of more trees in the city (Oslo kommune, n.d.) in order to fulfil UNs sustainability goals. Vegetation densification and its effect on local neighbourhoods and urban quality might be brought into question in future projects. Here, public evaluation of planting designs might be considered suitable for understanding local preferences for increased vegetation densities. Evaluation of planting design might also be beneficial when developing larger projects.

Presenting more than one scenario are however more common for larger, and more complex projects, which includes large infrastructure projects such as road or railway projects, or city expansions. Large road or railway projects usually incorporate several scenarios for decisions about route selection or other alternatives during an environmental impact assessment, which is mandated by regulation (Forskrift om konsekvensutredninger, 2017, §19 and §20). The municipality also have the right to propose different alternatives to private zoning plan proposals according to PBA §12-11 (Plan- og bygningsloven, 2008). Public evaluation of different planting design scenarios might be included in such processes, maybe with the additional use of VR if it is found to be beneficial for these types of evaluations.

Visualization, VR and Landscape Architecture

Traditional Methods

Maps, perspectives, or videos is frequently used when visualizing a plan proposals during public participation. Visualizations help people grasp the spatial properties of the new site, together with other thematic information. The map is a key illustration to show when presenting a proposal for an audience. It provides information in XY coordinates, but it fails to convey both verticality and scale in an easy to grasp way for those uninitiated with reading maps, in contrast to the use of a perspective or section. Details such as terrain form, storey heights, height of vegetation, planting arrangement, the general "atmosphere" of a site, or other complex planning details might be easier to understand with the use of perspective drawings or pictures from a 3D model (Hansen, 2013, p. 46). Perspectives are also thought to be useful as audiences sometimes have a hard time understanding maps and aerial images in a broader sense (Lobben, 2007).

The use of perspectives and maps in public participation meetings is common when presenting a new plan proposal (Hansen, 2013; Skaaland & Pitera, 2021). Hansen (2013) and Skaaland and Pitera (2021) found that visualizations from 3D models were shown to a lesser extent than 2D illustrations, even with continued development of 3D technology for the architectural, engineering and construction (AEC) industry, which is beginning to become more standard in planning projects.

The strong reliance on 2D visualisations in public meetings could be due to that 2D visualizations are easy to produce and present, while production of 3D models and 360-degree VR images are a bit more time consuming and difficult to produce (Lombardo, 2018, p. 17; Mengots, 2016). While drafting in 2D is efficient in early design stages and for smaller projects, 3D modelling might become more efficient when projects become larger and more complex (Solheim, 2011). 360-degree VR images also become easier to produce when 3D models are produced during the design process, as the production of 360-degree VR images relies on having a 3D model as its source data.

Visualization of Landscapes With VR

Using virtual reality headsets (VR) in the design process, and for demonstration purposes, have several advantages compared to traditional visualizations. Advantages include an enhanced sense of size, scale and depth, because of its ability to provide parallax effects and headtracking when visualizing landscapes (Lombardo, 2018; Schott & Marshall, 2021). While the use of VR has a few clear advantages in some aspects compared to traditional visualizations, the adoption rate of VR within the field of landscape architecture and planning have been slow (Li et al., 2014; Lombardo, 2018; Skaaland & Pitera, 2021).

Despite the low adoption rates of VR among landscape architecture professionals, several academics within the field have begun experimenting with VR as a scientific tool for research on topics such as urban liveability, landscape preference studies, and environmental psychology, among other topics. This adopted usage in research experiments could be of VR's useful properties when it comes to simulating real environments and landscapes, while having a simultaneous need for a controlled physical environment to test participants in. Reliability and validity with the use of VR in landscape preference studies have also been brought into question, but Shi et al. (2020) found that VR are a reliable tool for assessing landscape preferences when compared to On-site tests. The use of VR could be particularly useful for lab experiments. Its useful were multiple scenarios need to be compared against each other, which a more realistic visualization than an evaluation with 2D images and video, such as for this study.

One topic of research which could utilize VR's advantages is within landscape preference studies. These types of studies are particularly useful for planners and landscape architects, as it could be used as a basis for future landscape designs. Methodologies from these studies could also be adapted for use in public participation to evaluate public preference for landscapes.

This thesis will further expand on the topic of evaluating landscape preference with the use of VR. The controlling factor for this study is to see how much landscape preference change when vegetation density changes in a park environment, and what effects the use of VR has on the evaluation of landscape preference.

Landscape Preference Studies for Varying Vegetation Densities

Landscape preference studies tries to evaluate what effects vegetation and other elements have on our landscape preferences. We first need to look at how public preferences for landscapes and vegetation have been evaluated more generally in previous studies, before investigating the usefulness of VR in such experiments.

Here, the field of landscape psychology have long explored how different landscapes impact us, what landscapes we might prefer, and where we might thrive. According to Hägerhäll et al. (2018, p. 2), well established theories from the mid-1970s advocate for a universal consensus for human landscape preferences, which include “Prospect-Refuge theory (Appleton, 1975), the Savannah Theory (Orians, 1980), the Biophilia Theory (Fromm, 1964; Ulrich, 1993; Wilson, 1984) and The Preference Matrix (Kaplan & Kaplan, 1989; Kaplan & Kaplan, 1978; Kaplan & Kaplan, 1982)”. Hägerhäll and colleagues argue that “many of these theories make a clear connection between preference and visibility”, with many of these theories try to support the idea of a universal landscape preference. The above-mentioned theories should in essence align with a universal preference for landscapes where “preference will occur for landscapes where you can see without being seen (Appleton, 1975), landscapes with open expanses with clusters of trees (Orians, 1980), or landscapes which are visually understandable and offer possibilities for exploration (Kaplan and Kaplan, 1989)” according to Hägerhäll et al. (2018, p.2). These theories points towards preference for landscapes with medium dense vegetation. However, later studies contradict these theories, where results points to preferences for landscapes with a higher vegetation density.

Previous studies indicate that an increase in vegetation density increases landscape preference (see simplified model 1 in figure 2). Using real-world streetscape images from Midwestern U.S., Jiang et al. (2015), finds a dose–response curve for tree cover density and landscape preference, suggesting that landscape preferences increase massively when trees are added to treeless communities. The trend of increasing landscape preference when vegetation density increases remain positive when tree density changes from medium to high, but the effect is not as strong as from low to medium. In another study using digital 2D images, Van Dongen and Timmermans (2019) found similar results as Jiang et al. (2015) by the use of an online landscape preference survey in the Netherlands. They observed that landscape preference increased with the addition of trees, particularly when large trees were added.

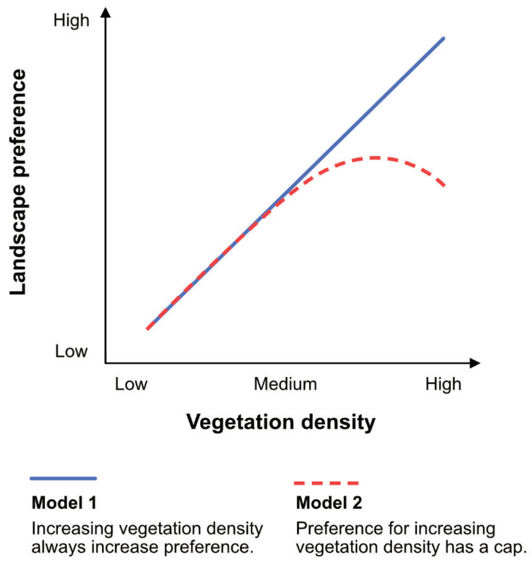


***Figure 2** - Simplified models of landscape preference in relation to vegetation density. The figure is made by the author.*

Other studies suggest that there could be a limit to landscape preference when vegetation becomes too dense (see model 2 in figure 2), especially for certain demographic groups. While Hägerhäll et al. (2018) finds that a non-western sample preferred the highest level of vegetation density in their experiment, preferences for more half-open landscapes were found when sampling two different student groups from Sweden. The findings of Hägerhäll et al. suggest that western samples could have other biases towards vegetation density change, than non-western samples.

Bjerke et al. (2006) finds similar results regarding preferences for moderate vegetation densities. Moderate vegetation densities were rated more preferably compared to scenes containing more open or denser vegetation when sampling participants from Trondheim. They also remark that "middle-aged, well educated, wildlife interested, and "ecocentric" segments of the sample express a higher preference for more dense vegetation" (Bjerke et al., 2006, p. 42).

A third study, now from Gao et al. (2019) also find preferences for landscapes with medium dense vegetation when conducting an experiment on students in China, now with the use of VR. However, scenarios used by Gao et al. (2019) show images from early spring, were leaves on trees were not yet developed, so images might not be as representative for a park scenario as for other studies. Answers from 180 college students were analysed, and their results suggest a preference for semi-open green space compared to two other scenarios with more open and closed green space. They mention however that gender and professional background had no influence on their results.

Hägerhäll et al. (2018) and Tveit (2009) warns that certain demographic groups could prefer landscapes more differently than others. This could apply especially to professional landscape architects and students (Tveit, 2009). Hägerhäll et al. (2018) emphasise that they found differences between the preferences of landscape architecture students versus humanities students, where landscape architects preferred more open landscapes than the humanities students. Findings by Tveit (2009) further demonstrates that landscape architecture students might prefer more half-open landscapes compared to the wider public, where the public preferred more densely vegetated landscapes. Tveit (2009) further suggests that students should not be seen as representative of the wider public when evaluating landscape preferences.

Landscape Preference Studies with the Use of VR

VR as a Tool for Studying Landscape Perception

VR have seldom been used in the evaluation of vegetation density preferences specifically, like for Gao et al. (2019) study. However, VR has been employed for the evaluation of landscape preferences within other aspects, such as evaluation of planting design layout, cityscape preferences, and effects of vegetation on relaxation and stress reduction. With VR's advantages compared to traditional visualization, like an increased perception of size and scale (Schott & Marshall, 2021), new hypotheses for landscape preference can be tested in clean lab environments, and previous findings could be re-evaluated with the use of VR.

While outside the scope of vegetation density, a review of these studies is relevant in reference to the evaluation of the viability of VR in public participation events. After a reviewing prior research using Web of Science with keywords linked to public participation and VR, several studies show use-cases for VR to evaluate landscape planting designs and landscape preferences.

VR for Studying Landscape Preferences

VR have been assessed for its usefulness in assessing landscape design layouts. Atwa et al. (2019) used VR to assess three park layouts in Egypt with participants. They looked at a wide range of aspects for each design scenario to pick the most preferred scenario. They concluded that "users respond well with the VR headset and it proved to be an easy, time-saving, and successful method for obtaining the accurate opinions of a workplace's users" (Atwa et al., 2019, p. 12). However, quantitative differences from users using VR, compared to the control group not using VR, seem to be small.

Lombardo (2018) explored use-cases for VR within landscape architecture design for landscape architect professionals. He concluded that VR "[...] can assist in evaluating design decisions, which can be based on accurate information presented realistically and intuitively". He also remarks that "creating and testing design options using VR is significantly more time-consuming than most alternative methods" (p. 72), but that professional participants still judged its development time as a very efficient use of time. This comes to show that the use of VR could very well assist landscape architects in their design phase, and potentially in dialogue meetings with customers and clients. The findings of Lombardo's study could also indicate that VR is suitable for small scale events in connection to public participation.

VR have also been used to isolate and evaluate the effects of vegetation on human psychology. While not applicable for the evaluation of vegetation density, some these articles could provide some explanation of why participants might appreciate increased vegetation density in their landscapes. On one hand, Zhu et al. (2021) found that an increase in the Visible Green Index (e.g. the amount of visible greenery in a space) alters brain wave strength, by testing landscapes with the use of VR. Wang et al. (2019) on the other hand finds that different forest resting environments can produce stress relief, and that interestingly the environment with the most plants were not the most effective. Thirdly, Piga et al. (2021) found that weighed saturation of green and lime colours could reduce unpleasantness in VR. Some of these studies might explain why some would prefer landscapes with more or less greenery, which could be based on our internal physiological and psychological responses. Their studies also show that VR is an effective tool when trying to isolate the effects of vegetation on human psychology.

VR have also been used to evaluate landscape preferences for other aspects than vegetation, as Mouratidis and Hassan (2020) explored a method for visual assessment of cityscapes in VR. Their study suggested that "traditional architectural styles for buildings – characterised by symmetry and ornamentation – are evaluated more positively than contemporary architectural styles" (p. 8). This comes to show that VR could be used for other aspects in public evaluation of landscapes than for vegetation exclusively.

Previous studies using digital technology similar to VR, also finds that digital technology could provide more engagement during public participation. Meenar & Kitson (2020), found that an IVR demonstration (images projected on a curved screen, providing a 3D effect) provided more public engagement than traditional methods using videos. In comparison, Dannevig and Thorvaldsen (2007) found that participants' gained an increased sense of scale when using glasses providing active stereoscopic vision (stereoscopic vision provides a depth effect to images), but they unable to assume that "VR is a more inspiring tool for use in public participation than the tools already in use" based on their data back in 2007 (Dannevig & Thorvaldsen, 2007, p. 52).

Definition of Vegetation Density

As this thesis will experiment with testing for landscape preference when vegetation density change, a definition of vegetation density needs to be explained. Vegetation densities of the scenarios have been defined based on Robinson (2016) definitions of landscape enclosure types in The Planting Design Handbook. His definitions are based on the degree of visual and physical openness in the landscape. Robinson (2016) find five different configuration types, while this study will use three of them to define vegetation density. The categories of vegetation density used in this study is defined as low, medium and high vegetation density (see figure 3). A simplification of Robinson (2016) model were made, the more visual and physical barriers there is in the landscape, the denser it becomes. Selected plant types were meant to closely resemble the chosen scenario, with tree canopies and plants becoming denser and less visually transparent for the denser scenarios.

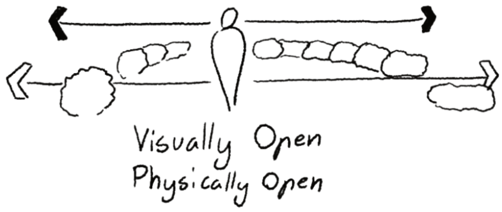
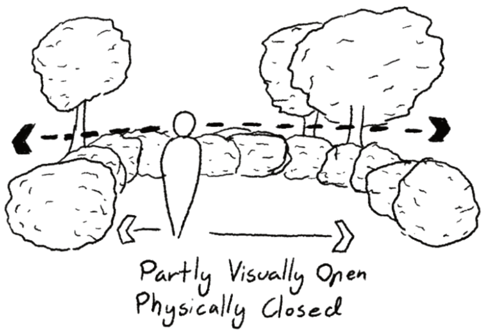
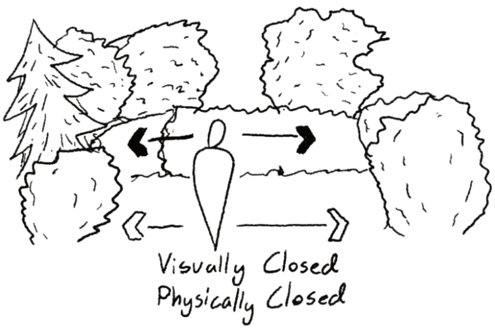
Scenario	Vegetation density	Composition
Scenario 1	Low density	
Scenario 2	Medium density	
Scenario 3	High density	

Figure 3 *- Vegetation density scenarios is based on design principles from Robinson (2016). Illustrations are adapted from Robinson (2016).*

Classifying vegetation density by this method is of course challenging as boundaries between each type of vegetation density becomes unclear. One way of controlling vegetation density exactly is to count the percent of how much vegetation covers a picture, like Tveit (2009) or Zhu et al. (2021). Zhu et al. (2021) calls this quantitative measuring approach the "green vegetation index". However, with this approach, it is still hard to know of what constitutes a "highly dense" vegetation in relation to medium dense vegetation for example. Classifying a whole site with this exact approach is also problematic, as participants do not review the site on an image-by-image basis. Defining vegetation density by design principles also enables for more freedom when designing each scenario.

An exact measurement of vegetation density, such as with a green vegetation index, could also be considered meaningless in relation to its use in public participation processes. Here, the idea is to compare early designs of vegetation scenarios against each other in order to estimate what citizens would want in their local parks and landscapes. Knowing public preferences for rough estimates of vegetation density based on design principles, such as with Robinson (2016) definitions, could also make it easier for the landscape architect to design after the fact, rather than designing after preferences for a select percent of vegetation.

4 | Research Question

Main Research Question

Is virtual reality headsets (VR) viable for evaluation of planting design concepts in public participation processes?

Secondary Questions

To answer the main research question, three aspects needs to be further examined.

Preference for a specific vegetation design

1. Do participants’ landscape preference vary when vegetation density change, even when looking at digital vegetation scenarios in VR?

Effects of VR when evaluating vegetation design concepts

2. Does the use of VR affect landscape design preferences compared to traditional presentation techniques currently used in public participation?

Viability of VR in public participation processes

3. Is evaluation of planting design concepts with virtual reality headsets viable for public participation processes, in a Norwegian context?

5 | Methodology

Method

The study combines both a quantitative and qualitative method in a research experiment to evaluate if VR is viable for assessing planting design during public participation, with the use of a case study in Ås, Norway. The method design is also developed to mimic a typical public participation process in Norway.

The controlled factor for this experiment was vegetation density, which was developed with a low, medium, and high-density scenario. This is to see if vegetation density affects the participants' landscape preferences. In addition, the effects of VR were checked using control and experimental groups, where the control group did not use VR during the presentation, while the VR group did.

A quantitative survey was conducted during the experiment to record the participants' landscape preferences. Then a qualitative short group interview followed to add nuance to questions also asked in the quantitative survey. The interview was also held to catch the participants' opinion about the use of VR during the presentation, which opinions might have been lost without interviews. Both control and experimental groups got a VR demonstration before group interviews were conducted. Answers were then later analysed using descriptive statistics, and statistical tests when applicable.

Case Study

To assess the effects of VR for the evaluation of planting design scenarios, a 3D case study model was needed. The case study site was situated in Ås (Norway), south of the local train station, and involved developing a combined residential and commercial area, in accordance to zoning plans and regulations made by the municipality of Ås in 2019. The decision to make the design in accordance to zoning plans was to have a legal framework which could help to design a more realistic project, while also designing a project that is both interesting and relevant for the invited participants.

While the case model encompasses a larger housing project, only a small portion of it was in focus for this study; a small park and a public square, which the participants is asked to evaluate. Then three vegetation density scenarios was made, based on Robinson (2016) design principles, carefully designed with about the same amount of time spent on the design of each of them. Time spent on each scenario design was cautiously monitored. This prevented overworking one scenario, which could lead participants to think that one design was more preferred by the side of the architect. This prevented participants preferring an overworked scenario. Scenario 1 was made with low density vegetation, having only a few plants and trees. Scenario 2 had a more moderate vegetation density, with more trees and denser tree canopies, and additional bushes were added.

Scenario 3 had a high density of vegetation, with dense evergreen trees, and even more hedges and bushes than in scenario 2.

Perspectives from the model were made from several key locations and rendered using Lumion. Here, one 360-degree VR image from each scenario were also extracted for three key locations in the model: one from the public square, one from the park pathway, and one from the park grass area.

Experiment Setup

The research experiment was set up as to resemble a public meeting, much like how public participation processes are traditionally conducted in Norway today (Knudtson, 2015; Nyseth & Ringholm, 2018). Participants first got an oral presentation of the case study, with information about its contents and location. This was then followed by showing the participants the three different scenarios with varying vegetation density, which was successively evaluated by participants using a quantitative survey. Afterwards they were asked to fill out general questions about themselves and their previous experiences with public participation and VR. A short group interview lastly followed about their experience and opinions gained during the research experiment. The following will now get into more detail about each part of the experiment.

First, participants were invited into the VR lab and asked to read and fill out the letter of information and consent. The research experiment was voluntary, and participants were able to leave if they wanted to during the experiment. Answers were anonymous, and participants would not be able to be identified in the data.

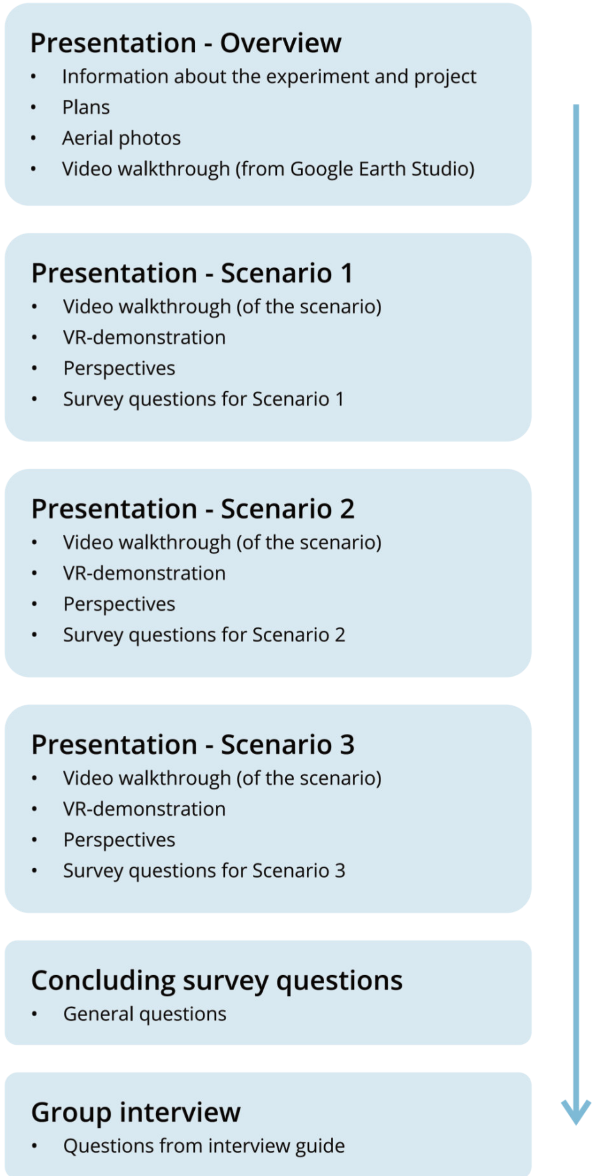


Figure 4 *- Experiment setup for VR groups. Non VR groups did not get a VR demonstration during the evaluation of each scenario.*

After everyone finished filling the consent form, participants were then informed the about the study, without revealing that the study looked at the effects of VR and the effects of varying vegetation density on landscape preference. The experiment proceeded with an oral presentation about the case study with the use of municipal plans, a map of the site proposal, aerial photos, and a video walkthrough of the site and its surrounding environment. The first part of the presentation was purposefully made to be similar for all groups.

Following the main presentation, participants were then presented with their first scenario. Here the two experimental groups got a slightly different experience. Which of the experimental groups the participants belonged to, and which sequence of scenarios they were shown was predetermined before the experiment began, see figure 6.

The control group was shown a short video walkthrough of the scenario, followed by perspectives from the three key locations. The video walkthrough paned through the small park in at human eye height, and followed across to the public park. Then it proceeded to give a bird's eye view of the whole scenario at the end. After being shown a video and perspectives, participants were then asked to evaluate the scenario in the quantitative survey. In addition, the experimental group got to see the site with the use of VR before their scenario evaluation. They were shown from three 360-degree VR images from the scenarios' key locations.

After the presentation and survey was completed, the Non-VR groups were also allowed to view the site with VR. At the end, a qualitative short group interview ensued with all participant groups. This was conducted in order to provide nuance and explanation to questions asked in the quantitative survey.

Figure 5 *- A group of participants experiencing scenario 3 with VR headsetsin the VR lab. Picture taken by Ramzi Hassan.*

Randomization of Sequence Ordering

Groups were shown scenarios in a random order so that the scenario sequence would not influence results (see figure 6). If groups were shown the scenarios in order 1, 2, 3 for example, participants might have gotten a clue about what the experiment was testing, as vegetation density with this sequence increase successively. Due to a lack of participants, only the ordering of scenario 3, 1, 2 and 2, 3, 1 was used. The chosen sequences were not continuously scaling with increasing or decreasing vegetation density, which purposely made it harder for participants to guess the testing criteria.

