Understanding the design

A qualitative study of architecture and urban planning visualisation techniques in a public consultation setting

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Abstract

Visualisation of proposed plans and designs can be done with a number of different techniques within the field of architecture and urban planning. But which visualisation technique is best suited when presenting a design proposal at a public consultation? Is there a breaking point where the user can form a general understanding of the proposed design depending on the degree of fidelity? To seek answers to these questions a qualitative study was conducted where five different visualisation techniques were tested on ten users to assess their understanding of a proposed design. Our findings show that there is not a single best visualisation technique for public consultation. Based on our results the preferred alternative would be a combination of several techniques. We could also see that the general understanding of a space increased until a certain degree, and after that a deeper more detail oriented understanding was achieved.

Keywords: HCI, human computer interaction, visualisation techniques, visualisation, virtual reality, VR, virtual environment, VE, head mounted display, HMD, architecture, urban planning, public consultation
1. Introduction
Digital visualisation techniques can be useful when examining proposed designs for architecture and urban planning. Being able to visualise comprehensive plans with different types of tools gives the opportunity to test and evaluate different kinds of plans and designs beforehand (Kuliga, Thrash, Dalton & Hölscher, 2015). When presenting a proposed design for urban spaces the digital tools that can be used for the visualisation today are e.g. static image, video walk/fly-through and virtual reality. They all have their advantages and disadvantages depending on the aim with the visualisation. Other factors are the context in which it is set and how well the technology works for the purpose (Westerdahl, Suneson, Wernemyr, Roupe, Johansson & Allwood, 2006). There is a natural development of visualisation tools within the architecture and urban planning scene which follows the technical advancements of computation power. Ranging from hand sketches to 3D rendered images to 3D animations to virtual environment, VE, to head mounted display, HMD, virtual reality, VR. The hunt for increased fidelity and interactivity is continuous (Wu, 2006).

1.1 Aim and purpose
This study examines the use of different visualisation techniques in an architectural and urban planning context. Related research shows that VR is a viable tool when designing pre-visualisations of physical spaces. It can successfully be used without any previous experience and seems to help designers understand the spatial relations of physical spaces better than older techniques (Friberg & Johansson, 2014). In this study we will focus on the public consultation part of the architectural process. This is relevant since the public consultation is the only part in the building process where the general public gets to speak its mind and to do so effectively good visualisation techniques are needed. The purpose of this study is to examine different visualisation techniques of varying fidelity in the public consultation context.

HCI, Human Computer Interaction, is a multidisciplinary research field which puts the human in focus. HCI practitioners promotes the human-centred approach during the design process and to make sure new techniques are adapted into new contexts in a holistic way an HCI perspective is needed. In this study we have taken the perspective of the the general public, the end-user, in the public consultation context. We are viewing the general public as the end-user since they will be the ones who lives around and uses the proposed design. We will look at their understanding of the proposed plan and their subjective opinions on different visualisation techniques which are and could be used during public consultations.

1.2 Research questions
The questions that this study intends to answer are:

1. Which digital visualisation technique is better suited when presenting a design proposal at a public consultation?
2. With an increasing degree of fidelity, is there a breaking point where the user can form a general understanding of the proposed design? If so, does the rest of the information then become excessive?
1.3 Delimitations

The focus of this study will be on the five digital visualisation techniques plan view, perspective image, animated video, virtual environment and virtual reality. These techniques fit the study well since the first three are commonly used in public consultations today and the last two are up and coming techniques. Other techniques such as sketches and physical scale models are still used in public consultations today but not as frequently which is why they are not included in this study. The material we had access to during the period of the study was a 3D model of a park environment. The 3D-model formed the basis for the plan view, perspective image, animated video, virtual environment and virtual reality experience which were created and used for the user tests in this study. This meant that the choice of 3D-model was from convenience but the visualisation techniques chosen were not, they were based on the related research and feedback from architects, urban planners and visualisation artists. Previous research gave us an understanding of what is more beneficial to use in terms of usability, spatial understanding and user experience. For example, perspective images give a better spatial understanding than sketches but they have their drawbacks since the user is not able to navigate freely in the space which is possible when using virtual environment and virtual reality. To summarize, the choice to exclude some visualisation techniques was made from relevance and related research.

A phenomenon which we will not address in this study is the multiplayer feature connected to VE and VR which would give the possibility to interact and explore the VE/VR alongside other users. This is neglected because of technical circumstances, only access to one HMD device and not sufficient time to set up a stable multiplayer system.