Scenario sequencing		
Sequence	**Ideal amount of participants**	**Actual participants**
3 - 1 - 2	5 (VR) + 5 (Non-VR)	8 (VR) + 11 (Non-VR)
2 - 3 - 1	5 (VR) + 5 (Non-VR)	9 (VR) + 6 (Non-VR)
1 - 3 - 2	5 (VR) + 5 (Non-VR)	0
2 - 1 - 3	5 (VR) + 5 (Non-VR)	0
3 - 2 - 1	5 (VR) + 5 (Non-VR)	0
1 - 2 - 3	5 (VR) + 5 (Non-VR)	0
Total	30 (VR) + 30 (Non-VR)	17 (VR) + 17 (Non-VR)

Figure 6 *- Sequence ordering for each group of participants. An ideal setup for this study was to conduct the experiment for all sequence possibilities, but this was not possible due a lack of attendees.*

Target Group for the Research Experiment

The initial target group of the experiment were students and residents who were not familiar with spatial design, such as landscape architecture or planning, as suggested by Tveit (2009). The ideal target group were selected with respect to their supposed lack of knowledge concerning spatial design and map reading abilities that planners, architects, and landscape architects gain during their education. Due to various circumstances, few participants from the ideal target group were interested in attending the research experiment. Several social media posts and physical invitational posters were hung around at the university to generate interest about the research experiment and the online registration form, but few were available or elected to attend.

Due to the lack of attendance from the ideal target group, it was therefore decided to invite all who were willing to attend. This increased participation significantly, up to 34 respondents, 23 of which said they study within the fields of architecture, planning or landscape architecture either now or before. As a result of this wider search criteria, a separate question regarding participants previous education was added to investigate the number of planners and architects attending the experiment, as this could affect results (Tveit, 2009). Readers should note that results may have been influenced by the of the mixture of professionals and outsiders in this study.

Survey

To assess the participants' preferences for different vegetation densities, a survey was designed to get quantitative feedback. This survey was structured with several Likert questions scaling with values from 1 to 5. Johannessen et al. (2011) argues that Likert questions should at minimum contain a scale of at least 1 to 5, but a 1 to 7 scale would also be considered sufficient. There is also a debate whether or not a neutral option should be included on Likert scales. There is a worry that respondens gravitate towards the more neutral option when it is included. Johannessen et al. reasons that neutral answers does not happen by chance, and if it happens, it usually does so because respondents usually have a neutral opinion (Johannessen et al., 2011, p. 290). It was therefore chosen to include a neutral option in the survey to include those who actually have a neutral opinion about the scenarios.

The Likert questions in the survey range from the scale of 1 to 5, from "Strongly disagree" (1) to "Strongly agree" (5), with a option to answer "Don't know" as a separate point. The reason for making a 5-point scale was because each point of the scale marks a significant difference in opinion. Adding more options, especially above a 7-point scale would not significantly improve the reliability and validity of results (Dawes, 2008), and adding a more detailed scale could make the participants mark each point more arbitrarily.

The survey can be found in Appendix 1.

Analysis

Results from the quantitative survey is mostly analysed using descriptive statistics, such as group means, to compare results from the groups against each other. In addition, non-parametric Mann-Whitney tests and a Kruskal-Wallis test were used to establish whether group differences were statistically different from each other. Non-parametric tests were initially chosen, as the Likert scale has previously been described as ordinal in nature (thereby being unable to be analysed parametrically). However, Norman (2010, p. 631) states that data containing Likert data could also be analysed parametrically (i.e., with t-tests and ANOVA tests), even though the data contains small sample sizes, with unequal variances, and with non-normal data, without the fear of coming to the wrong conclusion. The non-parametric test of this study were later cross-checked using parametric equivelents (Students t-test and one-way ANOVA-tests). As results from these were very similar between parametric and non-parametric equivalents, results from the parametric tests are not shown explicitly in this study.

The Mann-Whitney test were chosen to test for statistical differences between control and experimental groups. As results were analyzed for independent samples, a Mann-Whitney test is adequate to test if samples from one group score higher than another group. The Mann-Whitney test can detect differences in the shape and spread of the data as well as differences in medians, while the t-test could tests for differences in population means (Hart, 2001).

The Kruskal–Wallis test (a non-parametrical equvalent of the ANOVA test) is used where three or more groups are compared against each other, and checks whether there is a statistical difference between one of the groups. In this study, the Kruskal–Wallis test is used to compare preferences between the three vegetation density scenarios of this study against each other. A significant result from the Kruskal–Wallis test indicates a difference between one or several of the groups. When a significant result have been found in a Kruskal-Wallis test, a post-hoc Mann-Whitney test follows to establish where the significant difference might lie (between which of the groups).

Interviews

Following the quantitative survey, participants were then asked to attend a short semi-structured group interview, which purpose was to ask about the participant's views about their experience with VR during the experiment, and their opinion on VR's future use in public participation. The reason for conducting interviews in addition to the survey is that an interview allows to gather information which was not anticipated from the survey (Johannessen et al., 2011), and as a supplemental method for validating and methodically triangulate the quantitative data.

The interviews were semi-structured where questions followed an interview guide, but the interview design allowed for questions to be elaborated on. This method allows for asking clarifying questions after the interviewee's has answered the main question, to clarify opinions, and for it to provide further nuance to the quantitative survey.

The reason for conducting group interviews rather than individual interviews was because it was practical to conduct right after the experiments. Inviting to interviews separately after the research experiments would have been time consuming and more impractical for the participants, and it risked that the participant would forget some of their immediate experiences with VR. Conducting group interviews also allowed for a larger sample of different experiences, and provided for a discussion between individuals. This discussion also helped individuals to elaborate on more nuanced details of their experiences.

The interview guide can be found in Appendix 2.

Techinal Equipment

The digital case study 3D model was designed by the author in the autumn of 2021. It was designed with supplementary use of FKB basic data, which is some of the most detailed map data in Norway (Granum, 2020). FKB and cadastral data were provided by Geovekst in March 2021. The design was made with the use of Autodesk Civil 3D, with FKB data as underlying layers. The site design CAD layers was later imported into Infraworks, Trimble SketchUp and Lumion for further design and final rendering. Perspective illustrations, video walkthroughs, as well as 360-degree VR images were all extracted using Lumion 10. The VR solution, made for the purpose of the VR demonstration, was made with help from NMBU's VR-Lab. The solution enabled participants to experience the model easily with the use of VR. The rendered 360-degree VR images from Lumion were implemented into five Oculus Quest I's using 3DVista VR software.

A video walkthrough showing the existing situation was also created by using Google Earth Studio. Comparison shots between Google Earth and still renderings from Lumion were shown to make the participants able to compare the existing situation (shown with Google Earth 3D photogrammetry) with the new situation (showing the 3D case model made with the use of Lumion).

About the 3D Model

A digital 3D model was made for the purpose of this study. The model contained a rough design of the whole site (i.e. buildings, terrain and infrastructure), and with three separate layers made specifically for the three different vegetation density scenarios.

Buildings were displayed as plain beige façades, with black lines marking floor separation. The floor separation markings should allow participants to comprehend the number of floors for each building, which could provide for a better sense of scale. It was decided not to add an extensive amount of façade details, as this is beyond my professional capacity as a landscape architect. While the addition of façade details could have increased the realism of the project, a poorly detailed façade might also negatively affect participant impressions of the site. Drawing attention to poorly drawn façade details rather than the planting design might also have made participants focus on the wrong details of this study.

Other familiar elements such as cars and humans was also added, as it could enable participants to better judge the size and scale of the model (Macdonald, 2012). While the addition of human models might become a distracting element for the participants in the project, as our eyes are often drawn towards other people (Birmingham et al., 2009), human figures would also provide for easy scale comparisons and help produce a more realistic landscape scenarios.

A more detailed description of each scenario will be presented in the next chapter.

Figure 7 *- The case study model uses simplistic facades to indicate story height and count.*

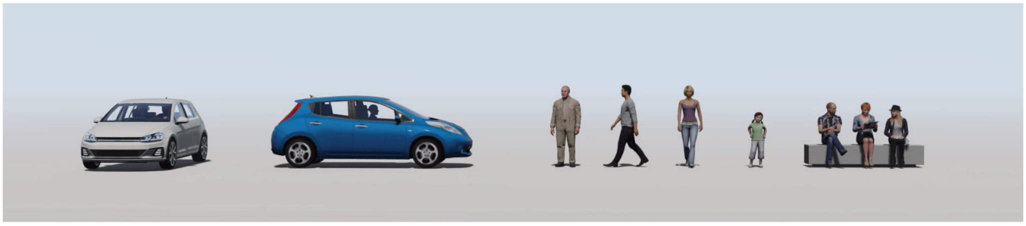


Figure 8 *- Familiar elements such as cars and trees could make participants better able to judge the size and scale of the model.*

Guide for Selection of Survey Questions

1. Questions Related to Previous Experiences. Design, Public Participation, and VR

There is a presumption that some of the surveyed participants have previous experience regarding certain aspects of this experiment. If participants are familiar with VR for example, this could have implications regarding their biases towards VR. The participants may also have some experience regarding public participation, or architectural experience, which might affect abilities to read and understand maps and perspectives effectively. Assessing participants' underlying experiences thus becomes an important limitation for later analysis.

- *Do the surveyed sample have previous experiences with VR?*
- *Do the surveyed sample have experience with public participation?*
- *Do the surveyed sample have experience with architectural or landscape design?*

2. Questions Related to Project Understanding

There is an uncertainty about how well the participants are able to understand presented plans, illustrations, and information (Lobben, 2007). Questions related to the participants' understanding of the project is crucial to investigate to see if the traditional presentation was enough to provide participants with a decent understanding of the project.

- *Do participants understand where the site is located?*
- *Do participants understand what the project is about?*

3. Questions Related to Planting Design Preferences

Prior research indicates that increasing vegetation density should increase landscape preference (Jiang et al., 2015; Suppakittpaisarn et al., 2019; Van Dongen & Timmermans, 2019), but too much vegetation density might negatively affect preference (Bjerke et al., 2006; Gao et al., 2019). This experiment will challenge these prior findings and see if they hold true when 3D digital designs of landscapes are shown with VR. Questions in the survey will investigate the participants' preference for different vegetation density scenarios.

- *Do participants rate each scenario differently from each other?*
- *Does a scenario score particularly better than others?*
- *Are scores affected when participants are given a VR demonstration from each scenario, rather than a traditional presentation?*

4. Questions Related to Engagement, Comfort, and Realism

While it is easy to create a digital 3D model of a site, improper visualizations might easily mislead the viewer (Hansen, 2013; Lombardo, 2018), which could might cause negative effects for later planning stages (Eggen, 2019). Using Sheppard (2005) "proposed interim code of ethics for landscape visualization" regarding accuracy, representativeness, visual clarity, interest and legitimacy, the 3D model is hopefully not visually misleading for the participants, and should be representative for the site location.

- *Do the participants feel that visualizations from the new 3D model is representative for the site location when compared to the current situation with Google Earth 3D photogrammetry?*

VR have seen increased usage and popularity in later years, especially since the introduction of the Oculus Rift and HTC Vive in 2016 (Lombardo, 2018). This could have made participants familiar with the experience and effects of VR. Participants who lack exposure to VR might change their impression if the site more than those with prior VR experiences. Evensen et al. (2021) warns of such a novelty effect. Some participants might also associate VR with gaming but seeing a more practical application of VR in planning and architecture might also change the participants' views regarding the viability of VR in such fields.

- *Do participants change their view on VR after the demonstration?*

The use of VR also affects human senses in several ways, and previous studies mention dizziness and cybersickness as negative effects amongst VR users (Mouratidis & Hassan, 2020; Rebenitsch & Owen, 2016; Schott & Marshall, 2021). A lack of comfort with the use of VR amongst participants might suggest a decreased viability and usefulness of VR in public events such as public participation.

- *Did participants feel uncomfortable using VR during or after the VR demonstration?*

5. Questions Regarding Future Applicability

While prior research indicate VR could help in the design stage with new landscape and architecture projects (Lombardo, 2018), the applicability of VR regarding public participation processes is less understood from the users' point of view. Meenar and Kitson (2020) concludes in their article that "level of public participation, memory recalls of planning scenarios and emotional responses to design proposals increase with IVR simulations when compared with standard 2D video presentation" (p. 16). Skaaland and Pitera (2021) also point to more engagement in public participation with the digital visualizations, such as with the use of VR. While results might point to that level of engagement during public participation might increase with the use of VR, we still might wonder if participants themselves view VR in public participation processes as a beneficial tool to increase their own understanding of the presented project.

- *Do participants feel that VR could be a beneficial tool for an increased understanding of a presented planning proposal?*

6 | Case Study: Moerveien

The case study site is located in Ås municipality in Norway, south of Ås railway station (see figure 10 and 11). The new development was designed in accordance with provisions in the municipality area zoning plan from 2019, called "Områdereguleringsplan for Ås sentralområde". With this new area zoning plan, the municipality want to "ensure that the town is well equipped to for future growth" (Ås kommune, 2022). In addition to about 3 000 new residences, they also want to facilitate for new business and commerce, and support the development of an efficient transport network with zero growth in passenger car traffic.

The selected area of the case study site is called BKB2 and B22 in the area zoning plan, which is located along Brekkeveien. The design of the site largely follows the site provisions for these areas, and the site is zoned for housing and business development (see figure 9). Site provisions specify that in dense urban areas with block buildings, the suitable area for play, activities and outdoor activities shall consist of at least be 20% of total net internal area (NIA). A new public square is also required on the site, covering minimum 500 sq. meters and must be at least 20 meters wide. With this ample space for a large outdoor area and a new public park, the site seemed good for development of a new park, while also being suitable for a research experiment. Designing the site in accordance with the municipal area zoning plan also helped to produce a site within a realistic context, and worked out neatly when simulating a public participation event later on in the research experiment.

To quickly produce a site design within design specifications set by the area zoning plan, Spacemarker was used to quickly generate several unique design proposals for evaluation. As the site itself was too large to design in detail, using Spacemaker helped immensely to quickly generate a realistic looking project. After a thorough evaluation of the generated proposals, the final selected proposal enabled for a large park in the south-western corner of the site, while also providing a connection between the park and the public square after some later rework (see figure 15).

Designing the Alternatives

After roughly designing the whole site (placing buildings, street network and shaping the terrain), the model was set up for developing multiple vegetation density scenarios in accordance with parameters described in chapter 3. Time spent on the design of each scenario was carefully monitored to not overwork one scenario more than others. If one scenario was much more detailed than the orders, this could have ended up skewing the results.

Figure 9 *- Cropped screenshot of the area zoning plan of the site (BKB2 and B22)*

Figure 10 *- Ås municipality in relation to Oslofjorden*

Figure 11 *- Site location in relation to the centre of Ås.*

Figure 12 *- Exterior plan of the case study*

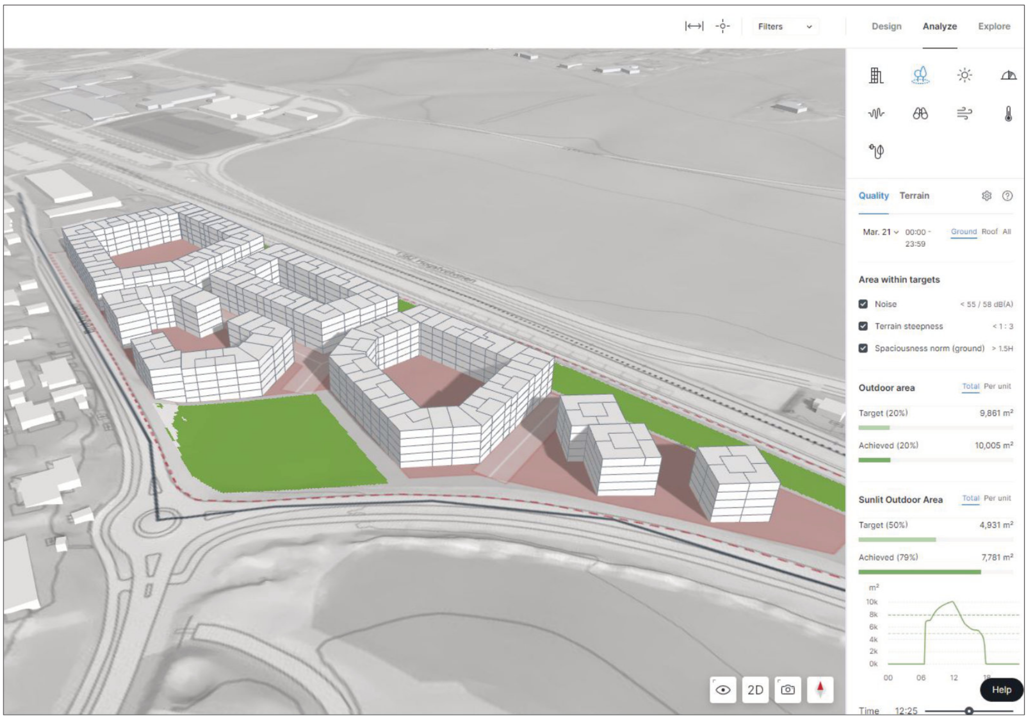


Figure 13 *- Screenshot of an early design with the use of Spacemaker*

Figure 14 *- Overview of the site, rendered from Lumion*

Figure 15 *- Connection between the park and the public square*

Scenario 1 - Low Vegetation Density

Scenario 1 is the most simplistic scenario, modelled after Robinsons' enclosure concept of visually open and physically open. To keep the park and public square visually open, Linden trees from Lumions' object library were used because of its translucent tree canopy. The park itself also have only a few objects placed to keep the space physically open. As a consequence of this enclosure type, Linden trees were only placed in a single row in the edge of the park. A few benches are also placed in the park with a few perennials planted next to them. In the public square, only a row of American Holly and Ivy hedges were places along the retaining wall and building edges. A few perennials were also placed on the seating element in the middle of the public square.

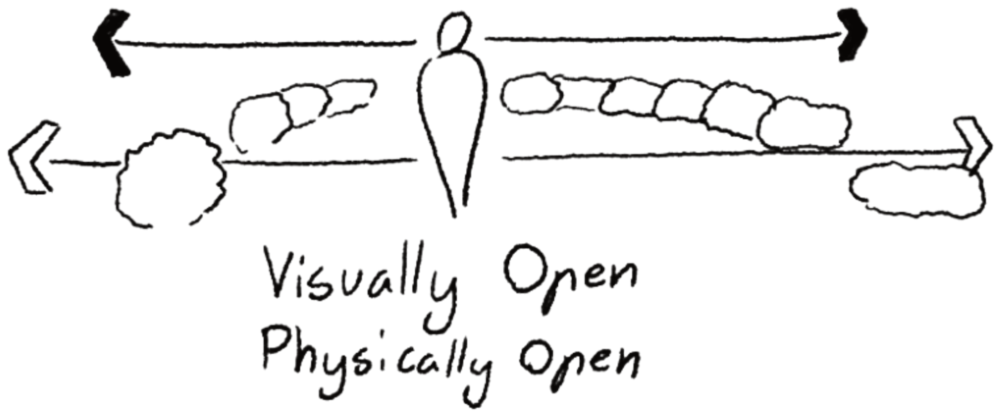


Figure 16 *- Design principles for scenario 1. Illustration adapted from Robinson (2016)*

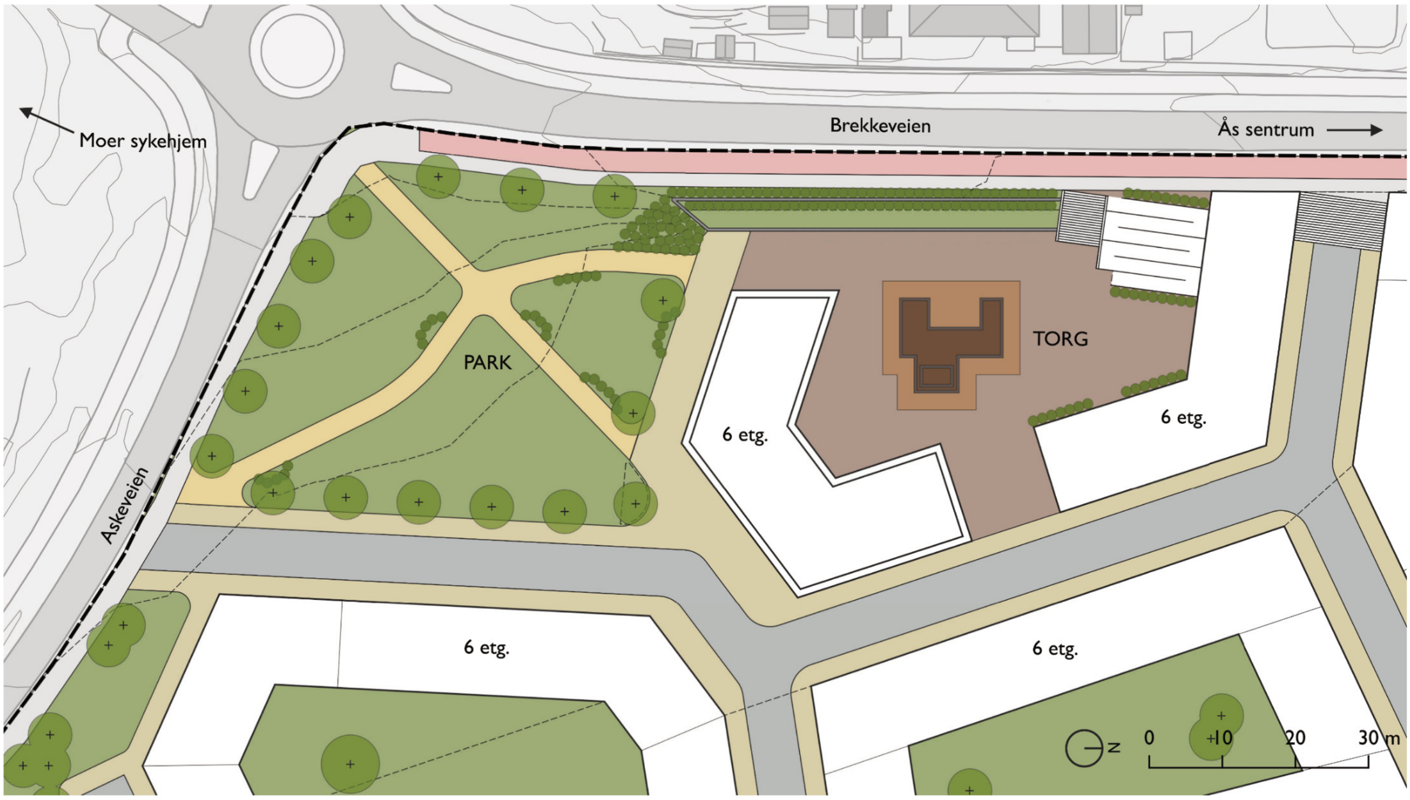


Figure 17 *- Overview of the planting design in scenario 1*

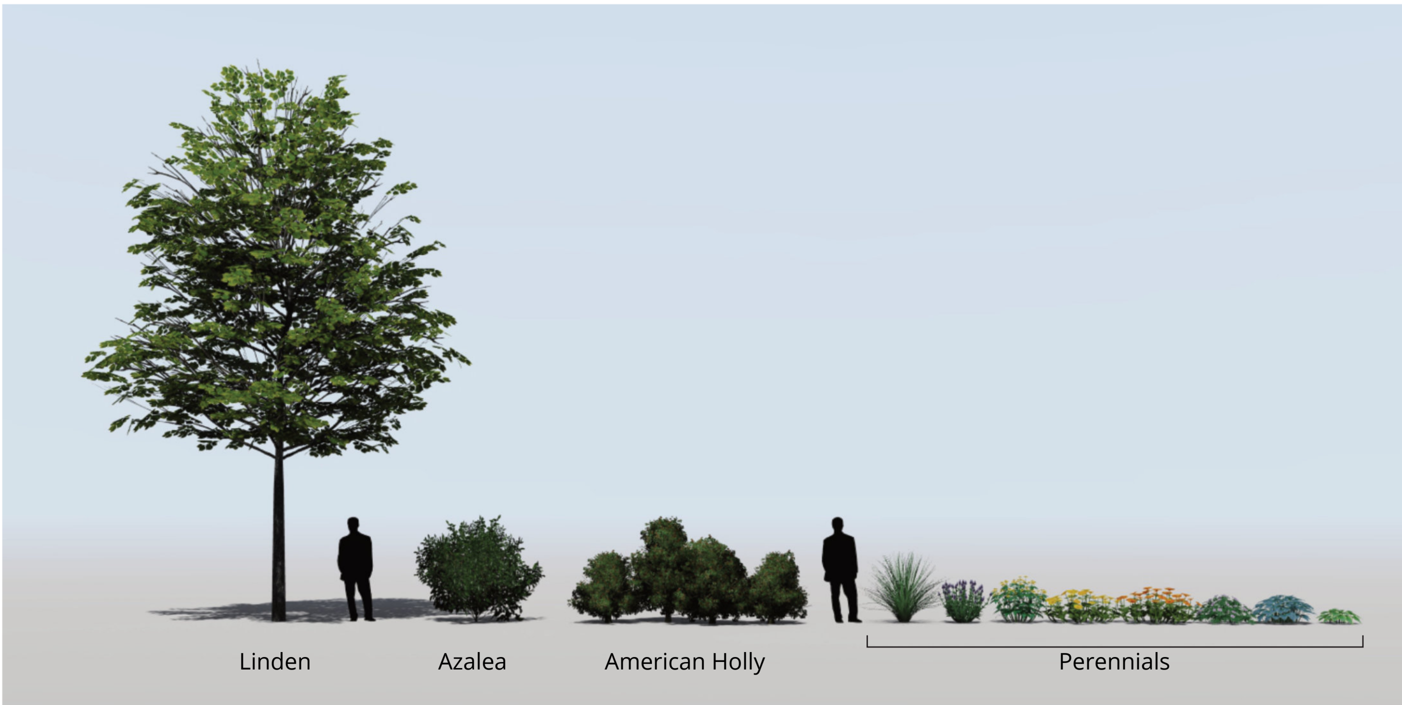


Figure 18 *- Overview of plant selection for scenario 1*

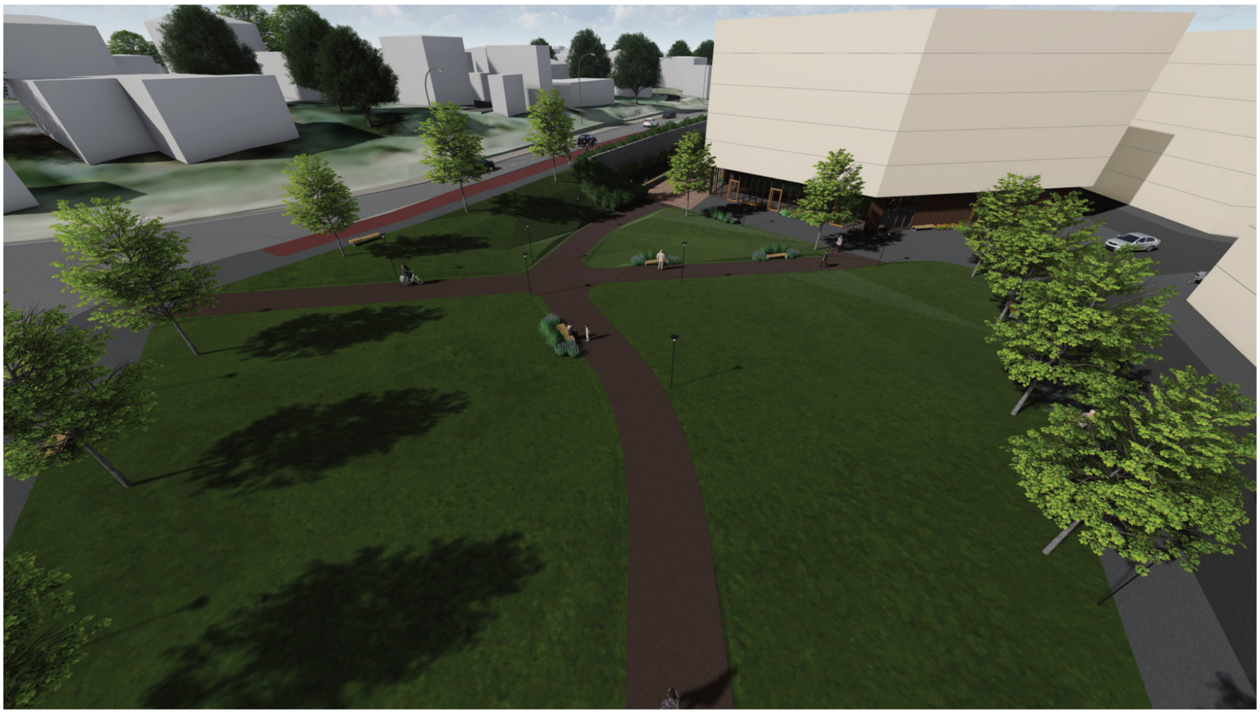


Figure 19 *- Overview of the park - scenario 1*

Figure 20 *- Overview public square - scenario 1*

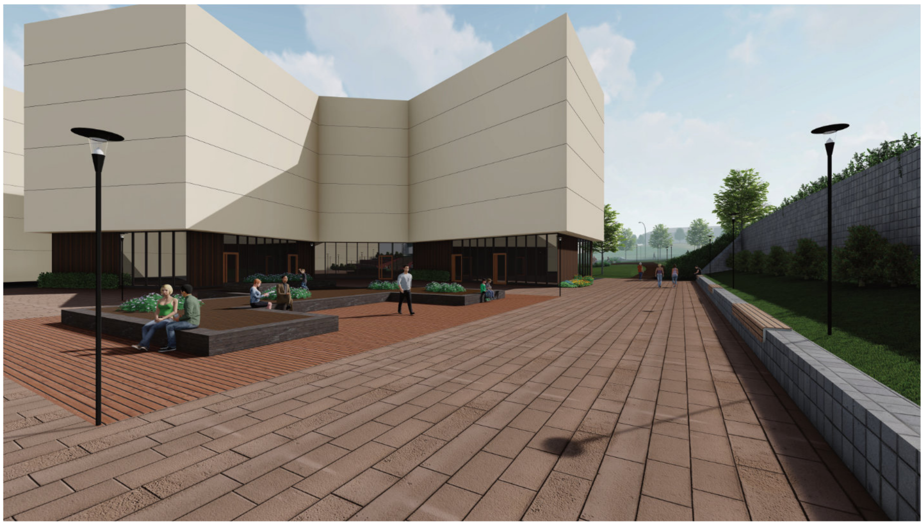


Figure 21 *- Rendering from the public square - scenario 1*

Figure 22 *- Rendering from the park pathway - scenario 1*

Figure 23 *- Rendering from the park grass area - scenario 1*

Scenario 2 - Medium Vegetation Density

Scenario 2 was the medium density scenario, modelled after the enclosure concept of partially visually open and physically closed (see figure 24). Trees such as Linden and Horse Chestnut are now not only placed on the parks' edge, but more freely placed within in the park itself. Horse Chestnut trees also have a more of a opaque canopy, providing more shadow and partially obstructing sightlines in the park. Linden trees have also been placed along the retaining wall in the public square, along with a few placed within in the central seating element. Several rows of Azaleas along the parks' pathways are now also more effective at obstructing vision throughout the park. A denser count of trees combined with multiple rows of Azaleas now makes the park more physically closed, which was meant to meet the design criteria of this scenario.

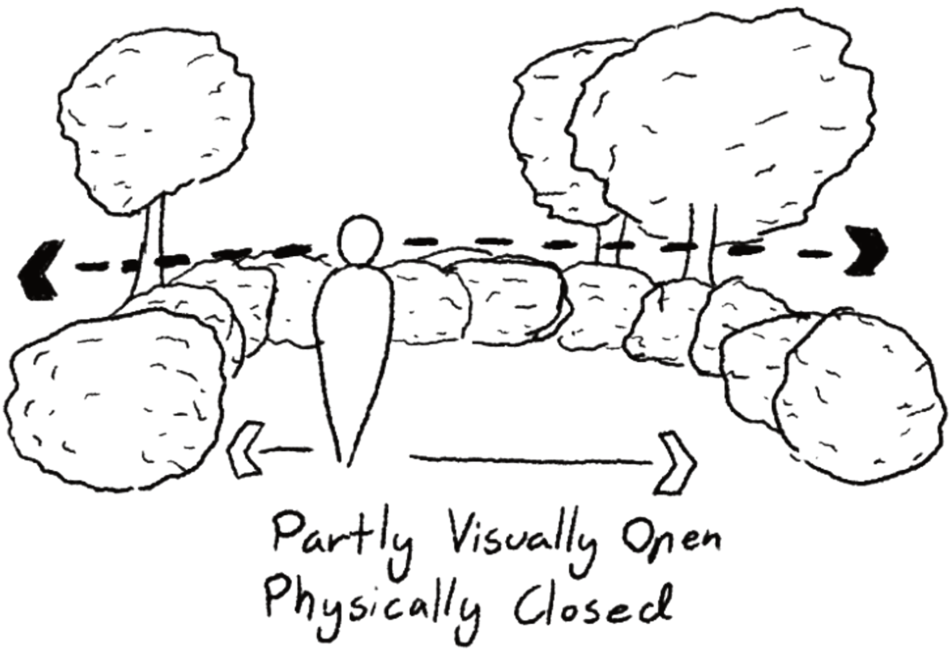


Figure 24 *- Design principles for scenario 2. Illustration adapted from Robinson (2016)*

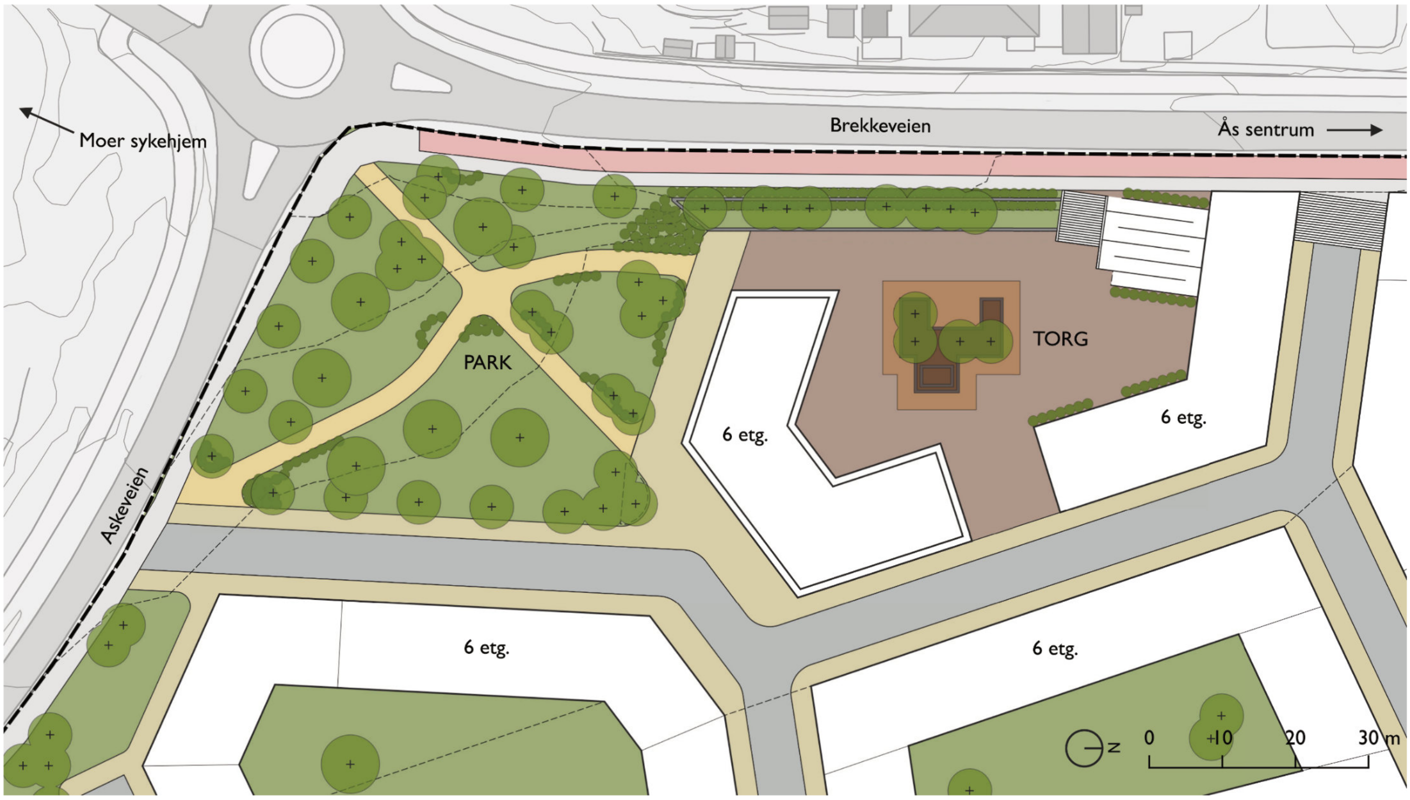


Figure 25 *- Overview of the planting design in scenario 2*

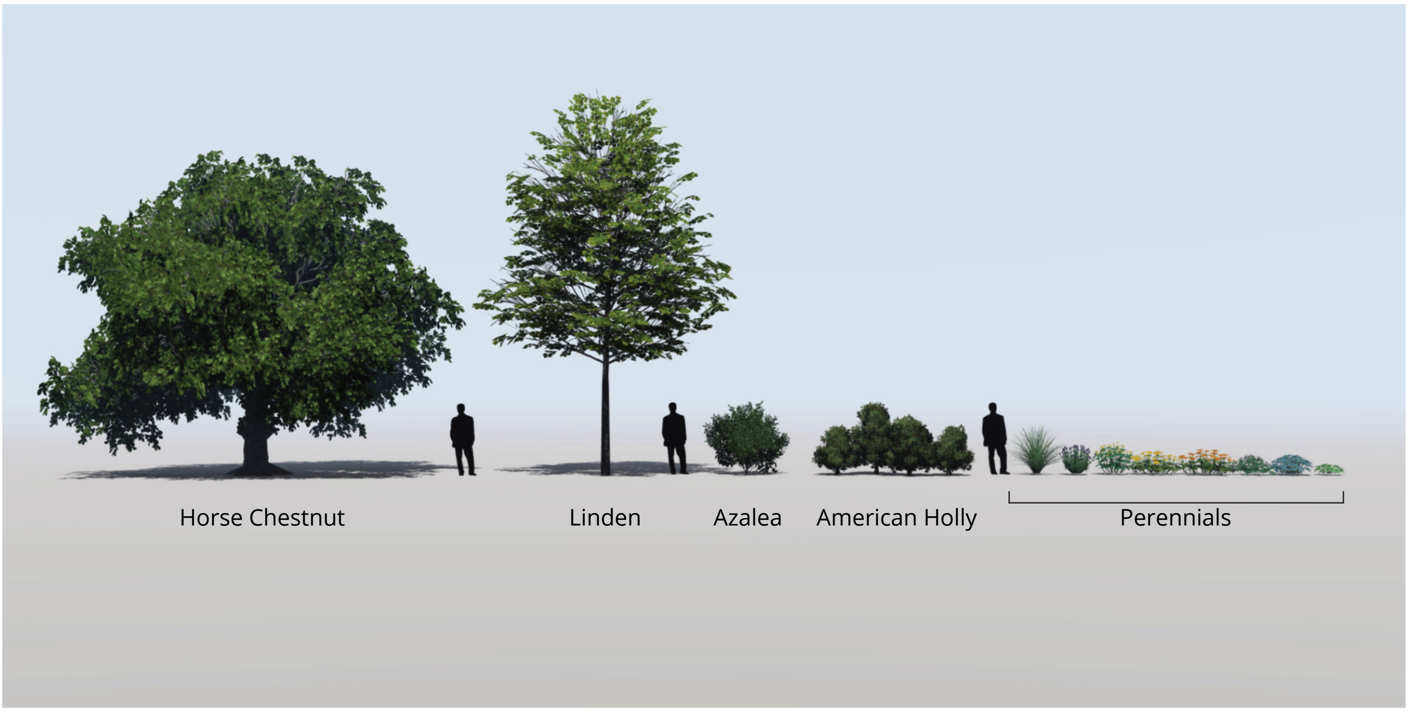


Figure 26 *- Overview of plant selection for scenario 2*

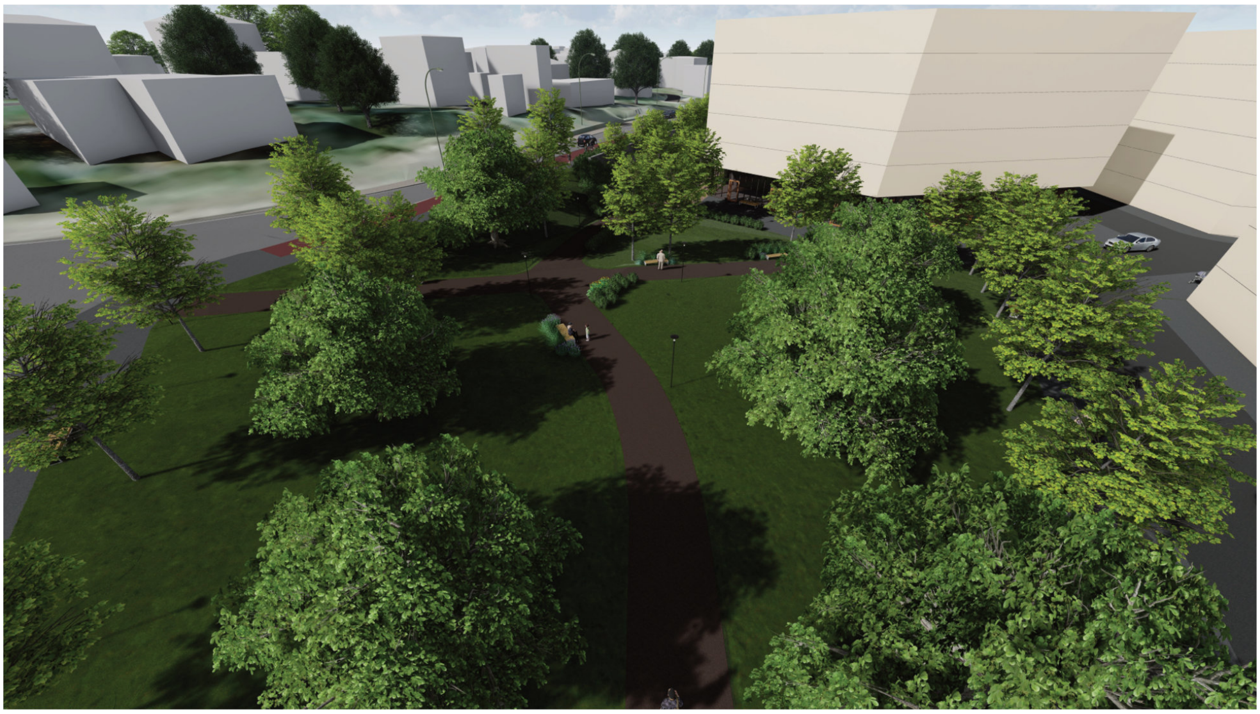


Figure 27 *- Overview of the park - scenario 2*

Figure 28 *- Overview public square - scenario 2*


Figure 29 *- Rendering from the public square - scenario 2*


Figure 30 *- Rendering from the park pathway - scenario 2*

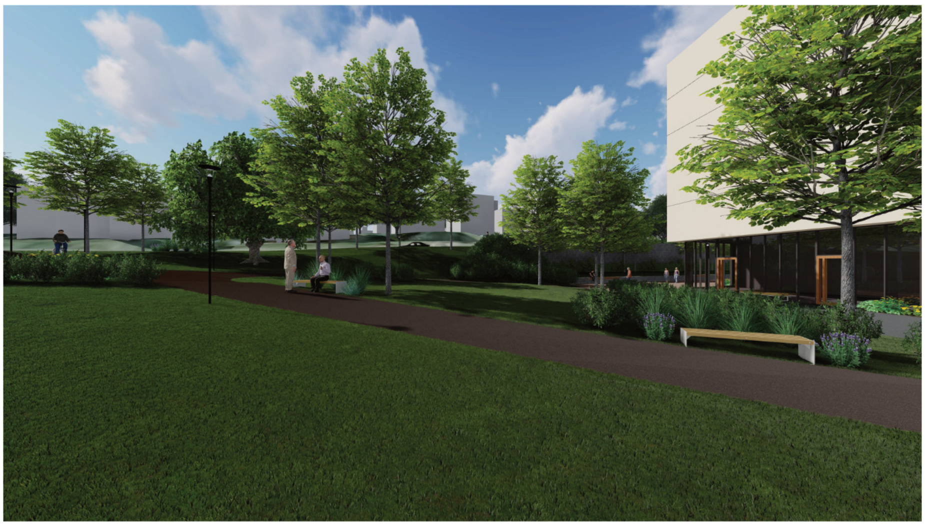


Figure 31 *- Rendering from the park grass area - scenario 2*

Scenario 3 - High Vegetation Density

Scenario 3 is the densest vegetation scenario, modelled after the enclosure concept of visually closed and physically closed (see figure 32). Trees such as Linden and Horse Chestnut have now been replaced by Japanese Cypresses and Norway Spruce, which have a much more opaque canopy with branches sticking out further down at the trunk of the tree. The rows of bushes (Junipers) have now become lengthier while also beginning to cover both sides of the pathway. This makes the bushes more effective at obscuring vision and movement possibilities within the park than in scenario 2. The public square is now also covered with an extra layer of branches of Ivy climbing against the retaining wall, in addition to a field of Espartos planted alongside it.