2. Public consultation

All municipalities must have a comprehensive plan covering the entire municipal area. The comprehensive plan includes land use, national interests, change of existing development and environment and possible risk factors. A comprehensive plan aims to contribute to long-term sustainable development. The comprehensive plan guides decisions of how land and water may be used, where and what something can be built and what areas to save for recreation. When establishing or changing a comprehensive plan the municipality needs to assess and evaluate the proposal. The comprehensive plan should be consulted with the municipalities citizens, the provincial government and neighbouring municipalities among others. At a public consultation the municipality’s citizens have a chance to speak their mind regarding the comprehensive plan. Presented during the consultation are the already developed proposals together with an analysis of economic, social and environmental consequences of the plan. It is of great importance that the plan is easy to understand to be able to know the possible consequences and outcomes. If not, it can be difficult to critique in some way or give feedback on the proposed plan. Public consultations exist in two forms, the planned public meeting and the unsupervised version which is available for the public. (Boverket, 2014)
2.1 Challenges with public consultations

A successful public consultation can create engagement in community development, increase trust between the municipality and its citizens and strengthen democracy locally (Boverket, 2014). The aim of a public consultation should be to get as many people as possible from different social groups to participate. But there are some challenges and limitations when it comes to public consultations (Howard & Gaborit, 2009; Lai, Chang, Chan, Kang & Tan, 2010).

Usually the proposed design is presented using images. When viewing the images, it can be difficult for someone who is not trained in architecture, to grasp how it will look when it is done, in the real environment. Another downside of using images is that the participants do not have any opportunity to navigate freely in the space. Therefore it can be difficult to view and understand the plan in a way that satisfies the participants. (Howard & Gaborit, 2009; Lai et al. 2010)

The comments on the comprehensive plan made during the public consultation are usually written in a notebook. This has its limitations since it lacks in precision and detail (Howard & Gaborit, 2009). To write comments when missing a clear point of references can be difficult. This since the images do not give the participant a lot of information among other things. Another thing that makes public consultation difficult is the fact that it requires some prior knowledge to fully understand exactly what you are looking at when viewing the images of e.g. a new residential area (ibid.). If the participants have a difficult time to grasp what they are looking at, how can they comment on what they see? The lack of effective communication can create misunderstandings and misperceiving’s among those involved.

2.2 Case

At the beginning of this study we were in contact with the architecture and urban planning company Tyréns and Umeå municipality regarding public consultations. They represent two out of three parts of a public consultation where Tyréns is delivering the architectural solutions and visualisations and the municipality is in charge of the urban planning and the community development. Their problems and expectations aligned with what is written above. To deepen our understanding of the third part and experience the general publics, the end-users, perspective of public consultations we visited the unsupervised public consultations available in Umeå. They are located in the city hall and in the public library and more or less consist of maps with an occasional perspective image of future changes, see figure 1. As the literature and our initial research shows there is no predefined industry standard of which visualisation techniques should be used but there is a strive for higher fidelity and easier inclusion of the general public.
3. Theoretical background and related research on visualisation

The aim of using visualisation techniques is to showcase and visualise knowledge. The purpose of knowledge visualisation is to, in an adequate way, transfer knowledge to more than one person e.g. a group of people (Burkhard, 2004). Transferring knowledge directly from one person to another cannot be done in a satisfactory way. Sketches, physical scale models, images and interactive visualisation are some of the more common visualisation techniques used (Burkhard, 2004; Meyer, 2010). Sketching is a common way of externalizing ideas in architecture and can work well as a model to have a discussion around. However, a problem with two-dimensional (2D) visualisations such as sketches and plan views is that the general public may have problems imagining how a proposed design would look when built and finished. 2D visualisations reduce exploration and communication of volume and space (Schnabel, 2004).

Professionals in architecture are trained to be able to look at a sketch or plan view and create their own inner visualisation of it whereas most citizens are not. Choosing the appropriate visualisation technique is vital to achieve understanding. (Sköld, 2002; Schnabel, 2004; Fröst & Warren, 2000; El Araby, 2002, and others). Viewing 3D-models however creates a common ground between architects and laymens. (Fröst & Warren, 2000) Studies done by Mohler (2007) show that human depth and spatial perception are very close or equal when comparing VR with a real life visit to the same places. VE applications, e.g. Second Life, are able to visualise architecture and urban planning. The 3D models provide depth and scale cues which make for easier understanding and a sense of realism (Cantimur, 2009). The distance between imagination and realization is reduced when viewing architecture designs as 3D visualisations (Schnabel, 2004). Problems are easily understood
and solutions are easier to come up with when viewing architecture designs represented in 3D and VE (Schnabel & Kavan, 2001; Fröst & Warren, 2000). A higher degree of fidelity can give the viewer, with or without knowledge about architecture and urban planning, a deeper understanding of what it is looking at. Adding to the enriched experience is the possibility to freely navigate around in VE or VR. The free control is preferable over a predefined walkthrough (Campbell & Wells, 1994).