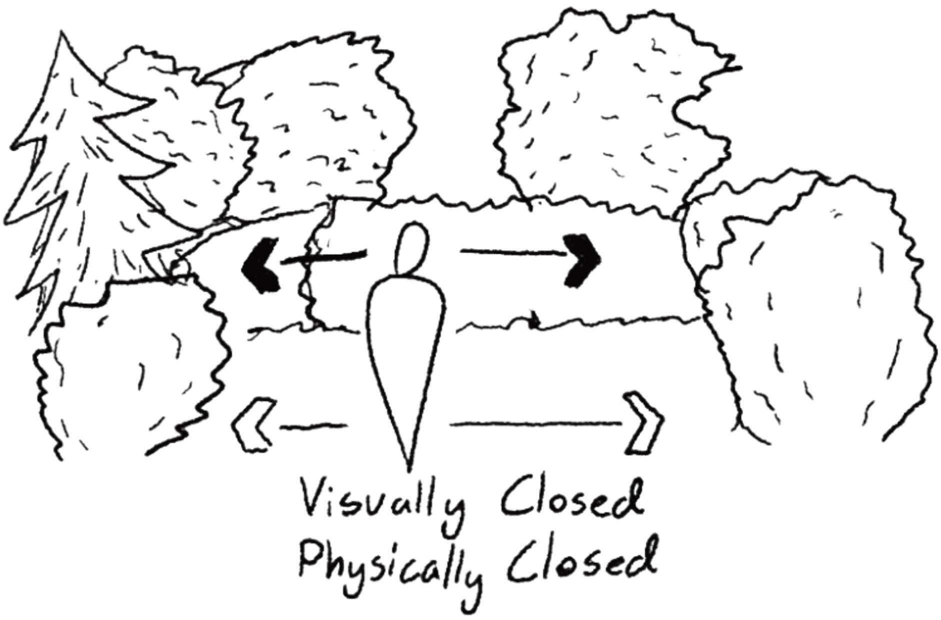


Figure 32 *- Design principles for scenario 3. Illustration adapted from Robinson (2016)*

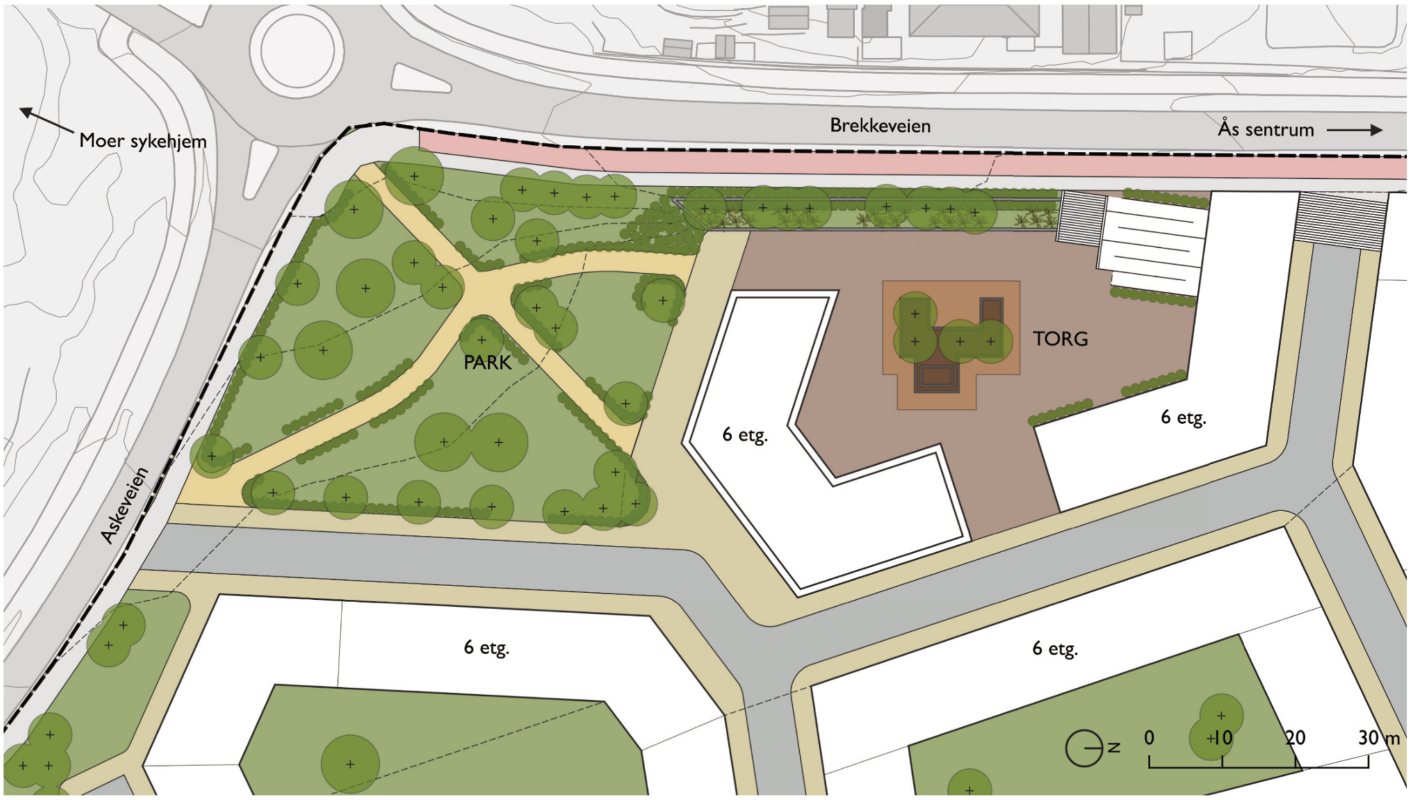


Figure 33 *- Overview of the planting design in scenario 3*

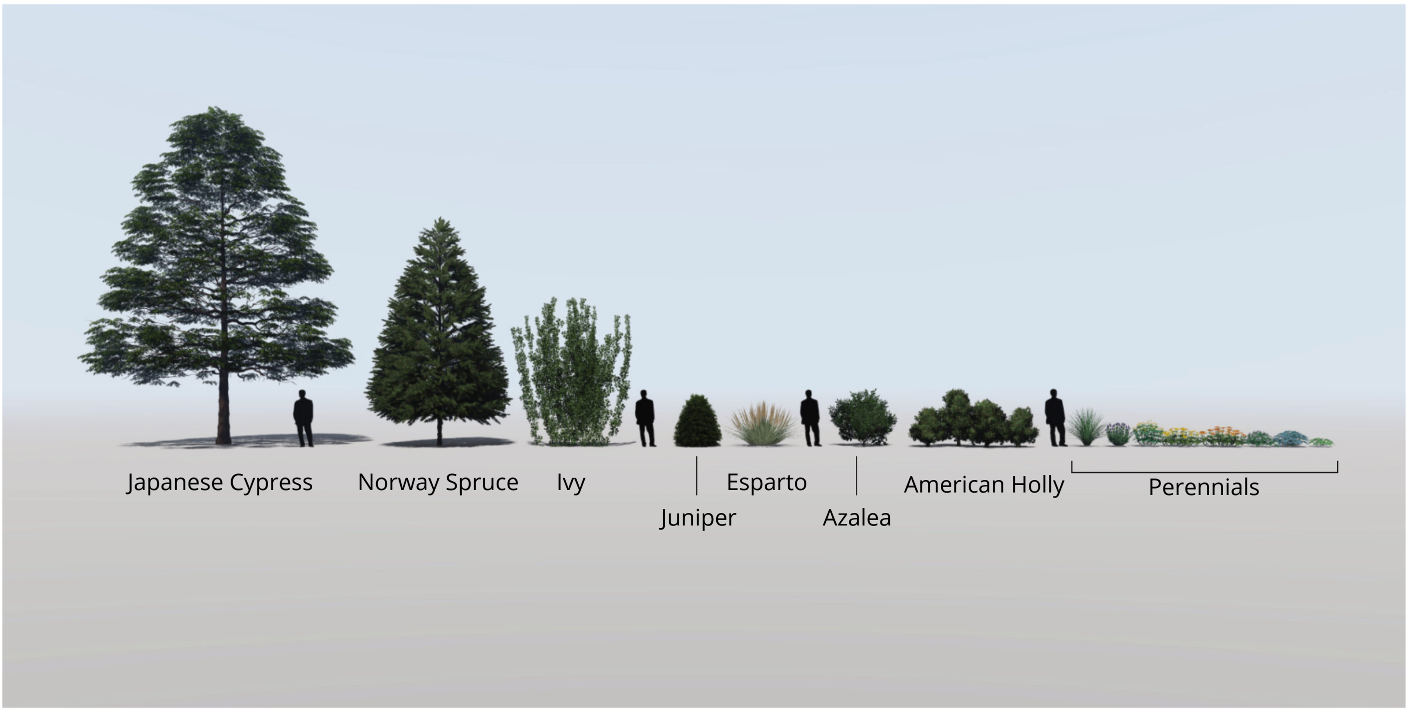


Figure 34 *- Overview of plant selection for scenario 3*

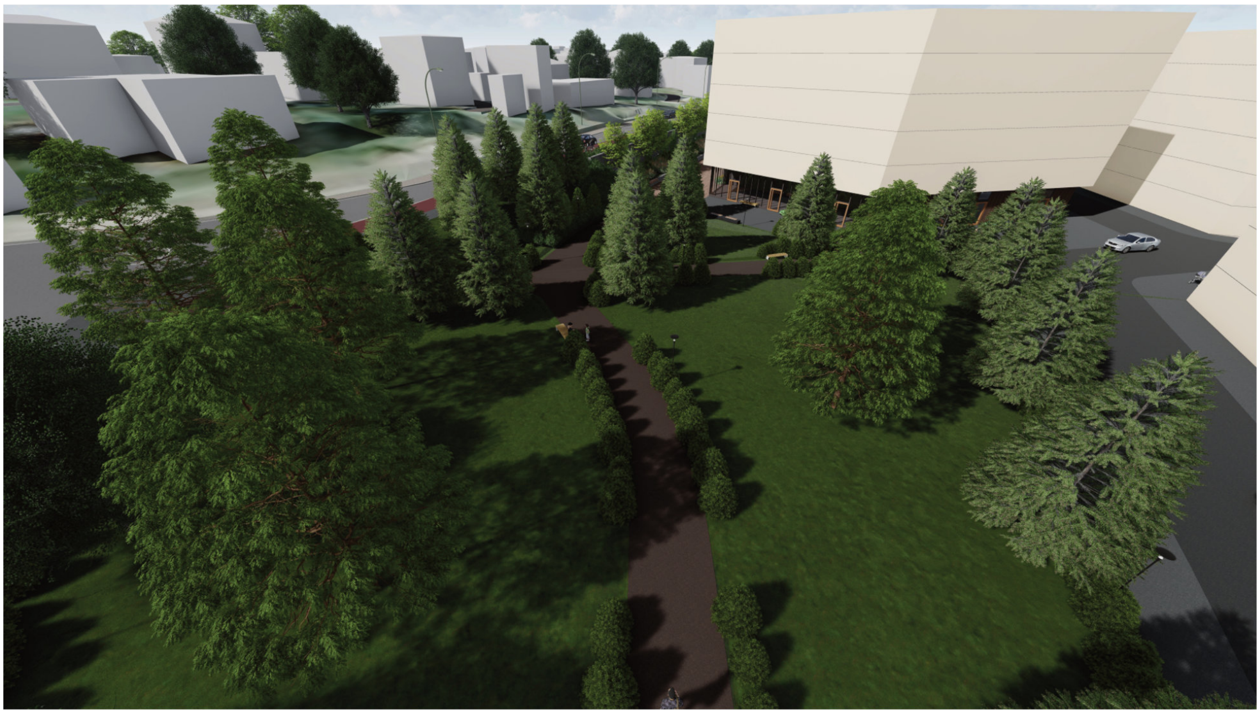


Figure 35 - *Overview of the park - scenario 3*

Figure 36 - *Overview public square - scenario 3*

Figure 37 *- Rendering from the public square - scenario 3*

Figure 38 *- Rendering from the park pathway - scenario 3*

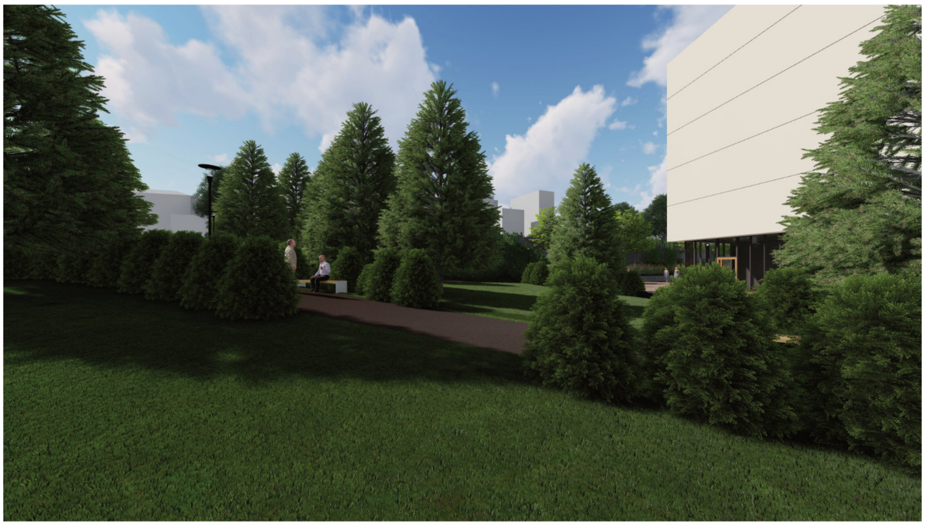


Figure 39 *- Rendering from the park grass area - scenario 3*

VR Demonstration

The model was produced with 360-degree VR images from three key locations in the model; from the public square, the park pathway, and on the grass. Both groups were allowed see the project using VR, but the Non-VR group got to see 360-degree VR images with VR after they filled out the survey questions.

Gazing points were added for the ease of use for the participants. They enable the user to freely look around, and jump from key location to key location without the use of a hand controller. This movement type is much easier to teach to participants, rather than movement with a hand controller.

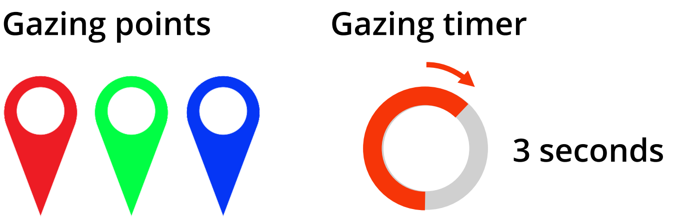


Figure 40 *- Gazing points. When participants look at a gazing point in the 360-degree VR image for a certain amount of time, they jump to that location without the use of a hand controller.*

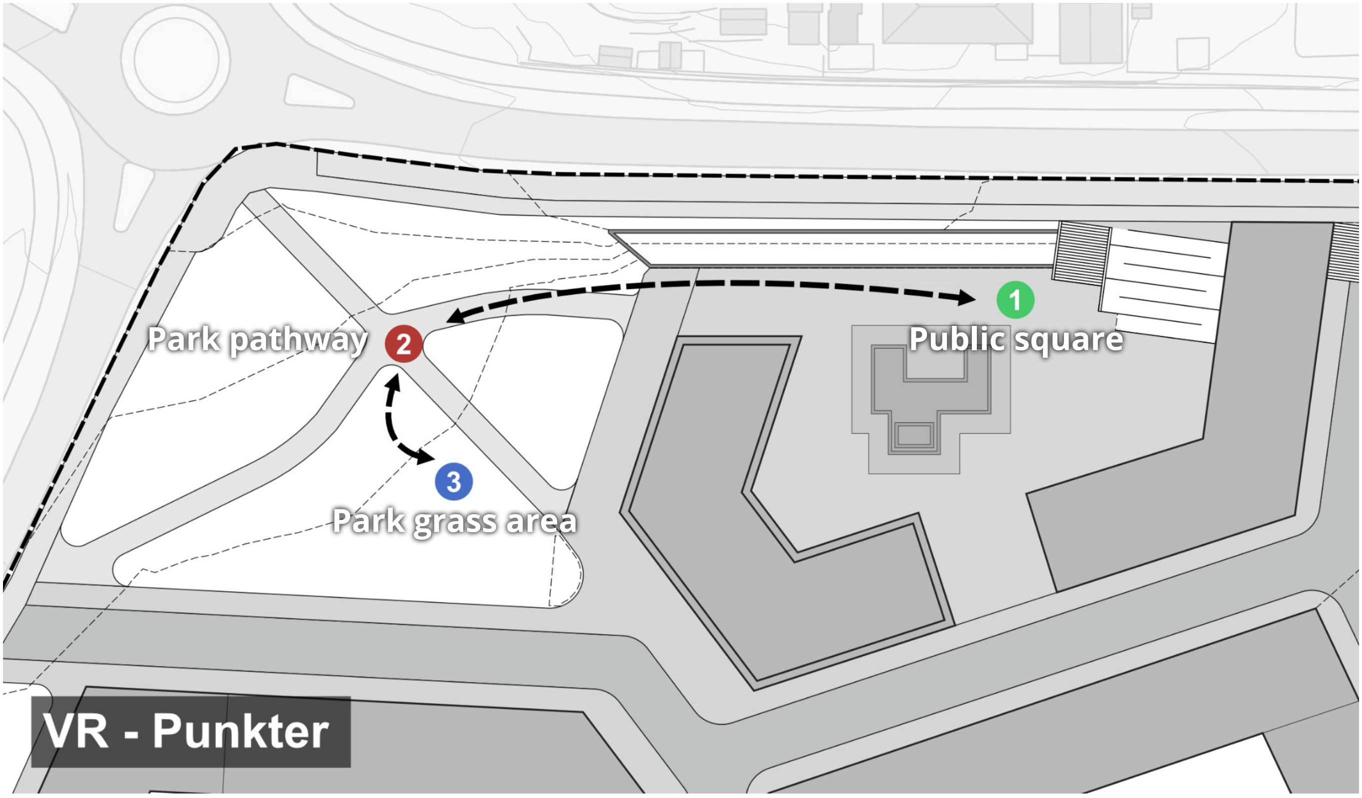


Figure 41 *- Overview of the 360-degree VR images locations and movement possibilities between each point.*

Figure 42 *- 360-degree VR image from the public square. Shown for scenario 2.*

Figure 43 *- 360-degree VR image from the park pathway. Shown for scenario 2.*

Figure 44 *- 360-degree VR image from the grass area. Shown for scenario 2.*

7 | Results

Group affiliation

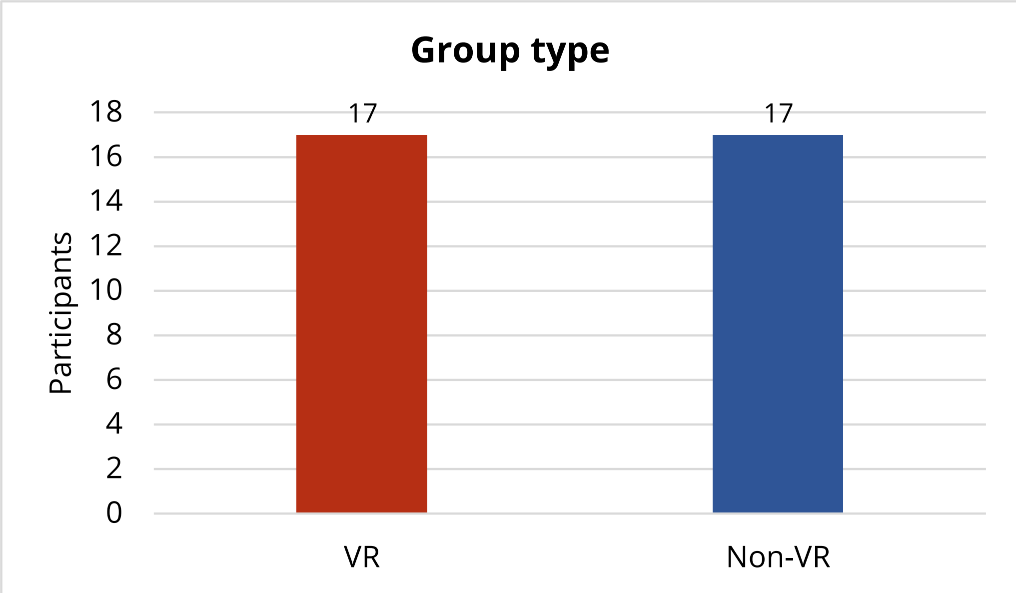


Figure 45 *- Group affiliation (n=34)*

The amount of participants in the experimental group (VR) and control group (Non-VR) were even, with 17 participants in each group.

Topic: Previous Experiences

Question 1. "Have you participated in a public meeting about a new planning proposal before?

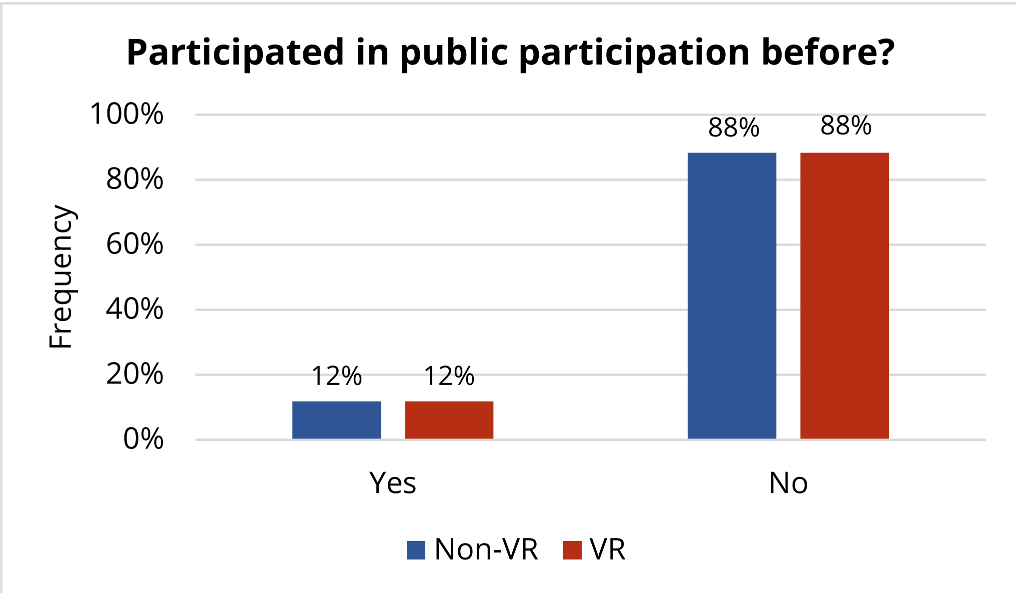


Figure 46 *- Previous experience with public participation (n=34)*

Results from the survey show that most participants do not have previous experience with public participation. This is even between both groups.

Topic: Previous Experiences

Question 2. "Have you, or do you study within the field of architecture, landscape architecture, or urban planning?"

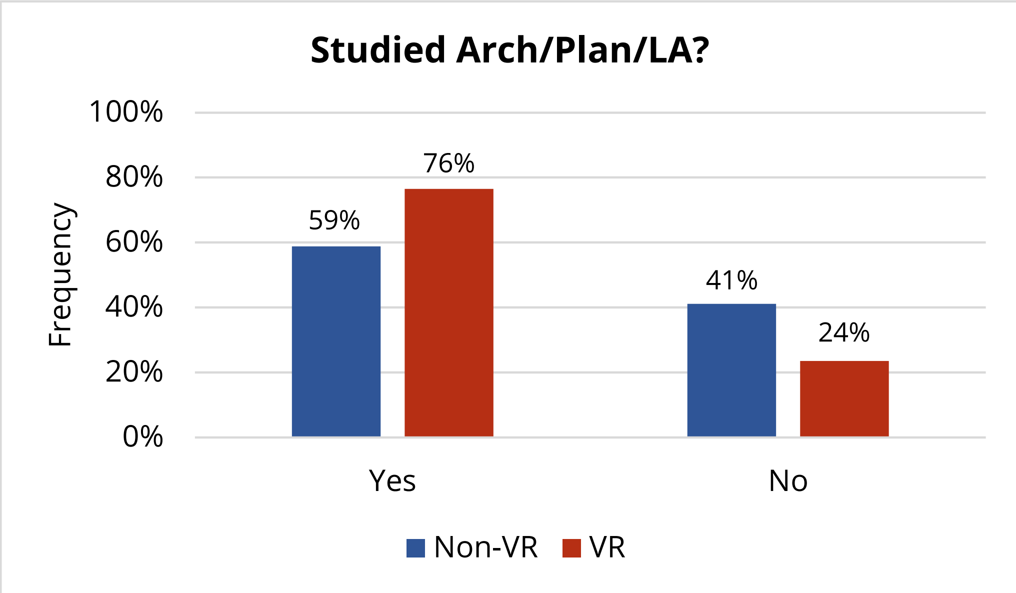


Figure 47 *- Affiliation to professional field (n=34)*

The results show that an overweight of participants have a connection to the field of landscape architecture or similar fields. The Non-VR group have a more even spread than the VR group, where the majority have an affiliation with spatial design. A combined 67% of participants have professional spatial related experiences.

Question 8. "Do you know the site from before, as it looks today?"

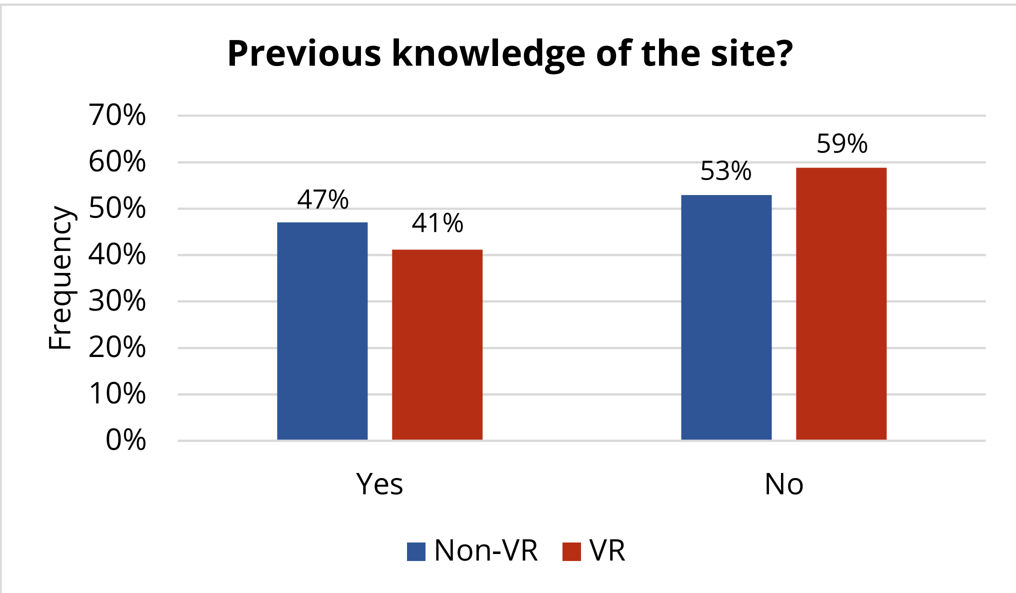


Figure 48 *- Previous knowledge of the site (n=34)*

Results show that some participants have previous knowledge of the site, although a small majority do not. Answers are about even between both groups.