![Figure 2. The fidelity stair - level of fidelity of the five visualisation techniques. “Plan view” representing the lowest degree and “Virtual reality” representing the highest degree.](image)

For gaining understanding of a space, our hypothesis is that 3D visualisation in general, and especially VR, is a superior tool for architecture and urban planning visualisation. Especially for the general public who are not specially trained in architecture, urban planning, construction and so on. Figure 2 shows how we presume the fidelity to be ordered. Is it necessary to use any other visualisation technique except for virtual reality when showcasing proposed plans for architecture and urban planning? This assumption is based on above stated related research and our own experiences gained during this study which are presented in the remainder of this paper.

### 3.1 Plan view

A traditional tool for architecture and urban planning is the plan view. A 2D drawn scale model of reality which allows for distance measuring and forming of mental images, see figure 3 and appendix 2. Paper plan views are simple but this simplicity is also a weakness. The scale is set, it is hard to visualise large amount of information, it is difficult to visualise complex information and the viewer needs to be a trained practitioner to be able to create an accurate mental model (Al-Kodmany, 2002).

### 3.2 Perspective image

There are generally two different ways to go about creating perspective images. Either mixing a photograph of the current environment with a computer generated version of the new architecture. Or creating everything with a 3D program, meaning that it will be completely computer generated. The difference between the techniques is that the first one is a mix of reality, the photograph, and 3D whereas the second technique only consists of computer generated 3D. The benefits with the first method are a clear distinction between the real
environment and the computer generated architecture, time saving since no environment has to be digitally created and it is possible to turn the computer generated architecture on and off. The benefits with the second method are the possibility to view the 3D model from several angles since everything is digitally created, it is possible to remodel the environment and animated fly-through videos can be created. The weakness of one method is the others strength and vice versa but the major weakness with both of the methods are that they do not offer any interactivity and it is more demanding to show several angles of the same design. (Al-Kodmany, 2002) In this study the second technique was used, see figure 3.

3.3 Animated video
Animated fly-through videos of 3D models gives a coherent experience and the added motion increases spatial understanding. It is possible to create several walk/fly-throughs with several areas of interest. A major strength is the combination of being able to choose the area of interest and showcase it while in motion. Weaknesses are primarily the long render times and lack of free navigation. (Al-Kodmany, 2002)

3.4 Virtual Environment
A virtual environment, VE, is a 3D environment which can be explored by the user, see figure 3. Interactions are performed by using standard devices such as a keyboard or gamepad. VE could be equal to a regular PC- or video game where the user is interacting with the computer generated world through input device and is watching a monitor to receive feedback. (Howard & Gaborit, 2009)

3.5 Virtual reality
Virtual reality is a computer generated artificial environment which the user can interact with in different ways. The environment is built in 3D and the goal is to make the user feel like it has stepped into a new world. The virtual reality technique exciting today has the capacity to simulate highly realistic environments, rich in detail and complexity. This allowing the user to get visual experiences with high realism, strongly relatable to real visual experiences. (Kuliga et al. 2015)

3.5.1 Virtual reality and head mounted displays
Consensus regarding the definition of what virtual reality, VR, is seems to be somewhat missing. In different studies, when talking about VR, the authors refers to different visualisation techniques e.g. virtual environment, VE, CAVE, head mounted displays, HMD, and so on (Lundberg & Nyström, 2012; Tang, Wu & Lin, 2009; Colley, Häkkilä & Väyrynen, 2015 and others). In this study the focus will be on the head-mounted displays, HMD. Hereafter when using the word virtual reality, HMD, is what we will be referring to and therefore other types of virtual reality will not further be discussed.
3.5.2 Head Mounted Display
A head-mounted display is a device which provides stereoscopic 3D through its dual display setup, one display per eye which shows the same thing but with a slight offset, see appendix 3. This binocular vision works the same way as the humans regular vision does, two views of the same world which are being combined by the brain into a single image (Goldstein, 2008; Sjöström, 2015). HMD offer real-time rotation of the head due to its head-based tracking and renders the surrounding world according to the heads position (Kuliga et al. 2015). This means that when the user wearing the HMD rotates its head to the right in real life the view in the VR world will also be rotated. This gives the user an opportunity to explore the VR with increased immersion (Sjöström, 2015).