Topic: General Description of the Participants

Question 3. "What is your gender?"

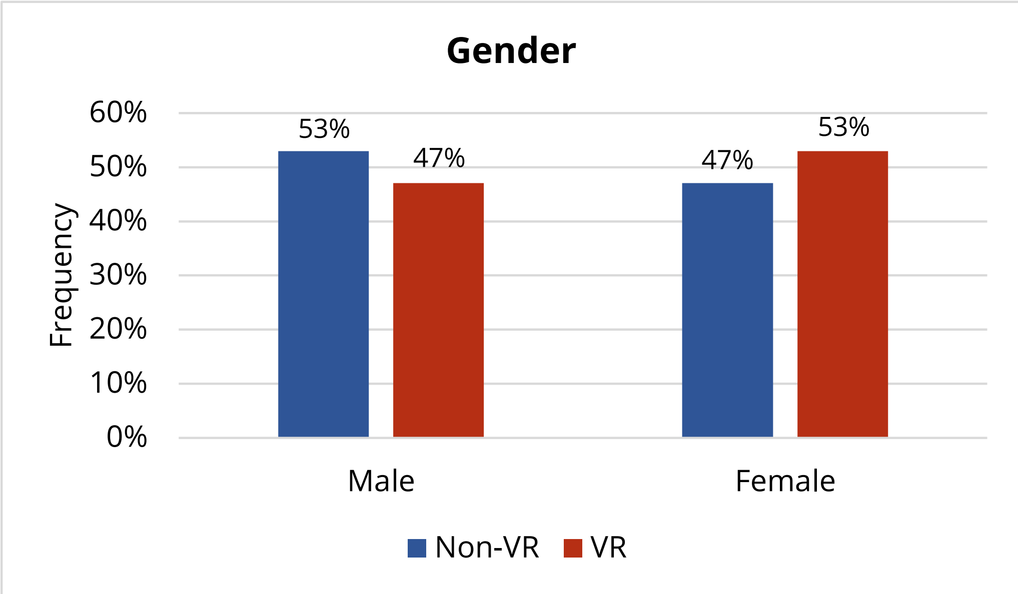


Figure 49 *- Distribution of gender (n=34)*

The distribution of gender were about even in both groups.

Question 4. "What is your age?"

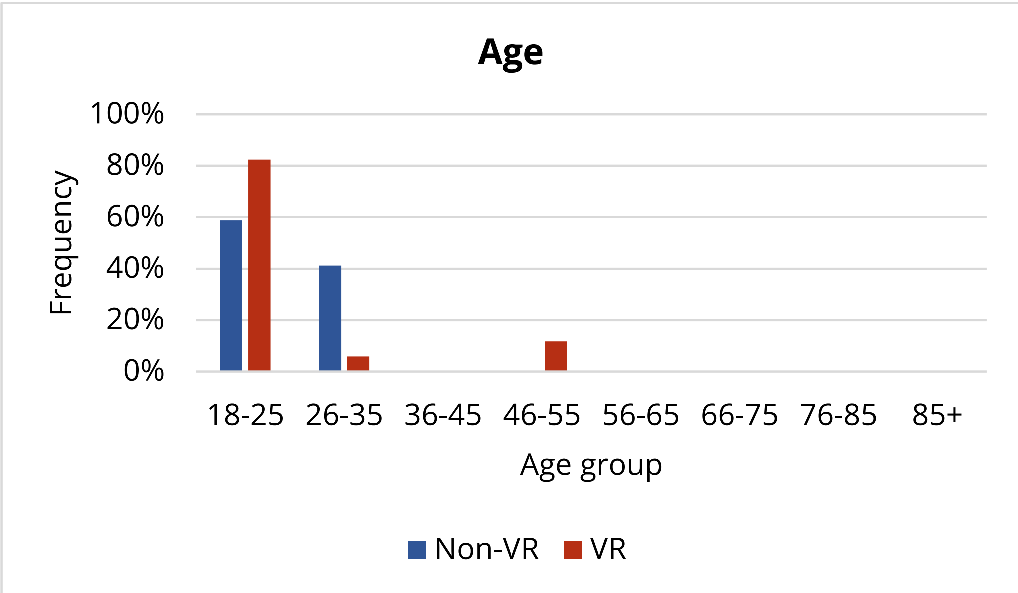


Figure 50 *- Distribution of age (n=34)*

60% of Participants from the Non-VR group were age 18-25, and 40% were aged from 26-35. Participants from the VR group were a bit younger on average, with most participants being 18-25 (over 80% of participants), although some were aged between 46-55 (12%) as well.

Topic: Statistical Difference Between Control and VR Group Regarding General Questions?

Summary of means and statistical significance between the Non-VR group and the VR group of general questions.

		Non-VR	VR	
Question		Mean	Mean	p (α=0.05)
Q9L1	Understanding of site placement	4.29	4.82	0.329
Q9L2	Understanding of size and scale	4.00	4.24	0.564
Q9L3	Understanding of the network of pathways and squares	4.24	4.41	0.659
Q9L4	Understanding of the choice of plants in each alternative	4.12	4.47	0.530
Q5	Realistic design	4.50	3.94	**0.027***
Q6	Realistic looking rendering	4.06	3.88	0.528
Q7	Realistic looking surroundings	3.93	3.75	0.692

Figure 51 *- The table show both mean differences between VR and Non-VR groups for general questions. The significance test are the results of a two-tail Mann-Whitney U test, using α = 0.05. Significance were p < 0.05 is marked with "* " and bold text.*

Results from the statistical test of the following questions regarding general questions (using a two-tail Mann-Whitney U test with α=0.05) show that there is almost no statistical significance in scores between VR groups and the Non-VR groups, except for question 5.

However, there are some differences in the scores, where the VR group scores from 0.2 - 0.5 higher within the categories for site understanding (Q9 questions). Non-VR groups seems to evaluate the visuals as a bit more realistic than the VR group.

For the Q9 questions, participants within the Non-VR group who has previous experiences with VR experience could possibly negatively skew results. This is however not been analysed, as participant numbers are too low to analyse with the use of statistics.

Topic: Overall Experiences From the Presentation

Question 9. Line 1. "To what degree did the presentation give you a understanding of site placement in Ås?"

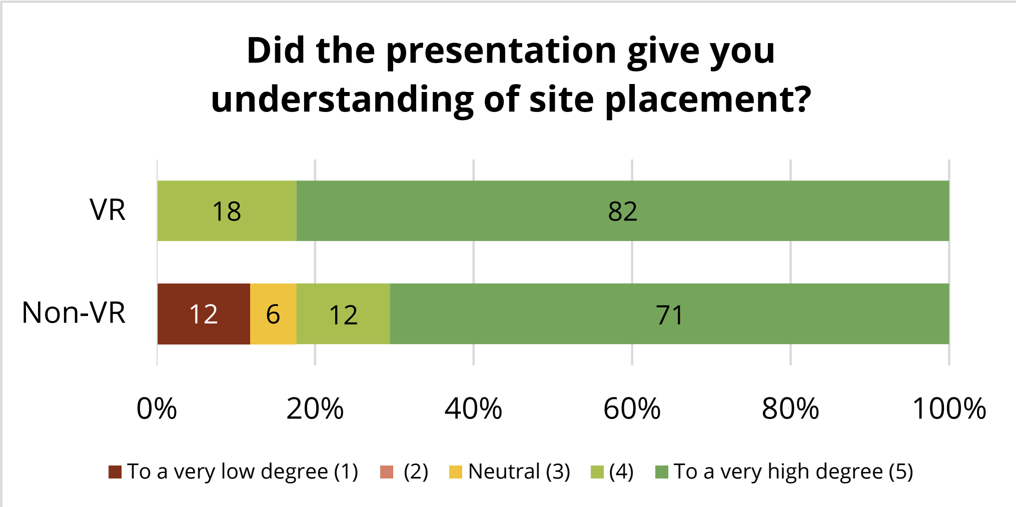


Figure 52 *- Understanding of site placement*

Although most participants either agree or strongly agree that the presentation gave a good understanding of site placement, some participants from the Non-VR group said that it did neither (6%) or did to a very low degree (strongly disagree, 12%).

Question 9. Line 2. "To what degree did the presentation give you a understanding of size and scale of the outdoor space?"

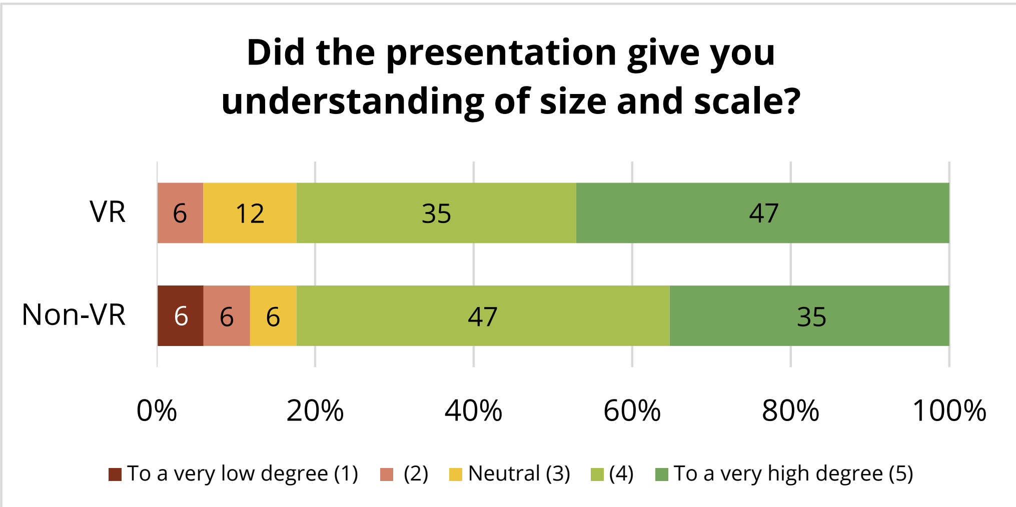


Figure 53 *- Understanding of size and scale*

The VR group did report that the presentation gave a slightly better understanding of size and scale of the outdoor space than the Non-VR group, however the difference is small.

Question 9. Line 3. "To what degree did the presentation give you a understanding of the network of pathways and squares?"

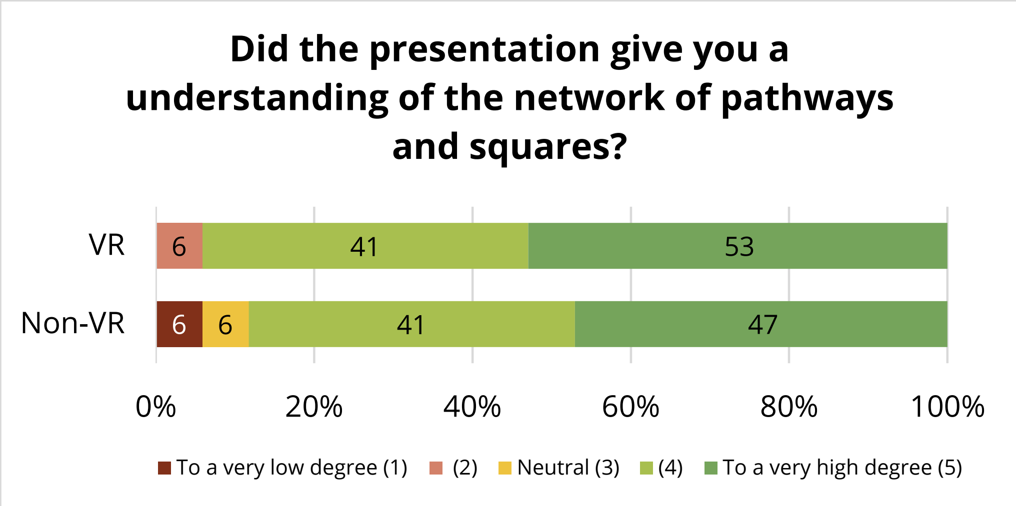


Figure 54 *- Understanding of pathways and squares*

The results show that the participants' understanding of the network of pathways and squares after the presentation was very even between both groups.

Question 9. Line 4. "To what degree did the presentation give you a understanding of the choice of plants in each alternative?"

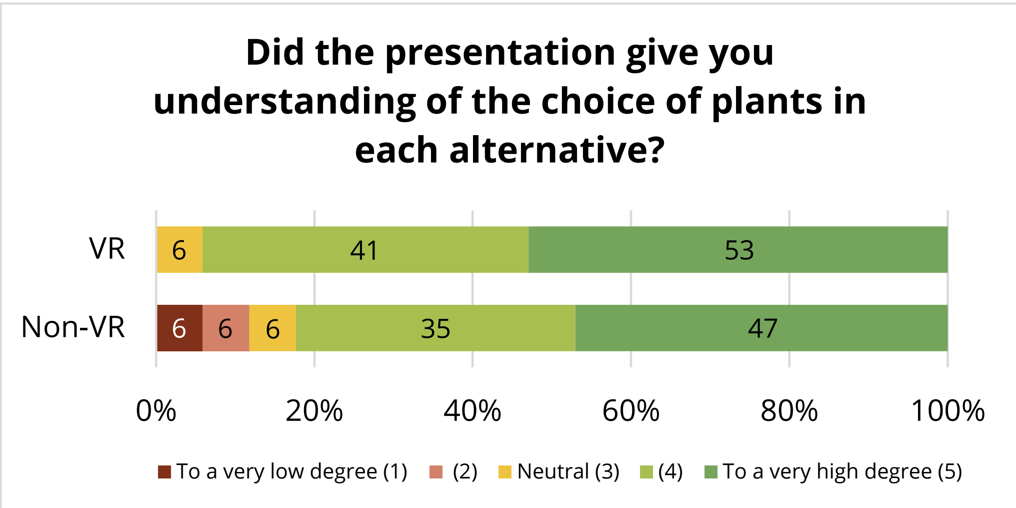


Figure 55 *- Understanding of choice of plants in each alternative*

A majority of the participants said that the presentation did give a high or very high degree of understanding (94% for VR and 82% for Non-VR) of the choice of plants in each scenario. A couple of participants from the Non-VR group said that it did not.

Topic: Experienced Realism

Question 5. "How realistic do think the design of the new project is?"

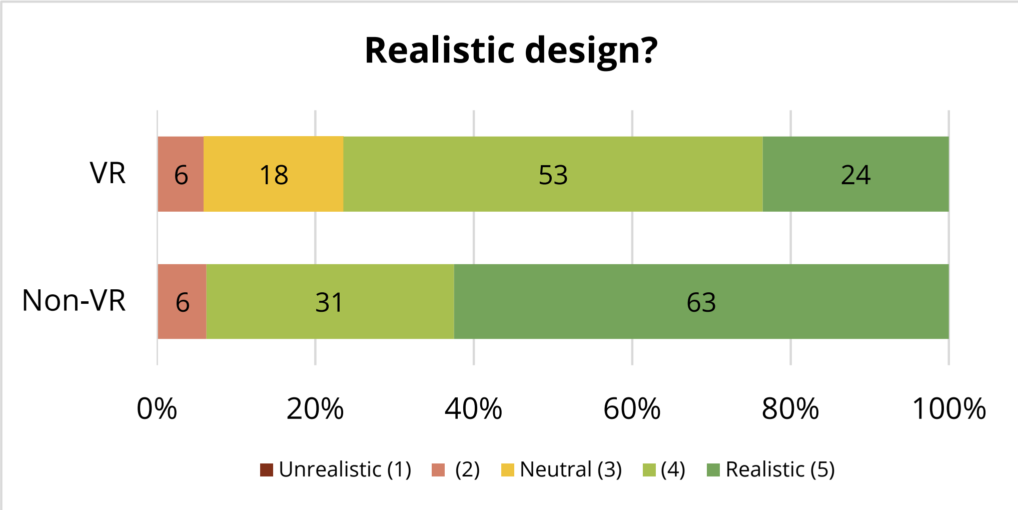


Figure 56 *- Opinion of realism of the design*

Respondents from the Non-VR group responded to a higher degree (63% strongly agree) that they felt that the new model's design was realistic than the VR group (24%). While this is a significant difference, both groups responded that they agreed or strongly agreed that the new model design was realistic.

Question 6. "How realistic do think pictures from the new model looks?"

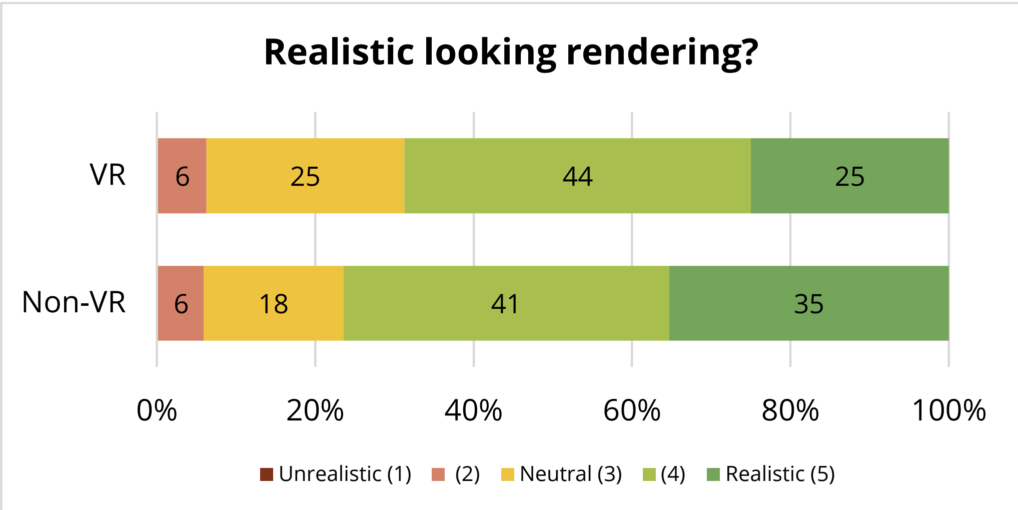


Figure 57 *- Opinion of realism about the renders*

A majority of the participants agreed or strongly agreed that the renderings in the presentation looked realistic (69% VR and 76% Non-VR). The difference between both groups seem to be small.

Question 7. "To what degree did the surrounding environment from the new model resemble surroundings from the real world (as shown in the first video?)"

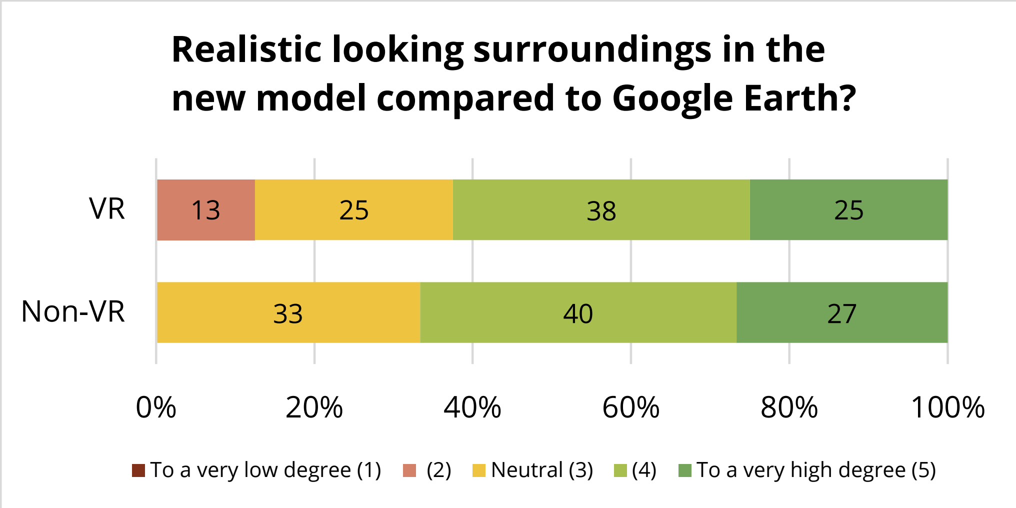


Figure 58 *- Realistic model resemblance to the real world model*

Participants from each group reported that new model looked somewhat or strongly realistic compared to a real world example (i.e. video made with Google Earth Studio).

Topic: VR-Related Experiences

Question 10. "To what degree did you get a feeling of taking part in the virtual world with the VR headset?"

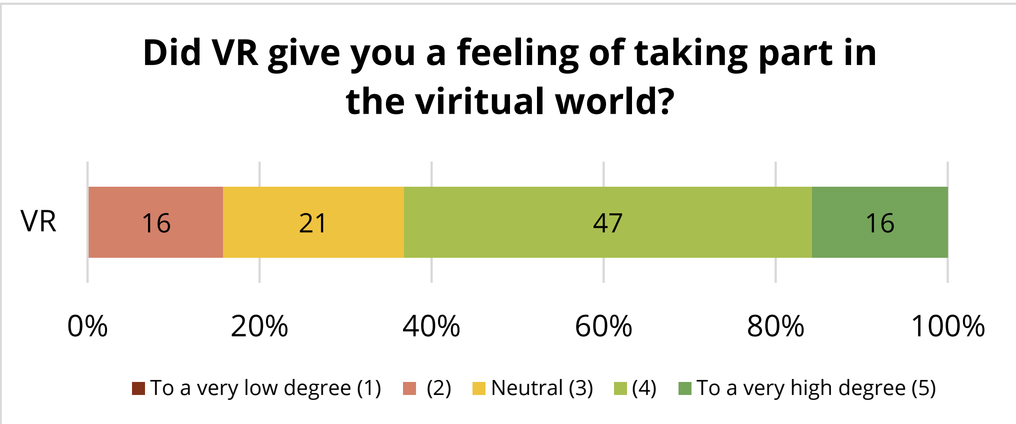


Figure 59 *- Feeling of taking part in the virtual world with VR headsets*

Most participants using VR reported that they to a high or very high degree felt that they took part in the virtual world by the use of VR headsets (63% combined). Some were neutral (21%) and a few did not very much (16%).

Topic: VR-Related Experiences

Question 11. "To what degree do you think the use of VR headsets influenced your impression of the different alternatives?"

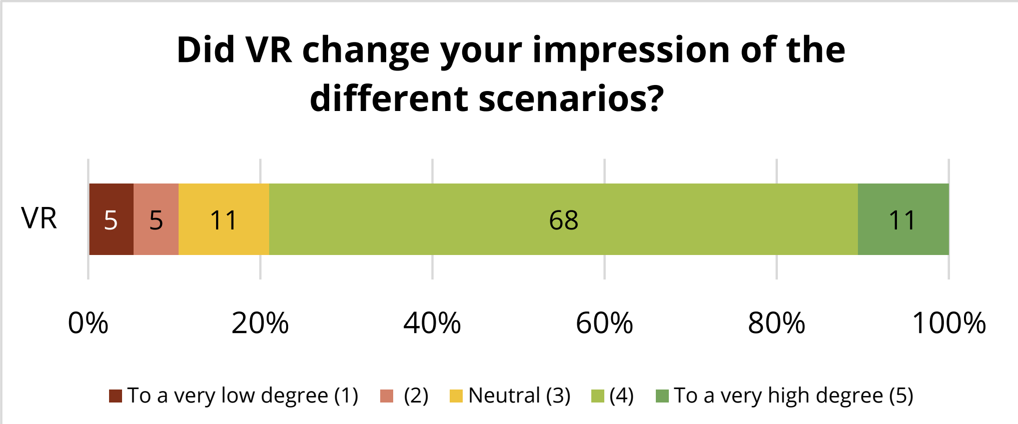


Figure 60 *- Thoughts about the influence of VR*

Results show that most participants in the VR group agree (68%) or strongly agree (11%) that the use of VR influences their impression of the different scenarios. A small minority did not have the same impression.