Figure 3. The five visualisation techniques visualised. Top-left: Plan View, top-right: perspective image, bottom-left: animated video and VE, bottom-right: VR.

3.6 Depth cues
Size is the most common depth cue. It is static and it is possible to estimate distance and depth by looking at how large an object is. The object has to have a known size for this depth cue to work which is why it only works with more or less standardized objects, e.g. cars and humans. Interposition is a static depth cue and it is active when objects are partly hidden behind each other which makes the hidden object to be perceived as being located further away. Motion parallax is a motion driven depth cue which helps with understanding of spatial relations during movement. It is experienced when objects that are closer to the viewer travel farther across the field of view than objects which are located further away during motion e.g. a panoramic sweep of a landscape or just the movement of the head. (Sekuler & Blake, 1994)

When viewing something in motion, e.g. an animated video, all these depth cues are active simultaneously. The size of objects is constantly changing, objects are switching place in the
viewer’s field of view which constantly activates interposition and the motion parallax is continuously active since new objects are entering the field of view.

4. Research methodology

To reach a scientific research goal specific validated methods are to be used (Patton, 2002). To gain an in-depth understanding of the studied phenomenon a qualitative problem oriented study with a predefined research question was setup (Bell & Nilsson, 2000).

In this study we have looked at which visualisation technique is better suited when presenting architectural and urban planning design proposals at a public consultation and if there is a breaking point connected to the user’s understanding as the degree of fidelity increases. To reach this goal ten separate user tests combined with structured interviews and longer in-depth semi-structured interviews were conducted. Combining these qualitative methods and thus attacking the phenomenon from several angles gives greater possibility for increased understanding. This is a mixed method approach where user tests give the big picture and the follow-up interviews give the in-depth understanding. Using this rigorous setup enables the possibility of cross-comparisons to discover patterns (Bell & Nilsson, 2000; Patton, 2002). Sampling of respondents, data collection, data analysis, method criticism and ethical considerations are presented in the remainder of this section.

4.1 Sampling of respondents

The number of participants in scientific research should be influenced by the goal of the study with a connection to triangulation, reliability and time (Bell & Nilsson, 2000; Ritchie, Lewis, Mcnaughton & Ormston, 2014). A balanced data gathering which accurately represents the phenomenon being studied by collecting data from several sources is known as triangulation (Bell & Nilsson, 2000). The selected participants for this study were chosen to be a representative sample of the public in terms of age, level of education, gender and so on. People schooled in architecture, urban planning, construction or other forms of map/floorplan reading were excluded since they poses a skill which could affect the results and is not representative for the general public. The sample was a convenience selection of people with some sort of prior relationship with the authors.

4.1.1 Sample size

A Latin Square design was used to decide the order of users and visualisation techniques. Since there were five different visualisation techniques being tested the number of participants had to be in equal sets of five to evenly add up with the Latin Square design. Our goal was to include ten participants which we managed to reach, see table 1. We decided on this number because a step down, five participants, would to be too few for a decent sample size with regards to triangulation and reliability and a step up, 15 participants, would be too time consuming. The sample size of ten should be a good trade off between time constraints and reliability. We made contact with twelve people in total which were all positive to participating in the study and finally ten suitable participants were selected. The few people contacted was a small but precise selection.
Table 1. The users in the study - individual number, age, gender and level of education.

<table>
<thead>
<tr>
<th>User</th>
<th>Age</th>
<th>Gender</th>
<th>Education level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>Female</td>
<td>Middle school student</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>Male</td>
<td>University</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>Female</td>
<td>High school</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
<td>Male</td>
<td>University Student</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>Female</td>
<td>High school</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>Male</td>
<td>PHD</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>Male</td>
<td>High school</td>
</tr>
<tr>
<td>8</td>
<td>55</td>
<td>Female</td>
<td>High school</td>
</tr>
<tr>
<td>9</td>
<td>67</td>
<td>Female</td>
<td>University</td>
</tr>
<tr>
<td>10</td>
<td>73</td>
<td>Male</td>
<td>University</td>
</tr>
</tbody>
</table>

4.2 Data collection

Three different data collection sources were used to make cross-referencing possible which in turn could increase validity (Bell & Nilsson, 2000; Patton, 2002; Ritchie et al. 2014). Observations during the user tests, structured interviews and semi-structured interviews were used to collect data.

4.2.1 User tests

Two initial pilot test sessions were conducted to be able to try out all the visualisation techniques together with the interview questions. An estimated time duration was also set. The first session resulted in some error prevention connected to the VE/VR software and hardware and an edited interview guide which was used in the second session. The second session resulted in some further practical training with the VR headset and another edit of the interview guide.

In the actual test sessions, ten participants went through the user tests individually. The tests were conducted on a laptop which was set up at a table or desk where the participants could comfortably sit in front of it. The preferred environment was the HCI-lab in the Informatic institution at Umeå University but some sessions were conducted at the home or workplace of the participants due to time constraints. Four sessions were conducted at the HCI-lab, five sessions were conducted at the home of the user and one session was conducted at a workplace.
Each test session started with an introduction to the entire study and was followed up with information of how the whole session would be conducted. Information about research ethics according to the Swedish authority Vetenskapsrådet was then presented. The participants were informed that they are participating in a scientific study and that they are doing so as volunteers who can retract their concurrence at any time, that the data collected is also confidential and will only be used and spread in accordance with the needs of the study (Vetenskapsrådet, 2002). Finally, some general information about public consultation was given and then the first visualisation technique was presented. The participant then, taking the time they want to look at the material, got to answer a set of structured interview questions, see appendix 1. The participant then got exposed to the next visualisation technique according to the Latin Square design, see table 2, and was followed up by a structured interview. This pattern repeated until the participant had tested all five visualisation techniques. Each session was finished with a semi-structured interview as well. The order of the different visualisation techniques was switched for each participant since we wanted to gain understanding of how each technique could affect each participant for the first time and also to look for any cumulative effects. The different visualisation techniques are named A, B, C, D, E and the following Latin Square design matrix (PennState, 2016) shows the order each user were exposed to them. Visualisation technique explanation; A: plan view, B: perspective images, C: animated video, D: virtual environment (VE), E: virtual reality (VR).

<table>
<thead>
<tr>
<th>User</th>
<th>Visualisation techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 7 &amp; 9</td>
<td>A  B  C  D  E</td>
</tr>
<tr>
<td>User 1 &amp; 8</td>
<td>B  C  D  E  A</td>
</tr>
<tr>
<td>User 3 &amp; 4</td>
<td>C  D  E  A  B</td>
</tr>
<tr>
<td>User 5 &amp; 6</td>
<td>D  E  A  B  C</td>
</tr>
<tr>
<td>User 2 &amp; 10</td>
<td>E  A  B  C  D</td>
</tr>
</tbody>
</table>

Table 2. Latin Square design matrix showing the order of the visualisation techniques the participants were exposed to. Each participant was called user and got an individual number.

Before each participant was exposed to technique D & E they went through a short practice round in a completely different 3D environment. Technique D involved training in using the gamepad to freely navigate around the 3D environment. Technique E involved calibration and training in using the VR-gear together with the gamepad to freely navigate the 3D environment.

The technical gear used for the test sessions was the HMD Oculus Rift developer kit 2 and a high end laptop PC-system. The gamepad was a Xbox One hand controller. We received a
complete 3D model from Tyréns which was built from scans of the current environment and 3D modelled geometry showing the future changes. Maya 2016 was used as the 3D software and the model was imported into the game engine Unreal Engine 4 via the FBX-format. Unreal Engine 4 allows for easy HMD implementation and testing with their built in VR features. Each test session took between 45-60 minutes, including interviews.

During the user test sessions the authors observed the users to gather data of the their use of the separate visualisation techniques. Bell & Nilsson (2000) describes observation as a research method that requires the ability to see important events. Observation was in this study done to pick up things the users did or commented on that was not mentioned during the interviews. Notes were taken during the test session and analysed with the rest of the data collected.

4.2.2 Interviews
The purpose with a combination of structured and semi-structured interviews was to increase the understanding of how the participants perceived the visualisation techniques and the space they were looking at.

The structured interview was used to make sure all of the participants answered the exact same questions about the visualisation techniques. The finishing semi-structured interview gave the participants room to more freely talk about how they perceived the different techniques and understood the space they had been looking at. This gave the participants a chance to further elaborate on their thoughts, feelings and understanding. Additional questions which arose during the test session were asked as well as follow up questions to clarify some earlier statements.