Question 12. "To what degree do you think the use of VR headsets are suitable for other planning projects where the developer or municipality invites to public participation?"

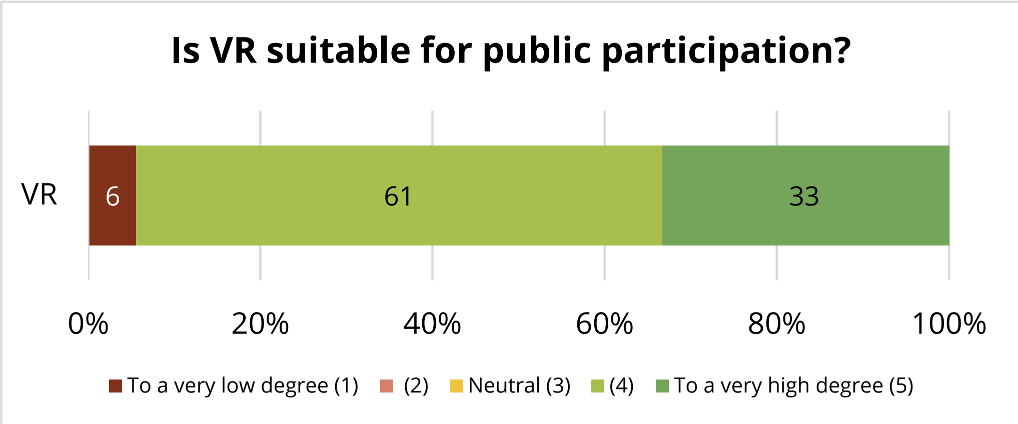


Figure 61 *- Thoughts about suitability of VR in public participation processes*

Participants from the VR group agreed (61%) or strongly agreed (33%) that the use of VR is suitable during public participation.

Question 13. "To what degree dd the use of a VR headset make you feel uncomfortable? (dizziness, nausea etc.)"

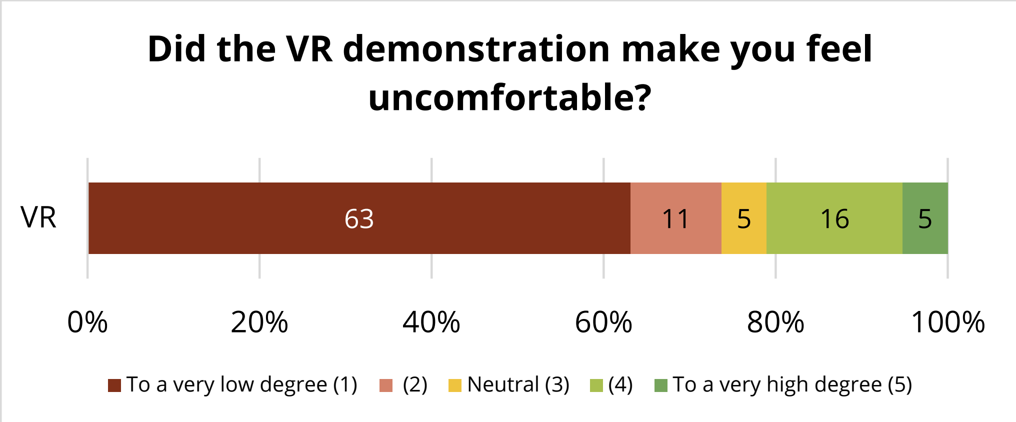


Figure 62 *- Discomfort using VR*

Over 60% of the participants using VR did not feel uncomfortable using VR, however 21% of participants reported that they to a high or very high degree felt uncomfortable using VR.

Question 14. "Have you tried VR headsets before?"

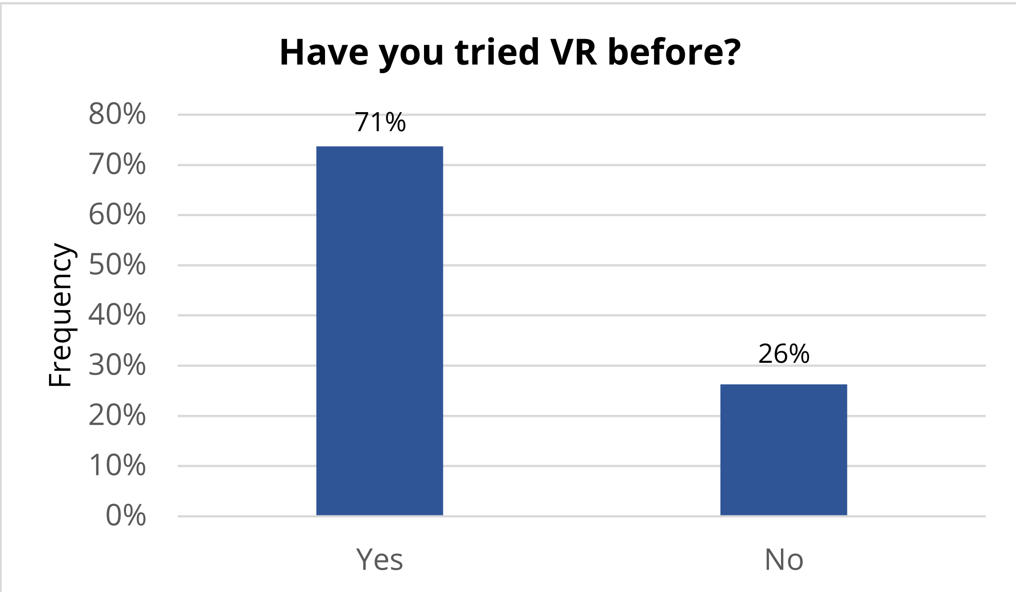


Figure 63 *- Previous experience with virtual reality headsets*

A majority of the participants (74%) in the VR group have tried VR before.

Topic: Statistical Difference Between Control Group and VR Group With Different Scenarios?

Summary of means and statistical significance between the Non-VR group and the VR group of the different scenarios.

			Scenario 1	
			Non-VR	VR
Type of question	**Question**		Mean	Mean
Positive aspects	AL1	"I would like to visit the park and the public square"	2.47	3.19
	AL3	"I would feel satisfied here"	2.75	3.18
	AL4	"I think the park is pretty"	2.59	3.06
	AL5	"I think the public square is pretty"	2.41	3.12
	AL9	"I would like to sit in the park"	2.44	2.94
	AL10	"I would like to sit in the public square"	2.38	2.88
Negative aspects	AL2	"I think the site is confusing"	1.53	1.41
	AL6	"I would walk past the site, without visiting"	3.88	3.41
	AL7	"I would feel uneasy in the park"	1.29	1.47
	AL8	"I would feel uneasy in the public square"	1.41	1.59
Overall score	B	"Give the scenario a score"	2.59	3.06

Figure 64 - *The table show both mean differences between VR and Non-VR groups reviewing the different scenarios. The significance test are the result of a two-tail Mann-Whitney U test, using α=0.05. Significance were $p < 0.05$ is marked with " ***** " and bold text. A higher mean score is better within positive aspects, and a lower score is better within negative aspects.*

Results from the statistical test of the following questions regarding different scenarios (using a two-tail Mann-Whitney U test with α=0.05) show that there is almost no statistical significance in scores between VR groups and the Non-VR groups, with the exception of question 1 and 5 on scenario 1. Mean differences between groups are also alternating between positive and negative values within both of the postivitve and negative aspect categories.

		Scenario 2				Scenario 3			
		Non-VR	VR			Non-VR	VR		
Diff.	p (α=0.05)	Mean	Mean	Diff.	p (α=0.05)	Mean	Mean	Diff.	p (α=0.05)
+0.72	**0.041***	3.76	4.06	+0.30	0.338	3.35	3.44	+0.09	0.756
+0.43	0.174	4.12	3.76	-0.36	0.239	3.47	3.12	-0.23	0.236
+0.47	0.146	4.18	3.94	-0.24	0.488	3.47	3.18	-0.29	0.429
+0.71	**0.009***	3.65	3.81	+0.16	0.537	3.29	3.53	+0.24	0.223
+0.50	0.180	3.50	4.00	+0.50	0.222	3.06	3.24	+0.18	0.760
+0.50	**0.032***	3.13	3.53	+0.40	0.260	3.25	3.71	+0.46	0.159
-0.12	0.538	1.88	1.94	+0.06	0.867	2.65	2.88	+0.23	0.669
-0.47	0.294	2.47	2.53	+0.06	0.942	3.29	3.00	-0.29	0.333
+0.18	0.490	1.47	1.53	+0.06	0.769	2.29	2.65	+0.36	0.467
+0.18	0.660	1.65	1.47	-0.18	0.654	1.76	1.76	+0.00	0.881
+0.47	0.159	4.00	4.06	+0.06	0.818	3.18	3.24	+0.06	0.823

Topic: Statistical Difference Between Each Scenario?

Summary statistical significance between the ratings of each alternative. VR groups and Non-VR groups are combined.

Type of quesiton	Question	
Positive aspects	AL1	"I would like to visit the park and the public square"
	AL3	"I would feel satisfied here"
	AL4	"I think the park is pretty"
	AL5	"I think the public square is pretty"
	AL9	"I would like to sit in the park"
	AL10	"I would like to sit in the public square"
Negative aspects	AL2	"I think the site is confusing"
	AL6	"I would walk past the site, without visiting"
	AL7	"I would feel uneasy in the park"
	AL8	"I would feel uneasy in the public square"
Overall score	B	"Give the scenario a score"

Figure 65 - *The table show statistical differences each scenario using a Kruskal-Wallis-test with α=0.05, followed by a post-hoc Mann-Whitney U test to check difference between pairs. Significance were p < 0.05 is marked with " ***** " and bold text. An "X" in the difference table indicates a statisitcal difference between the two listed scenario. A higher mean score is better within positive aspects, and a lower score is better within negative aspects.*

Results from the statistical test above (see figure 65) show that the three scenarios are preferred differently from each other (the VR and Non-VR group are combined). The largest difference of preference seems to be between scenario 1 (with low vegetation density) and scenario 2 (with medium vegetation density). Between these two scenarios, all positive aspects are statistically different from each other, where scenario 2 is rated higher than scenario 1. This is also the case in when we look at the overall score.

For scenario 3, there are more differences between scenario 2 in regard to the negative aspects. Participants rate scenario 3 more negatively compared to scenario 2, and sometimes scenario 1. This is quite apparent in the questions regarding confusion on site and uneasiness in the park.

	Kruskal Wallis test		Scn 1	Scn 2	Scn 3	Difference test		
	p (α=0.05)	**H-stat**	**Mean**	**Mean**	**Mean**	**S1 - S2**	**S2 - S3**	**S1 - S3**
	0.00041*	15.6232	2.82	3.91	3.39	X		
	0.00035*	15.9394	2.97	3.94	3.29	X	X	
	0.00001*	22.3859	2.82	4.06	3.32	X	X	
	0.00004*	20.2033	2.76	3.73	3.41	X		X
	0.00286*	11.7172	2.70	3.76	3.15	X		
	0.00121*	13.4366	2.64	3.33	3.48	X		X
	0.00002*	21.9880	1.47	1.91	2.76		X	X
	0.00052*	15.1159	3.65	2.50	3.15	X	X	
	0.00044*	15.4684	1.38	1.50	2.47		X	X
	0.49956	1.3880	1.50	1.56	1.76			
	0.00001*	25.6084	2.82	4.03	3.21	X	X	

Topic: Positive Aspects From the Scenarios

Question A. Line 1. "I would like to visit the park and the public square"

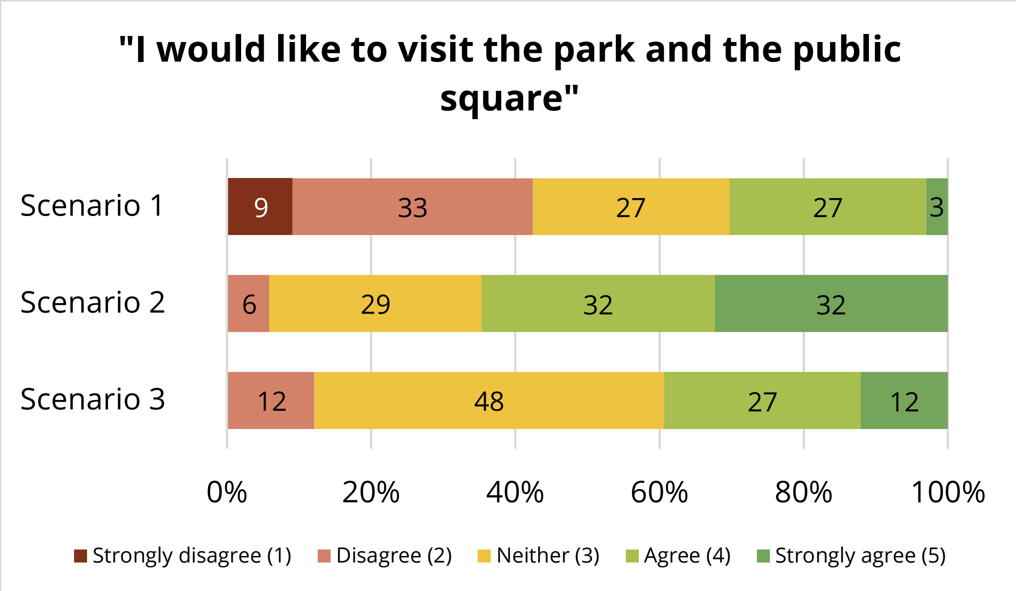


Figure 66

Participants seem to prefer scenario 2, followed by scenario 3 and 1 respectively. Scenario 1 also have the most negative answers. Interestingly, there is a significant statistical difference between the VR group and control group regarding scenario 1, where the VR group prefer scenario 1 more than the control group.

Question A. Line 3. "I would feel satisfied here"

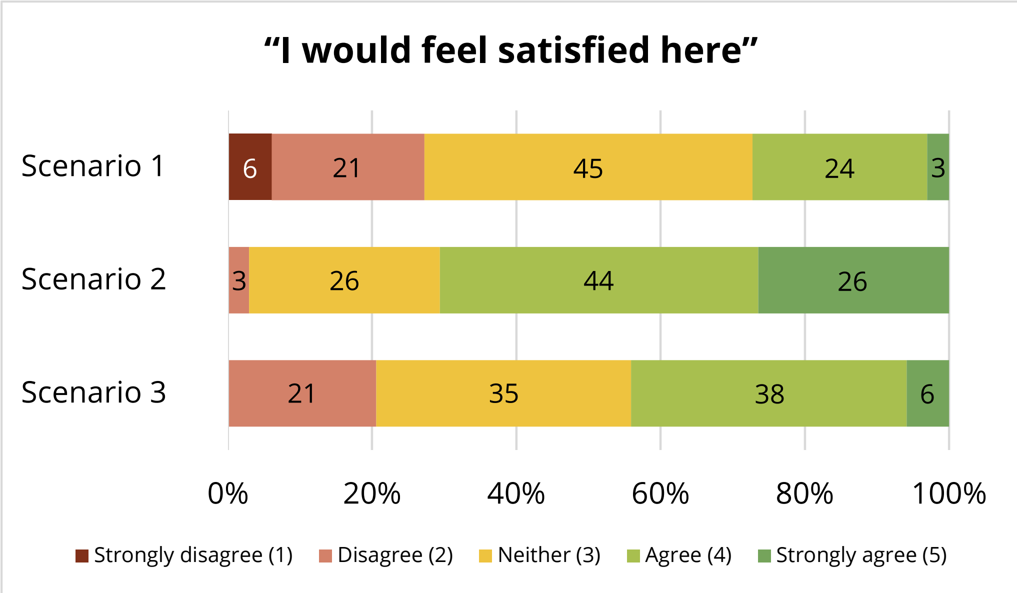


Figure 67

The results almost follow the same pattern as the previous question. Scenario 2 seems to be the most preferred scenario, where many report that they are somewhat satisfied. This is followed by scenario 3 and 1 respectively, where participants have a more neutral stance. Although the pattern are similar to the previous question, scenario 1 and 3 are more similar to each other than previously.

Topic: Positive Aspects From the Scenarios

Question A. Line 4 "I think the part is pretty."

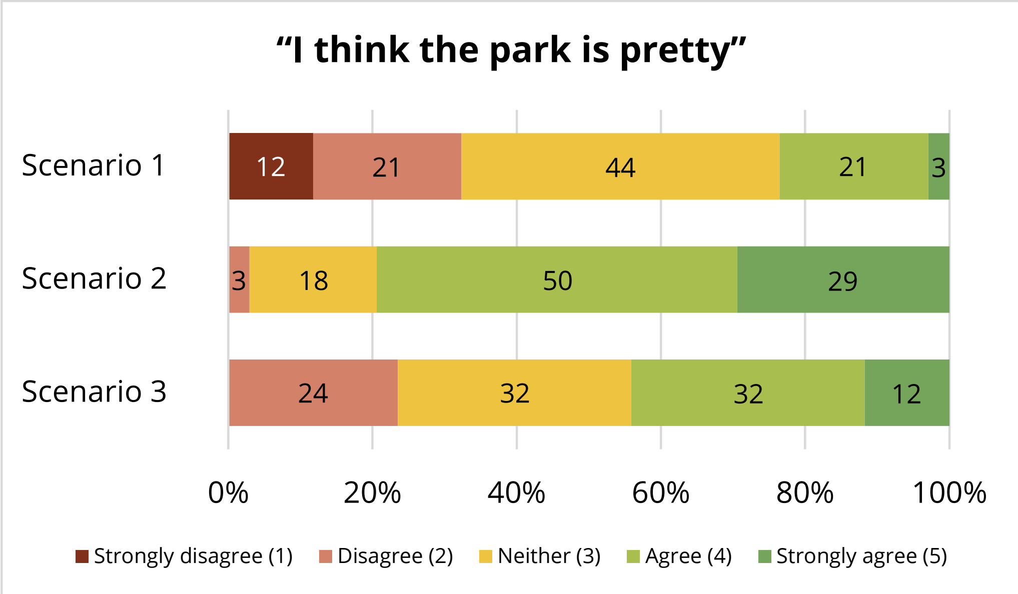


Figure 68

Results follow approximately the same pattern as previous question about satisfaction. Scenario 2 was the most preferred, followed by 3 and 1.

Question A. Line 5. "I think the public square is pretty."

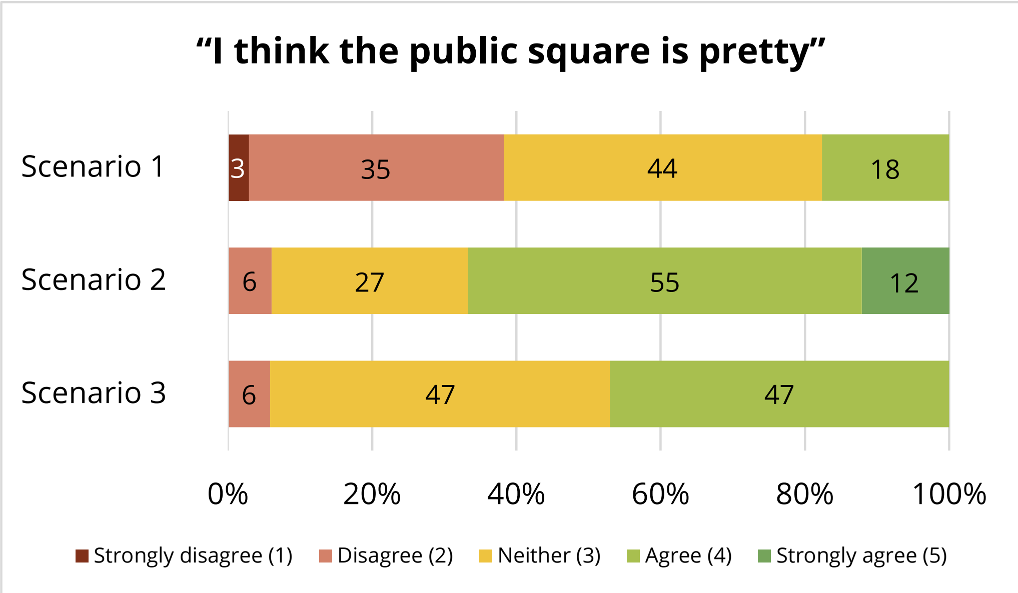


Figure 69

Answers regarding the prettiness of the public square is a bit different than in the park. Scenario 2 is still the most preferred, but is now more closely followed by scenario 3. Answers regarding scenario 1 have also become more negative than in the park.

Question A. Line 9. "I would like to sit in the park."

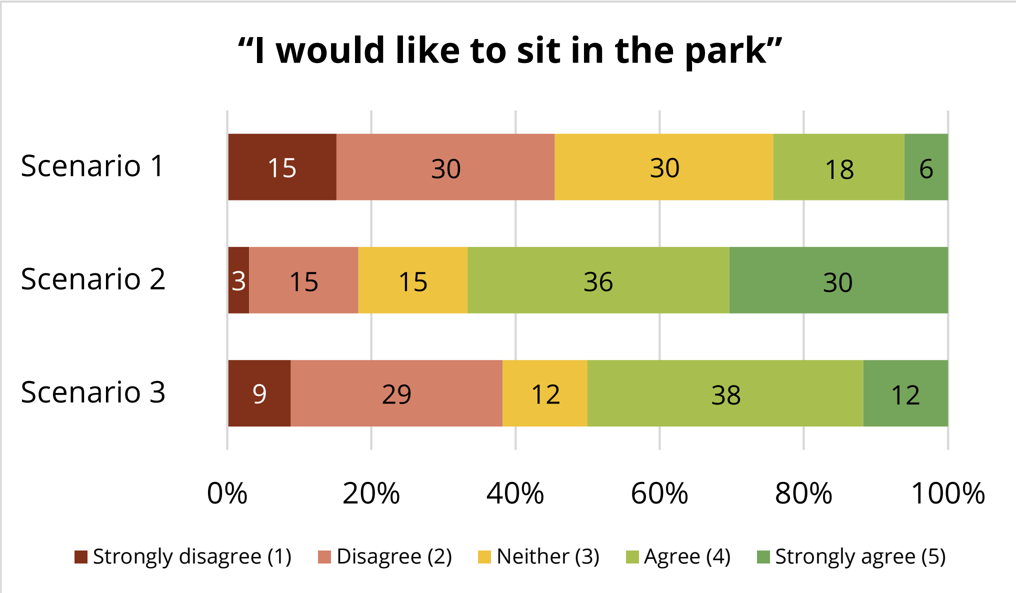


Figure 70

This question is meant to analyse participants' willingness to spend some time in the park, sitting down. The answers still seem to follow the same pattern as before but appear to be more negative than previously. Scenario 3 seems to stand out by having more negative answers.

Question A. Line 10. "I would like to sit in the public square."