When designing the semi-structured interviews we took Patton’s (2002) general interview guide into consideration and created an interview guideline to have a framework to follow, see appendix 1. This approach ensures an overall similarity between each interview session, even though they are semi-structured, and makes the data collection more systematic (Patton, 2002). The interview guide was divided into separate themes based on the earlier related research conducted at Umeå municipality, the architecture company Tyréns and our own observations and visits to public consultations. With these background experiences as a foundation along with the academic related research the themes emerged.

4.3 Data analysis
The transcription of the interviews was started immediately after the first interview finished and were carried out by both of the authors due to the time consuming nature of transcriptions (Bryman, 2011). Transcription guidelines were established to guarantee consistency and the transcriptions were literal. By starting with transcriptions from the very beginning we had the possibility to continuously iterate on the interview guideline if any missing aspects were identified.

The data that was generated from the interviews was interpreted with the help of thematic analysis. Thematic analysis is a widely used method but is not so much an approach in itself but more a generic method for analysis (Ritchie et al. 2014). This since thematic coding is used in a variety of analysis methods and traditions (ibid.). Through the reading of the transcribed data patterns were discovered and sorted out. The data was cooked down to its
bare essentials and inserted in two separate matrices, one for the structured part and one for the semi-structured part. Some parts of the semi-structured interviews is summarised in text instead of in the table since it was a better fit for the data. This is presented as the results in this study. To be able to present the raw data in an understandable way we utilized the concept of pattern recognition through the whole data analysis (Bryman, 2011).

While grouping the fragments of data into themes it is easy to lose the context (Ritchie et al. 2014). This possible problem was sidestepped by keeping shortened versions of the questions along with the fragments and the fragments were also color coded. The fragments were then grouped after visualisation technique and inserted under the relevant themes resulting in each theme had all relevant fragments. Each step in the process was done in a new document to keep the original data and make backtracking possible. Based on these initial themes further processing was done and clusters started to emerge. The clusters gave the possibility to develop possible explanations and further sense making of the processed data. This part of the process is presented in the analysis/discussion.

4.4 Method criticism

When it comes to research, it is important to be critical of how a study has been conducted, to see the role of the researcher, methods used, interpretation and analysis of the data and so on. Everything is coloured by the researcher’s preconceptions, prior knowledge, previous experience, along with studies and research made in the field of interest. This makes it difficult, for us as researchers, to know how and in what way we affect the study (Fejes & Thornberg, 2009).

An interview session is a social interaction, thus influencing the respondent in some way is always a risk that is important to have in mind. Another problematic aspect of interviews are the questions themselves. It is always difficult to know which questions are right, what works well and not and so on. In an attempt to create a solid interview guide several iterations were done. The questions were reviewed by researchers and fellow students as well as architects and urban planners who had prior experience with public consultation. The results were rephrasing, adding and changing of the interview guide according to the feedback. The pilot study also helped in refining the questions in the interview guide. Our use of an elaborate interview guide should reduce interview inconsistency.

In the context the user test and observation is done can also be something that affects the participants in some way. It can be perceived as somewhat odd since it is not an ordinary setting. As researchers, our aim is to make the participants as comfortable as possible in the situation. To aid in making the participants feel comfortable during the sessions conducted at the HCI-lab we made sure the lab was completely empty and that there was plenty of time set aside for the whole session. The sessions which took place outside of the HCI-lab demanded extra effort to find peace and quiet as well as making sure there was plenty of time set aside. All users knew one of the authors since before which helped making the user feel comfortable during the session since the author who had the previous relationship with the user was also the one who lead the whole session. This prior relationship might affect the data due to the user being bias. Extra effort was made with regards to this possible problem by explicitly explaining that the authors were only testing these visualisation techniques and had no
further investment in them. Even though these extra precautions were taken we cannot be sure how our earlier relations with the users affected their performance or the data.

Quantitative methods were discussed and might have been viable for this study and when looking at the related research in this genre they are common. Our decision to go for a qualitative method is based on the sort of data we wanted to collect. An in-depth understanding of the users is vital to be able to answer our research questions and to collect this data we found a qualitative approach to be the best choice. Since the whole point of a public consultation is to get the subjective opinion of the citizens we too wanted their subjective opinions of the visualisation techniques tested.