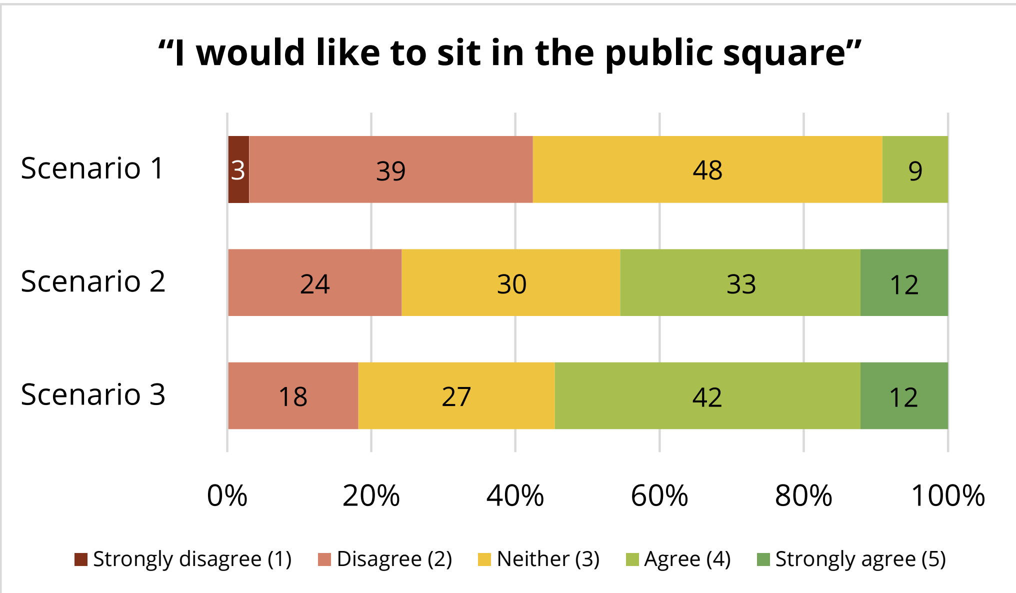


Figure 71

This question is meant to analyse participants' willingness to spend some time in the public square, sitting down. Unlike previous answers, scenario 3 now seems to be the most preferred scenario, followed by scenario 2 and 1.

Topic: Negative Aspects From the Scenarios

Question A. Line 2. "I think the site is confusing"

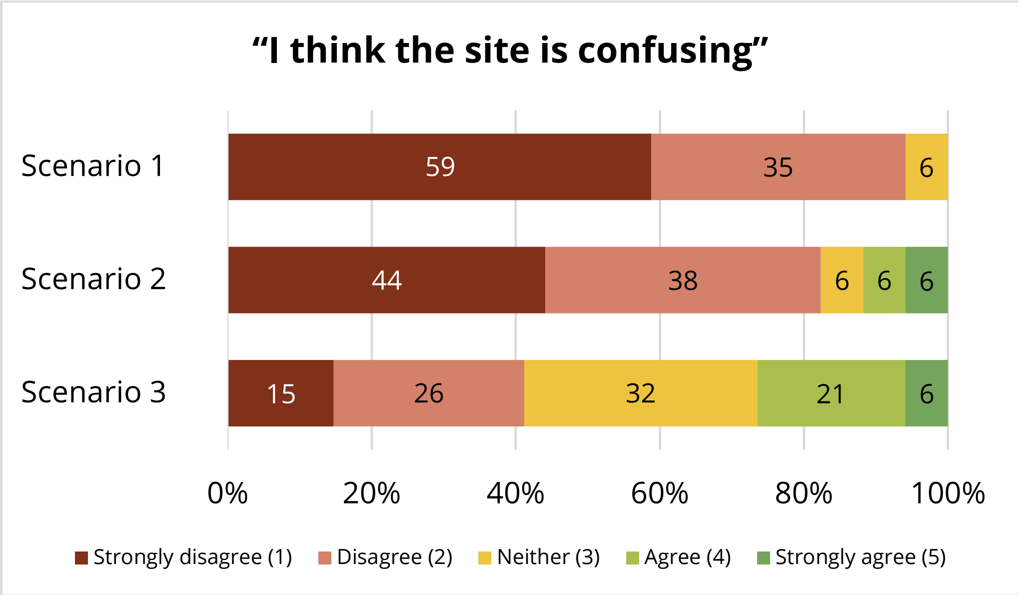


Figure 72

Participants rated scenario 3 as the most confusing alternative. This was followed by scenario 2 and 1, with scenario 1 rated as the least confusing.

Question A. Line 6. "I would walk past the site without visiting"

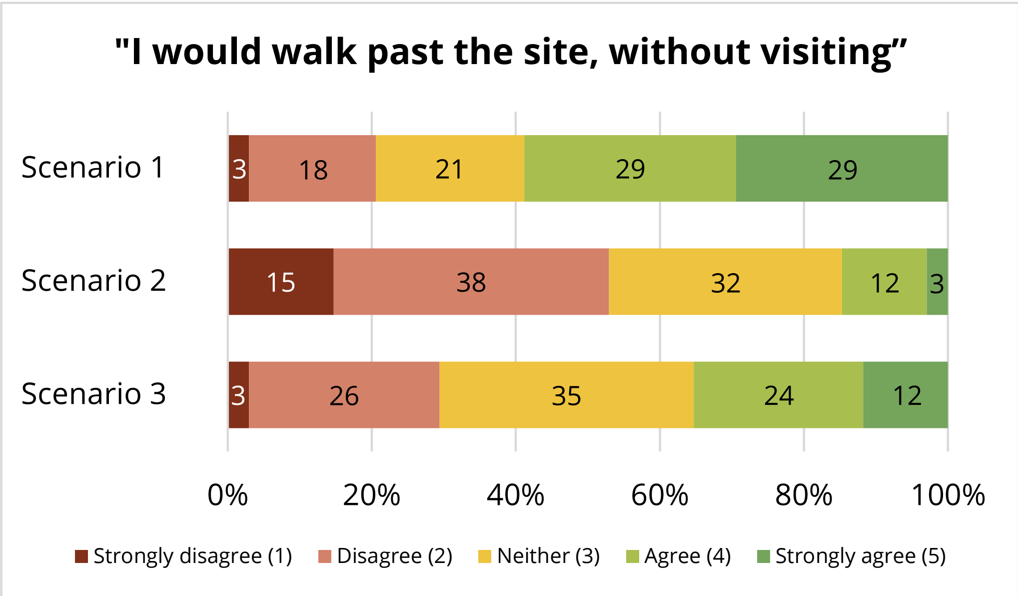


Figure 73

Again, scenario 2 seems to be the most preferred scenario where most participants report that they want to visit. This follows the same pattern as before.

Question A. Line 7. "I would feel uneasy in the park"

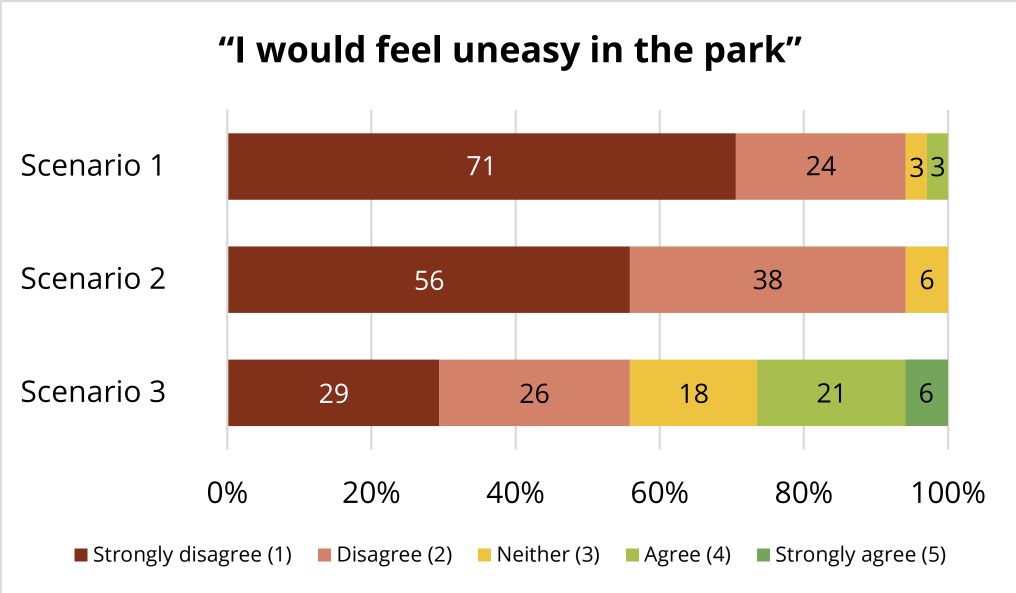


Figure 74

Results show that participants do not feel uneasy in the park for the most part, with the exception of scenario 3, where 26% either agree or strongly agree that they do.

Question A. Line 8. "I would feel uneasy in the public square"

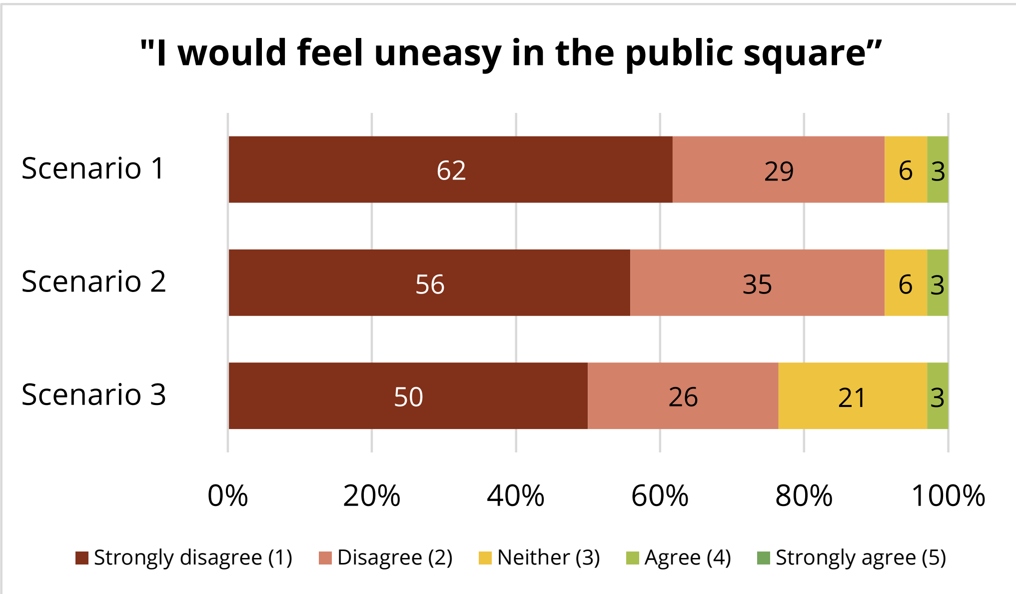


Figure 75

Answers from the participants did not differentiate much between each scenario in the public park, but it follows the same pattern as the previous question.

Topic: Overall Impression of the Scenarios

Question B. "Give the scenario a score"

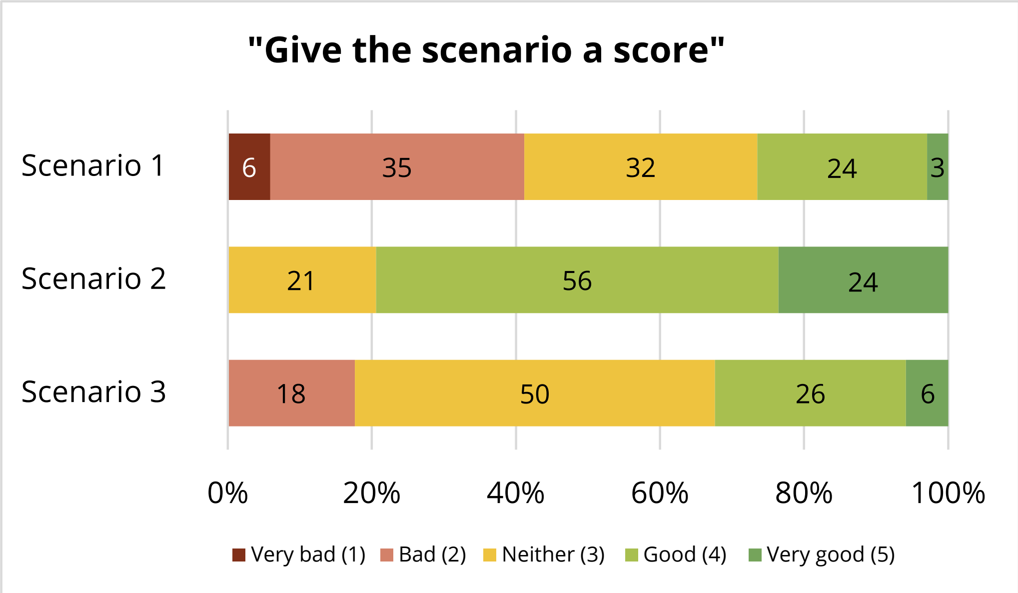


Figure 76

Lastly, participants were asked to holistically evaluate the different scenarios. Scenario 2 was clearly the most preferred scenario. This was followed by scenario 3 where more participants had a neutral stance, and then scenario 1 which was the least preferred.

Topic: Interviews

In addition to quantitative data from the survey, a group interview was held after the experiment to provide qualitative data, and to provide more validity for the study. While participants from the VR group was shown scenarios with VR during the presentation, participants from the Non-VR group was allowed to try VR after their completion of survey questions. Because the group interview was held after the survey, with both groups having tried VR, answers regarding VR come from both groups. Three main questions were asked, and the following will summarise the answers which were collected. Answers were translated from Norwegian to English.

Question 1

Was the VR demonstration easy to take part in, or was it complicated in any way? How?

VR groups:

The VR group said that the demonstration "worked well when we first got started", as a few respondents reported some trouble with the Oculus guardian system / grid and black screens at the beginning. Many stated that they found the demonstration easy to take part in and that the gazing points in the VR demonstration worked well. One also thought that the view height was a bit high, even though the view height was set to 1,7 meters above ground, which in within range of a standard viewing height for a standing human.

Non-VR groups:

The Non-VR group reported mostly the same as the VR-group (i.e., that there was trouble with the Oculus guardian system / grid and black screens, but it worked very well after the trouble was resolved). Like the VR group, participants also said that the gazing points in the model felt intuitive and that it was easy to move around. Some also reported that they got a little dizzy using VR. One was also complaining that the picture seemed to be unsharp. One also reported that the human figures inserted into the model also helped to understand and comprehend the scale of the project.

Question 2

Did the VR demonstration change your impression of the different design alternatives? Why?

VR groups:

Respondents from the VR group said that they got a better experience in VR, especially regarding the size and scale of the scenes. Others said that they got a better impression of the site, with getting a better overview of the site with the use of VR. A few also said that they thought it was more pleasant to look at the project when they had control of what they chose to look at. Some stated that they also got a better impression of the vegetation.

Non-VR groups:

One respondent from the Non-VR group said that they did get the same experience from both looking at the video and pictures, as the VR demonstration. Another said that stating on the grass scenario 3 (where vegetation was at its densest) felt much more safe in VR than the impression they got from the video. She thought that the sense of scale felt different in VR, and that this could have impacted of how compact spaces felt compared to the pictures and videos.

Question 3

If you attend a similar presentation with public participation again, would you try VR once more? Why?

VR groups:

Many participants from the VR groups said that they were willing to try VR once more in public participation if they got the chance, and if was easy to take part in. Some also said that they would attend again because it was fun and because it works. One also added that the scale planning proposals could be easier to understand with the use of VR.

A few respondents also dwelled on some of the problems regarding the use of VR in public participation settings. One respondent said that it could be somewhat difficult to comment on the model afterwards. Another asked about other possibilities to watch the VR model without the use of VR. This was probably referring to 360-degree images, which could be easy to shown on a 2D screen. Others asked for possibilities of collaborating with other participants inside VR.

<u>Non-VR groups:</u>

Participants from the Non-VR group said that that they got a better overview of the project using VR, and it thereby having value in a public participation process. Some also stated that it was easier to understand the scale of the project and that it was easier for them of get an impression of the project using VR. Others said that visualisation with VR was a good tool because the visualisations did not feel as “final” as pictures and plans. Almost all said that they wanted to try VR if they got the chance again in public participation.

8 | Discussion

This chapter will discuss the results found from the research experiment in light of the theoretical background presented in chapter 3. The last section will discuss the thesis' limitations.

Main Research Question

Is virtual reality headsets (VR) viable for evaluation of planting design concepts in public participation processes?

To answer the main question, sub question will break the main questions into three different aspects.

Question 1 - Preference for a Specific Vegetation Design

1. *Do participants landscape preferences vary when vegetation density change, even when looking at digital vegetation scenarios in VR?*

This first question relates to participants' landscape preferences when vegetation densities vary, with the use of a digital 3D model presented with and without VR.

With the context of prior research presented in chapter 3, it is difficult to conclude that all humans would have a universal landscape preference for a particular vegetation density in the landscapes. While most studies suggest that the presence of vegetation is more preferred than no vegetation (Jiang et al., 2015; Van Dongen & Timmermans, 2019), it is harder to establish clear preferences for landscapes with either medium or higher density of vegetation (Hägerhäll et al., 2018; Tveit, 2009). Although human preferences for a universal vegetation density is almost impossible to prove, previous studies about landscape preference still provide valuable insight for the design of landscapes for citizens in more local contexts. Locally produced landscape design proposals might not even want to follow a universal hypothesised vegetation density preference, as the local landscape preferences of citizens might be different than the universal proposed average. This is particularly applicable in connection to public participation regarding landscape design.

While this study is not trying to prove a universal landscape preference for a select amount of vegetation density, the first research question is asked to understand the landscape vegetation density preference of the sampled participants, based on Robinson (2016) categories presented in chapter 3. Testing this will also challenge or confirm results from prior studies, now analysed under conditions where participants look at digital vegetation models using VR, rather than using 2D images or 360-degree VR images displaying captured reality, as previous studies have done. Can this study reaffirm previous findings? Do participants prefer vegetation in landscapes that trends toward medium to high vegetation density (Gao et al., 2019; Hägerhäll et al., 2018; Jiang et al., 2015; Van Dongen & Timmermans, 2019), even when participants are shown digital vegetation scenarios using VR?

Direct comparisons between the three vegetation density scenarios were tested. Here, vegetation density is the only factor that changes, all else being equal. The Kruskal-Wallis-test, followed by a post-hoc Mann-Whitney U test, was used to check if participants' change preferences between the three scenarios. Results from this test, shown in figure 65 (page 67) find that the scenarios were preferred statistically differently from each other to a various degree.

In general, the pattern appears to show that scenario 2, with medium vegetation density, was the most preferred. This is followed by scenario 3 with high vegetation density, and lastly scenario 1 with low vegetation density. This pattern of preference can also be observed in overall scores (figure 76), and as a pattern from answers regarding statements for the individual aspects of the design (seen from page 69 to 74). These findings seems to align with findings from Bjerke et al. (2006) and Gao et al. (2019), that finds that there is a threshold to landscape preference when vegetation density increases. This pattern seems to follow the trajectory of model 2 in figure 77 presented previously in chapter 3.

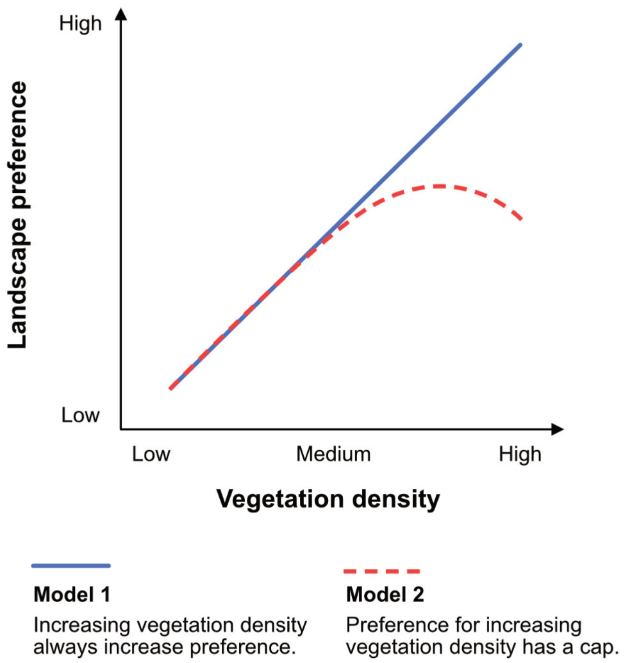


Figure 77 *– Two simplified models of landscape preference in relation to vegetation density*

In more detail, the Kruskal-Wallis test on page 67 show that scenario 2 was the more preferred regarding positive aspects, followed by scenario 3 and 1 respectively. Highest differences were found between scenario 2 and 1, while scenario 3 had less statistical differences compared to scenario 2 within positive aspects.

For negative aspects, an interesting finding from the results is that scenario 3 was more negatively rated compared to scenario 2 and 1 respectively, even though it was the second most preferred according to the overall score. The most negative scores seem to show that the site in scenario 3 was confusing, and that participants felt uneasy in the park. Explanations for these results could be many, but one explanation could be that of scenario 3's dense vegetation, which is highly view-blocking. View-blocking vegetation have previously been associated with a higher fear of crime (Sreetheran & van den Bosch, 2014), and other studies have found that the effects of dense vegetation could negatively affect perceived safety of female users in particular (Evensen et al., 2021). While results have not been analysed regarding the effect of gender, these previous studies might partly explain why scenario 3 might be rated more negatively within negative aspects compared to scenario 1 and 2.

Although scenario 2 seems to be the most preferred scenario overall, questions regarding the public square seems to differ. Here, scenario 3 is the most preferred, as seen in figure 74 and 75 in the results chapter, even though the scenario is more less preferred in other settings. An explanation of this change of preference could come from the fact that the public square is less densely vegetated overall in comparison to the park. If we have an assumption that participants' landscape vegetation density preferences follow model 2 from figure 77, this could indicate that the vegetation density in the public square have not yet been saturated enough for preferences to decrease. This finding could provide support for that there is a threshold to landscape preference when vegetation density increases.

An important factor to consider when interpreting the results, is the composition of the sampled participants. Participants were relatively young (most belonging to the age group of 18 - 34), with about half having studied in a field involving spatial design. As Hägerhäll et al. (2018) and Tveit (2009) suggests, the sampled population might have certain biases towards landscape preferences. For example, Hägerhäll et al. (2018) and Tveit (2009) sample groups had a background involving spatial design, which suggested a preference for more medium dense vegetation in landscapes, compared to landscape preferences of the wider public. As this study sample from roughly the same demographic group as Hägerhäll et al. (2018) and Tveit (2009), and preferences are found for medium densely vegetated landscapes, results should be interpreted with caution. The sampled group may skew results compared to a wider public, and other preferences might have been found if a different demographic group had been sampled.

To sum up, landscape preferences do indeed change when vegetation density increases, and the presence of vegetation is shown to be better than none. This aligns with the findings from previous studies, but now reaffirmed with the additional use of VR and with the use of digital 3D models of vegetation. Medium vegetation density was also the most preferred option, followed by high and low density respectively. This seems to be in accordance with some of the prior studies, but results should not be confused with a claim for a universal vegetation density preference, as prior studies warn of pre-existing biases from the sampled group of this study.

The developed method of this study, which examines participants' landscape vegetation preferences with the use of VR, might become useful in a setting where wider public participation is employed. If the sampled group had been representative for the local population, a park design with a medium dense vegetation might have been selected for construction, if decisions were purely based on the public preference.

Question 2 - Effects of VR When Evaluating Vegetation Design Concepts

2. *Does the use of VR affect landscape design preferences when compared to traditional presentation techniques used in public participation?*

This second question is asked to examine if the use of VR would affect landscape preferences in evaluation of landscape vegetation designs compared to traditional methods. Previous studies would suggest that participants judge size and scale differently when using VR compared to traditional methods such as with maps, perspectives or video (Schott & Marshall, 2021). Does the use of VR affect participants' preference of landscapes compared to traditional methods?

Landscape preferences for various vegetation densities were directly compared between control and experimental groups by using data from the conducted quantitative survey. The main hypothesis for this question was that the additional use of VR would deepen participants' spatial understanding of the site, but not change their initial preferences to a high degree. If parts of this hypothesis are true, quantitative differences between control and experimental groups should not change considerably in either positive or negative direction for each scenario. This seems to remain largely true in the data. Results finds only a few statistically significant differences between the two groups with the use of a Mann-Whitney test (see figure 64), and results sway in both positive and negative direction between traditional methods and with the use of VR.