There are limitations with this approach. No control was conducted if the users actually understood what they were evaluating. This could be done by e.g. letting the users draw the park after each exposure to the visualisation techniques and comparing the drawings to each other and to the actual 3D model and seeing if it matches. Using the drawing approach was discussed but ignored in the end since it would not help the purpose of this study. An additional approach or add on to the interviews could be to use focus groups. The benefits it could bring are the users can build on each other’s answers and thus delve deeper into the topic. These sort of group sessions do come with their own limitations, e.g. weaker personalities might be suppressed and it is easy for users to support other users opinions, due to social standards, even though they might not agree. Our main reason for not choosing this technique was mainly due to practical reasons. Since we had to go visit more than half of the users it was not feasible to try to arrange a group session.

The collected data in this study is widely spread, this partly due to a relatively small sample size. The users in this study have been chosen to get a wide range of people with different education level, age and gender. Even though this is the case, it is important to make clear that the results from the collected data are not generalizable to the general public. Despite this, conclusions will still be drawn from the collected data.

4.5 Ethical considerations
The Swedish authority Vetenskapsrådet (2002) has summarized the strict research ethics which applied to social science research into four major parts which we abided to. The four parts are: demand of information, concurrence, confidentiality and rights of usage. Participants needs to be informed that they are participating in a scientific study and that they are doing so as volunteers who can retract their concurrence at any time. The data collected is also confidential and will only be used and spread in accordance with the needs of the study. (ibid.) The users were given this information at the beginning of the test sessions. No user aborted their participation and everyone accepted taping of the interviews. A consent from both the parents was given for the adolescent to participate in the study.

5. Results
Based on the background research conducted, six major themes emerged from which the interview guidelines were created. The themes were identified by interviewing urban planners at Umeå municipality and architects, urban planners and visualisation artists at the
architecture & urban planning company Tyréns. The structured interviews had the four themes Feelling, Understanding, Presence and General impression. The semi-structured interviews had the three themes Preferences, Differences and Improvements. No further dividing was done.

5.1 Structured interviews

The structured interviews consisted of four themes; Feeling, Understanding, Presence and General impression. In table 3 below a summary of the structured interviews and themes are presented.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Plan</th>
<th>Perspective</th>
<th>Animation video</th>
<th>VE</th>
<th>VR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeling</td>
<td>+ Geographical location</td>
<td>+ Could form mental model of the area</td>
<td>+ Could form mental model of the area</td>
<td>+ Could form mental model of the area</td>
<td>+ Could form mental model of the area</td>
</tr>
<tr>
<td></td>
<td>- Can not form mental model of how it will look</td>
<td>+ Silhouettes gave perspective</td>
<td>+/- Only shows selected parts</td>
<td>- Short</td>
<td>- Some users got dizzy or nauseous</td>
</tr>
<tr>
<td></td>
<td>- Lack of surrounding information and context</td>
<td>- Lack of surrounding information and context</td>
<td>- Lack of surrounding information and context</td>
<td>- Lack of surrounding information and context</td>
<td>- Lack of surrounding information and context</td>
</tr>
<tr>
<td>Understanding</td>
<td>+ Understanding where objects are placed and what it is</td>
<td>+ Understand where objects are placed and what it is</td>
<td>+ Understand where objects are placed and what it is</td>
<td>+ Understand where objects are placed and what it is</td>
<td>+ Understand where objects are placed and what it is</td>
</tr>
<tr>
<td></td>
<td>+ Understanding level differences</td>
<td>+ Understand level differences</td>
<td>+ Understanding proportions</td>
<td>+ Understanding of proportions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Bird's eye view</td>
<td>+ Silhouettes gave perspective</td>
<td>+ Surroundings included</td>
<td>+ Spatial understanding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+/- Better understanding if plan view were showed first</td>
<td>+/- Better understanding if plan view were showed first</td>
<td>- Good overview</td>
<td>+ Walk around freely</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Missing reference objects (e.g., silhouettes)</td>
<td></td>
</tr>
<tr>
<td>Presence</td>
<td>Most users answered not at all and others said a little</td>
<td>Most users answered a little, much and very much</td>
<td>A mix of answers between a little, much and very much</td>
<td>A mix between the answer a little, much and very much</td>
<td>A mix of answers from the users varying from a little, much and very much. Most saying much and very much.</td>
</tr>
<tr>
<td>General impression</td>
<td>- Lack Information</td>
<td>+ Simple and straightforward</td>
<td>+ General impression is positive among users</td>
<td>+ All users liked VE</td>
<td>+ Most users liked VR even though they got nauseous</td>
</tr>
<tr>
<td></td>
<td>- Too simple</td>
<td></td>
<td>+ Proposed plan became clearer than perspective images</td>
<td>- Used individually, might not be good for public consultation setting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Works as a complement but not by itself</td>
<td></td>
<td>+/- chosen information for the viewer</td>
<td>- Feeling of being in the pre/R</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Some users got dizzy or nauseous</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Matrix showing the results from the structured interviews.