According to interviews however, the supplementary use of VR did for some participants generate a slightly different impression of the site, based on their new insights with VR. This facet was also found in the quantitative data from the survey in figure 60, where most participants agree that VR changed their impression of the scenarios compared to traditional media. This mismatch, that preferences for scenarios are almost equal between VR and traditional media on one hand (see figure 64), and participants opinion that VR changed their impressions of the scenarios on the other (see figure 60 and interviews), is hard to explain. A possible explanation is that impressions gained from traditional methods, such as plans, pictures or video seems to be mostly sufficient to establish a primary impression of the different scenarios, while the additional use of VR seems to deepen spatial understanding, especially regarding the size and scale of the site (see interviews), which aligns with previous findings from Schott and Marshall (2021). In more general terms, several participants highlighted that they got a better experience of the site using VR, while a few also said that they got a better impression of the vegetation using VR (Interview question 2).

One particularly interesting result is that one participant told that she got a better impression of scenario 3 with VR, were vegetation was at its densest. She said that the use of VR helped her change her opinion of the most compact spaces in the site, compared to the images and video she saw before. This comment was both interesting and unexpected, and could potentially show that VR could be advantageous for the exploration of compact spaces in landscapes. Compact spaces are notoriously hard to communicate easily with the use of images or plans, as you would need a highly distorted image to capture the experience, or use a map, which some people have a hard time reading (Lobben, 2007). A VR demonstration might be the best alternative for showing such landscapes in these scenarios, or maybe with the use of alternative solutions such as 360-degree images. An evaluation of how to present compact spaces in landscapes with VR should be explored in further research.

A few participants were also very positive to the fact that they were allowed to freely look around in the model using VR (Interview question 2). This is very unlike traditional methods, where perspectives from images and videos are usually shown from a fixed perspective. Allowing users to freely navigate in a model during public participation should also be explored further.

Participants were also asked about their holistic experience of the entire presentation, with and without the use of VR. Results from these questions show almost no statistical difference between control and experimental groups (see figure 51). Both groups scored almost evenly when asked about their impression of site placement, size and scale, network of pathways and squares, and plant choice. Although not significant, participants seem to get a slightly better impression of the site with the use of VR, but the Non-VR group rate the visuals as more realistic than the VR group.

An interesting result from these questions is that there are almost no quantitative differences between control and experimental groups when asked about their impression of the size and scale of the model (see figure 53), even though group interviews seem to indicate that VR changed impressions of size and scale. This finding could be explained by the Non-VR participants not having the experience of VR to compare against, thereby scoring the question almost the same as the VR group. A word of warning is that participants might have also misread the question, and think that they were evaluating their impressions from the oral presentation exclusively. They might have mentally excluded impressions gained from the whole presentation where the VR demonstration was included. Evensen et al. (2021) also worries that the introduction of VR to those that have not tried it before could create a novelty effect. While this is a legitimate concern for this data as well, most of the participants say that they have tried VR before (see figure 63), which would supposedly make the novelty effect rather low.

To summarize question 2, primary impressions gained from traditional methods does not change much compared to impressions gained from the additional use of VR. However, it seems that participants allowed to use VR gains a deeper spatial understanding of the site compared to those who only got a traditional presentation. Some participants also report that they got a better impression of the landscape and vegetation with VR, with some highlighting that compact spaces are easier to understand with the use of VR. A recommendation could be that VR should be employed in cases were an increased spatial understanding of size and scale is critical for site understanding. The employment of VR could be particularly useful for sites were landscapes contain tall vegetation or compact spaces.

Question 3 - Viability of VR in Public Participation Processes

3. *Is evaluation of planting design concepts with VR viable for public participation processes, in a Norwegian context?*

The third question is asked to evaluate the viability of VR for use in public participation in Norway where vegetation design is to be evaluated.

Positive Aspects

Participants were asked if they thought VR were suitable for public participation in future projects. On a direct question, a majority of the participants (94% either agree or strongly agree) thought that VR is suitable for public participation processes (see figure 61). Why they found VR suitable for public participation is harder to explain with the exclusive use of the quantitative results. Participants was therefore asked in the interview if, or why, they would want to try VR in public participation again (Interview question 3). Several participants said that they would use VR again because they got a better overview of the site and gained unique impressions of the project with the use of VR, than from other presentation methods such as images, videos, and maps. Their increased sense of size and scale with the use of VR was also mentioned positively in relation to the interview question.

Some participants also speculated that it was easier to provide feedback on the project using VR, as the project did not feel as final with the use of VR compared to presented maps and illustrations. A few thought that it would be easier to provide feedback on an unfinished looking design, than towards projects that gives an impression of being completed. Some also stated that they would like to try VR again because it was fun to use and easy to take part in.

These results could support that the use of VR have some positive aspects in regard to public participation, especially towards engagement and project understanding. Results seem to align with previous findings from Skaaland and Pitera (2021), that a VR demonstration during public participation could lead to an "improved understanding and more engagement among the public compared to traditional visualizations," like their professional respondents perceived (Skaaland & Pitera, 2021, p. 182).

Negative Aspects

While most feedback from the use of VR was positive, some participants also reported problems. Almost all participants reported some technical issues with the use of the VR early on in the VR demonstration. This was most likely due to the Oculus guardian system losing its initial tracking of a preassigned perimeter. The issue could mainly be due to participants swapping headsets between each other, from the front of the lab to the back of the lab. This resulted in initial black screens, a grid showing on a black background, or other similar problems.

Participants said that once the issues were resolved, the demonstration with VR worked well. Technical problems with the use of VR were expected during the experiment. While unfortunate, technical issues demonstrated that the technology is still a bit weak regarding giving a clean user experience, but participants still seemed to like the demonstration despite its initial problems. Technical issues could have been easier to avoid with the proper use of dedicated software, but this was a bit too advanced for the purpose of this thesis. This also comes to show that VR technology still has a way to go regarding its user friendliness. The ease of implementation should be considered before adopting it to wider public participation processes.

A few respondents also found the use of VR to be a bit uncomfortable, as they felt a bit dizzy after the VR demonstration, but most participants felt fine (see figure 62). Reports of participants experiencing cybersickness with the use of VR is also well documented in prior research, and participants were also warned before the experiment that VR could cause mild discomfort. Cybersickness is described as a polysymptomatic and polygeneic condition, a condition with many associated symptoms, and where the experienced symptom type might differ between individuals. Associated symptoms may include symptoms such as "nausea, pale skin, cold sweats, vomiting, dizziness, headache, increased salivation, and fatigue," together with eyestrain (Rebenitsch & Owen, 2016, p. 103). Severity of symptoms might also differ between individuals.

In their review, Rebenitsch and Owen (2016) found that most participants largely recover from symptoms of cybersickness within an hour, while a few experience effects that might linger for longer. In addition, their findings suggest that allowing for frequent breaks might help reduce symptoms, and taking an hour break after long exposures were recommended (Rebenitsch & Owen, 2016). Participants in this experiment were exposed to VR by reviewing three scenarios for approximately one minute each, with a few minutes break between each scenario. Stationary scenes were also chosen in the experiment, as there is an indication that this could help reduce symptoms (Calogiuri et al., 2018; Mouratidis & Hassan, 2020).

Discomfort with the use of VR might decrease its viability for implementation in public participation processes. This is because the use VR might exclude some users from the experience, as some might be predisposed for negative symptoms when or after they use VR. However, only a few respondents from this study reported discomfort after the use of VR. Reasons for why only a few of the participants experienced negative symptoms could be many. One reason could be the age group most belonged to. Testing this experiment on older demographic samples could have yielded other results.

A recommendation would be that participant attending public participation with VR should be informed about the possibility of negative symptoms connected to cybersickness before trying VR. To solve this problem, alternative solutions to VR should be developed if VR is to be included in public participation to ensure universal design for all participants. This could for example include additional use of 360-degree images of the project, which could be rendered on a 2D screen. Users could also be shown a navigable 3D model as well, as the use of 3D models in public participation processes have also been previously been anticipated to increase spatial understanding among participants compared to traditional methods (Skaaland & Pitera, 2021).

The Role of VR and Planting Design Evaluation in Different Planning Stages

Public evaluation of planting design is not considered common in public participation processes, as previously discussed in chapter 3, but use-cases may appear where an agreeable planting design is needed or vital. Examples could be where a design is needed for green spaces in residential areas, for new public parks, or in other cases where you might need an opinion poll about vegetation design. Projects were an substantial amount of vegetation is supposed to be added in order to fulfil sustainability goals, such as for Oslo kommune (n.d.), could be an example where such a poll might be needed.

Evaluation of planting design, nor the use of VR, is required for public participation when minimum requirements of the Norwegian Planning and Building Act is considered. However, project developers and the planning and building authorities are free to go beyond the minimum requirements of act if they so choose (Nyseth & Ringholm, 2018), as public participation is thought to reduce conflicts and make it easier to implement adopted measures (Regjeringen, 2015). The most anticipated use-case for the kind of evaluation used in this study, within the ordinary planning processes, would be for detailed zoning plans (PBA §12-3). This is because county or municipal master plans do not go into specific details for vegetation.

As the use of VR could be considered costly and time consuming to conduct with a large public audience, its use could be more beneficial for smaller sessions such as for planning workshops and city-labs. Other use-cases could be in discussions and clarifications with affected public authorities, landowners, lessees, and rightsholders.

Engagement in public participation is also key in order to have successful participation processes. As Nyseth and Ringholm (2018) commented, public meetings are usually characterized of being one-sided communication where public empowerment and involvement is quite low. With results from this study and prior studies taken into consideration, the inclusion of VR might provide additional engagement in public participation processes compared to traditional media. As previously stated, a few participants also thought it would be easier to provide feedback when using VR. Adding VR to public participation processes might provide additional value, as it could contribute to keep public engagement high during the session.

However, in practical terms, the use of VR might only provide small changes regarding actual design alterations after public participation. This is because primary impressions of the planting design changes little with the additional use of VR, as the previous research questions have shown. The use if VR might provide an improved impression of size and scale of the project, and the possibility of increased understanding of compact spaces, with all else being roughly equal to impressions gained from traditional methods.

Conclusion of Question 3

To summarize question 3, findings indicate the VR only have a limited effect in the evaluation of planting design in public participation processes. Findings suggest participants' understanding of size and scale might change with the use of VR, with some positive aspects regarding the evaluation of compact spaces. VR might also benefit public participation processes in that it could provide more engagement and feedback to projects, which could in some cases offer more perspectives on a project proposal, which is in line with previous findings (Skaaland & Pitera, 2021). However, its implementation should be considered with caution as a few participants could experience negative symptoms with VR, making it unavailable for some participants. Continued technical issues with VR also discourages its implementation during large public meetings, making it more applicable to smaller sessions such as for planning workshops and city-labs.

Policy Implications

A policy recommendation of this study would be that the use of VR would be beneficial in evaluation of projects with high spatial complexity, where spatial understanding of the size and scale of the site is critical. However, employment of VR in events for a large group of participants could be problematic, as quality equipment is expensive and technical difficulties might still be a problem. A suggestion would be to include VR in small scale events for public participation, such as for planning workshops and city-labs. Other use-cases could be in discussions and clarifications with affected public authorities, landowners, lessees, and rightsholders.

Limitations

Selection of Participants

The selection of participants for the experiments were initially meant to be people without spatial experience, as this sample might have different preferences for vegetation density compared to the rest of the population (Hägerhäll et al., 2018; Tveit, 2009). While this limited participant selection this was the ideal target group for the experiment, few participants turned up and the selection criteria was loosened to allow for a larger sample group. This was a necessary step as the scope of this study was limited in time. A separate question was added to control for professional background, which show that 67% of participants have professional spatial related experiences (see figure 47). The sampled group of this study might have been biased, as proposed by Hägerhäll et al. (2018) and Tveit (2009). Following studies could explicitly exclude professionals and students with spatial experiences when testing for landscape preference in similar experiments.

The sampled group were also quite young, most ranging from 18 – 34 years old. Sampling an older age group might also have provided other results.

This thesis was also written during the period from January to May 2022. During this period, Corona restrictions were in place from January to mid-February, making lab-experiments harder to conduct. During March, when the experiments were held, effects of the restrictions could have impacted the participants chance and willingness to attend the experiments. Results should be considered in view of these circumstances.

Selection of Site and Design Limitations

Location of the case study site in Ås was chosen for its size, placement, ease of design, and previous knowledge of the site. Its municipal context regarding zoning regulation, and its relevancy to local inhabitants and students due to its proximity to the VR lab and the centre of Ås, was also beneficial in this selection.

While the site was relatively easy to plan and design, it also came with a few considerations. It was of a relatively large size, making parts of the model less relevant for the experiment. The more general parts of the model were also less detailed. Extensive façade details were also excluded, because of a lack of expertise in this field. A more detailed façade could have increased the realism of the model, which might have impacted participant impressions and scores. However, designing only parts of the model with high realism, on which parts the participants are meant to evaluate, could also focus their attention.

Proposing a design on agricultural land could also be considered controversial in Norway, which could have made participants rate scenarios worse than expected due to their ideological views on land development. To negate this, participants were informed that the model was a theoretical design where their initial reactions to the site design was the main concern of the study. Although another site might have been preferable concerning this aspect, using a site familiar to the participants was beneficial in order to provide a realistic context for public participation. The increased relevancy regarding the site location could also have been helpful in generating interest for the experiment, in relation to recruitment for the research experiment.

Research Design

The research design, with the use of group interviews, could also be seen as problematic. Social conformity could arise, making an individual uncomfortable to share experiences that is not similar to the rest of the group (Johannessen et al., 2011). Special reactions to specific topics could also be hard to catch with a group interview. To counter this, the quantitative survey was conducted before the group interviews, so that an eventual discrepancy in the data would show itself as a difference between the two datasets.

Questions made for the quantitative survey may also have been inaccurate or poorly formulated. This could have made participants misread questions and answered with false premises. Most questions had an option for answering "Don't know" if participants were unsure, but it is impossible to know if participants actually misread questions. The study design was therefore made with methodical data triangulation. Here, qualitative and quantitative data was checked against each other, which helped to catch potential errors.

Technical Equipment

Experiments were conducted using Oculus Quest 1 VR headsets. Differences in VR specifications (i.e., screen resolution, refresh rate etc.) could impact comparisons between these findings and other research using older or newer VR technology. This could for instance result in different findings regarding user experience and user feedback.

9 | Conclusion

This thesis has explored if VR is viable for evaluation of planting design concepts in public participation processes.

First, it was found that participants had clear landscape preferences for select types of vegetation densities, where medium dense vegetation was the most preferred scenario. While prior studies would suggest that there are no universal preferences for select vegetation density, establishing local preferences for vegetation densities and planting design in general could be beneficial for public participation in local contexts.

Second, results from this study suggest that VR would only provide small benefits when it's used in public participation for evaluating landscape vegetation compared to traditional methods. Benefits include that users gain an increased sense of the size and scale of the project with VR, and a few also report that they understood the vegetation better. A particularly interesting result from the study was that one participant also commented that VR particularly helped in the understanding of compact spaces. As compact spaces are notoriously hard to convey easily with the use of images or maps, VR could be advantageous in these situations. This should be investigated in further research.

The use of VR also had its shortfalls. A good amount of participants reported technical problems with the VR demonstration, and a few also felt minor discomfort regarding symptoms associated with cybersickness. But to summarize, most found the VR demonstration enjoyable, and fun to use in a public participation setting.

However, evaluation of landscape planting design is not considered common in public participation processes today, which would provide only a few use-cases for the type of event used in this study. If it would become more common, or the method is adapted for other uses, the use of VR would be best suited for small scale public events, or dialogue meetings with stakeholders and relevant authorities. While it would be difficult to implement the use of VR in large scale public meetings, it could be beneficial to have a few VR headsets ready for use in city-labs or planning workshops. Here, members of the public would have more time to experience a site with VR and make comments.

Conflicts of Interest: The author declare no conflict of interest.

10 | References

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List of Figures

All non-cited figures are made by Marius Ellefsen.
All maps are made with the use of FKB-data and Cadastral data in UTM32 Euref89, and is downloaded from Geonorge March 2021.

The following figures have other or additional sources:

Figure 1. Ellefsen, M. (2022). Illustrations adapted from Albracht, R. (2016). *Visualizing urban development: improved planning & communication with 3D interactive visualizations*. Masters. Manhattan, Kansas: Kansas State University

Figure 3. Ellefsen, M. (2022). Illustrations adapted from Robinson, N. (2016). *The Planting Design Handbook*. 3 ed. New York: Routledge.

Figure 5. Hassan, R. (2022). *Photo of participants experiencing scenario 3 with VR headsets in the VR lab*.

Figure 9. Ås kommune. (2022). *Vedtatt områdereguleringsplan for Ås sentralområde (R-287)*. Available at: https://www.as.kommune.no/omraaderegulering-aas-sentralomraade.565756.no.html#p64208682 (accessed: 29.03.2022).

Figure 10. Ellefsen, M. (2022). *Ås municipality in relation to Oslofjorden.* The map is made with data from @2022 TerraMetrics, Kartdata @2022.

Figure 11. Ellefsen, M. (2022). *Site location in relation to the centre of Ås.* The map is made with data from @2022 CNES / Airbus, Maxar Technologies, Kartdata @2022.

Figure 13. Ellefsen, M. (2022). *Screenshot of an early design with the use of Spacemaker.* The screenshot is made with Spacemarker software.

Figure 16. Ellefsen, M. (2022). Illustration adapted from Robinson, N. (2016). *The Planting Design Handbook*. 3 ed. New York: Routledge.

Figure 24. Ellefsen, M. (2022). Illustration adapted from Robinson, N. (2016). *The Planting Design Handbook*. 3 ed. New York: Routledge.

Figure 32. Ellefsen, M. (2022). Illustration adapted from Robinson, N. (2016). *The Planting Design Handbook*. 3 ed. New York: Routledge.

Appendix 1 - Survey

Spørreskjema | Bakgrunnsinformasjon

1 Har du vært med på medvirkningsmøte (folkemøte) om ny planlagt bebyggelse tidligere?

Et medvirkningsmøte i planlegging er et møte hvor innbyggere blir informert om nye planer og byggeprosjekt i kommunen. I etterkant blir deltagerne invitert til å gi sitt innspill til prosjektet.

Ja ◯ Nei ◯

2 Har du studert eller studerer du innenfor fagene *arkitektur*, *landskapsarkitektur* eller *by- og regionsplanlegging*?

Ja ◯ Nei ◯

3 Hva er kjønnet ditt?

Mann ◯ Kvinne ◯ Annet ◯ Ønsker å ikke svare ☐

4 Hvor gammel er du?

18-25 ◯ 26-35 ◯ 36-45 ◯ 46-55 ◯ 56-65 ◯ 66-75 ◯ 76-85 ◯ 85+ ◯

Spørreskjema | Alternativ 1

Hvor godt passer følgende påstander for deg?

A Påstander:

Påstander	Svært dårlig				Svært godt	Vet ikke
• Jeg ville gjerne besøkt parken og torget	○	○	○	○	○	☐
• Jeg synes området virker uoversiktelig	○	○	○	○	○	☐
• Jeg ville følt meg tilfreds her	○	○	○	○	○	☐
• Jeg synes parken er fin	○	○	○	○	○	☐
• Jeg synes torget er fint	○	○	○	○	○	☐
• Jeg ville bare gått forbi området, uten å besøke det	○	○	○	○	○	☐
• Jeg ville følt meg utrygg i parken	○	○	○	○	○	☐
• Jeg ville følt meg utrygg på torget	○	○	○	○	○	☐
• Jeg ville gjerne satt meg ned i parken	○	○	○	○	○	☐
• Jeg ville gjerne satt meg ned på torget	○	○	○	○	○	☐

	Svært dårlig 1	2	3	4	Svært god 5	Vet ikke
B Gi alternativet en poengsum	○	○	○	○	○	☐

Alternativ 1

Spørreskjema | Alternativ 2

Hvor godt passer følgende påstander for deg?

A Påstander:

Påstander	Svært dårlig				Svært godt	Vet ikke
• Jeg ville gjerne besøkt parken og torget	○	○	○	○	○	☐
• Jeg synes området virker uoversiktelig	○	○	○	○	○	☐
• Jeg ville følt meg tilfreds her	○	○	○	○	○	☐
• Jeg synes parken er fin	○	○	○	○	○	☐
• Jeg synes torget er fint	○	○	○	○	○	☐
• Jeg ville bare gått forbi området, uten å besøke det	○	○	○	○	○	☐
• Jeg ville følt meg utrygg i parken	○	○	○	○	○	☐
• Jeg ville følt meg utrygg på torget	○	○	○	○	○	☐
• Jeg ville gjerne satt meg ned i parken	○	○	○	○	○	☐
• Jeg ville gjerne satt meg ned på torget	○	○	○	○	○	☐

B

	Svært dårlig 1	2	3	4	Svært god 5	Vet ikke
Gi alternativet en poengsum	○	○	○	○	○	☐

Alternativ 2

Spørreskjema | Alternativ 3

Hvor godt passer følgende påstander for deg?

A Påstander:

Påstander	Svært dårlig				Svært godt	Vet ikke
• Jeg ville gjerne besøkt parken og torget	○	○	○	○	○	☐
• Jeg synes området virker uoversiktelig	○	○	○	○	○	☐
• Jeg ville følt meg tilfreds her	○	○	○	○	○	☐
• Jeg synes parken er fin	○	○	○	○	○	☐
• Jeg synes torget er fint	○	○	○	○	○	☐
• Jeg ville bare gått forbi området, uten å besøke det	○	○	○	○	○	☐
• Jeg ville følt meg utrygg i parken	○	○	○	○	○	☐
• Jeg ville følt meg utrygg på torget	○	○	○	○	○	☐
• Jeg ville gjerne satt meg ned i parken	○	○	○	○	○	☐
• Jeg ville gjerne satt meg ned på torget	○	○	○	○	○	☐

B

	Svært dårlig 1	2	3	4	Svært god 5	Vet ikke
Gi alternativet en poengsum	○	○	○	○	○	☐

Alternativ 3

Spørreskjema | Generell del

5	Hvor realistisk synes du designet til det nye prosjektet virker?	Urealistisk ○	○	○	○	Realistisk ○	Vet ikke □
6	Hvor realistiske synes bildene fra den nye modellen er?	Urealistisk ○	○	○	○	Realistisk ○	Vet ikke □
7	I hvor stor grad synes du omgivelsene fra den nye digitale modellen etterlignet omgivelsene fra virkeligheten (fra første video)?	I svært liten grad ○	○	○	○	I svært stor grad ○	Vet ikke □
8	Kjenner du til prosjektområdet fra før av, slik det ser ut i dag?	Ja ○	Nei ○				

9 I hvilken grad har presentasjonen gitt deg forståelse for:

	I svært liten grad				I svært stor grad	Vet ikke
• **Plassering av prosjektområde i Ås**	○	○	○	○	○	□
• **Størrelse og skala av uteromet**	○	○	○	○	○	□
• **Nettverket av stier og torg på prosjektområdet**	○	○	○	○	○	□
• **Plantedesign i de ulike alternativene**	○	○	○	○	○	□

Spørreskjema | Generell del - VR

Nr.	Spørsmål	I svært liten grad				I svært stor grad	Vet ikke
10	I hvilken grad fikk du følelsen av å være en del av den virutuelle verdenen med VR-brillene?	◯	◯	◯	◯	◯	☐
11	I hvilken grad synes du bruken av VR-brillerne påvirket inntrykket ditt av de ulike alternativene?	◯	◯	◯	◯	◯	☐
12	I hvilken grad synes du bruken av VR-briller egner seg i andre planprosjekter, der utbygger eller kommunen inviterer til medvirkning?	◯	◯	◯	◯	◯	☐
13	I hvilken grad gjorde bruken av VR-brillene deg ukomfortabel? (Svimmelhel, kvalme etc.)	◯	◯	◯	◯	◯	☐

Nr.	Spørsmål	Ja	Nei
14	Har du prøvd VR-briller i andre sammenhenger tidligere?	◯	◯

Appendix 2 - Interview guide

Intervju | Guide

1 Gikk det greit å bruke VR-brillene under presentasjonen?

Var det noen vanskeligheter eller var det enkelt?

På hvilken måte?

2 Fikk du noen andre inntrykk av alternativene når du brukte VR-briller, enn på videoen og bildene?

På hvilken måte?

3 Hvis du skulle vært med på et lignende møte om et nytt byggeprosjekt I nærområdet ditt, ville du ønsket å bruke VR-briller igjen?

Hvorfor?

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