5.2 Semi-structured interviews

This section consists of 12 semi-structured questions and three themes; Preferences, Differences and Improvements. Some of the data is presented in table 4 while parts of it is presented in text.

5.2.1 Preferences

Most of the users preferred virtual reality and virtual environment. Virtual reality seemed to be popular since it is entertaining to use, most users had not tried a head mounted display
before and like the experience it offered. The negative thing about virtual reality was that, although it was fun to use, it might have been taking focus away from the task - to understand the proposed plan. The positive thing about virtual reality was that the users, that preferred it, thought that it was easier to see details compared to virtual environment. User 8 said that VR also gave better understanding for dimensions and perspective. During the test session we observed that some users, when using VR, walked around exploring the area like they were there in real life, e.g. sitting in the swings, looking up and down on the trees and trying sitting at the benches. The fact that the users could walk around freely within the park area with VE and VR was something pointed out as positive. Other than VE and VR, the animated video was preferred as well as the perspective images. User 3 said that the perspective images were easy to understand but a little boring compared to VR. The downside with the images are the fact that it misses background and therefore it is more difficult to grasp the surrounding environment.

Almost all of the users disliked the plan view the most. This because it did not give more information than geographical location, it has very little detail and is difficult to understand on its own. User 10 said that he would not want the plan view to not be there but, maybe it is better when combined with other visualisation techniques.

User 5 liked VR the least because she got dizzy and said that if she had not been dizzy she might have liked virtual reality more. User 9 liked the perspective images the least, this was because she, compared it to the other techniques, and thought that the images were somewhat unnecessary.

All of the users agreed on the fact that you can not get too much information. Therefore, none of the visualisation techniques gave more information than necessary according to the users. However, some users said that maybe with virtual reality you can forget what you are supposed to look at and just focus on the experience and how to navigate in the space. User 6 said that he might look at what he can see rather than what he sees. User 9 asked if she really need all of the detail that, for example, virtual reality offers the user. Maybe it is important to see a lot of detail for some groups of people, e.g. urban planners and architects, while the general public do not need it to the same extent.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Plan</th>
<th>Perspective</th>
<th>Animation</th>
<th>VE</th>
<th>VR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview</td>
<td></td>
<td>Bird's eye view</td>
<td>Selected information for the viewer</td>
<td>Walk around freely and explore</td>
<td>Feels natural to look around</td>
</tr>
<tr>
<td>Geographical location</td>
<td></td>
<td>Silhouette gives proportion</td>
<td>Good overview of the park area</td>
<td>Detailed</td>
<td>Realistic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected information for the viewer</td>
<td>Looks professional</td>
<td>Understanding for level differences</td>
<td>A feeling of being there in the park</td>
</tr>
<tr>
<td>Weaknesses</td>
<td>Lack of detail</td>
<td>Lack of information about surrounding area and context</td>
<td>Lack of information about surrounding area and context</td>
<td>Lack of information about surrounding area and context</td>
<td>Blurry image</td>
</tr>
<tr>
<td></td>
<td>Lack of information about surrounding area and context</td>
<td>Too short and fast</td>
<td>Too short and fast</td>
<td>Missing vertical movement</td>
<td>Nausea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can not walk around freely and look at details</td>
<td>Can not walk around freely and look at details</td>
<td>Missing some angles</td>
<td>HMD complicated to put on and use</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lack of information about surrounding area and context</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unfocused on the task</td>
</tr>
</tbody>
</table>

Table 4. Matrix showing results from the strengths & weaknesses question from the semi-structured interviews.
5.2.2 Differences
Many users said that the differences between the visualisation techniques got bigger and bigger ranging from the plan view to virtual reality. Some users thought that it was not a huge difference between VE and the animated video except with the video it was already decided what the user got to see. VE and VR were more engaging than other techniques according to most users since it offered a more detailed understanding of the space.

When it comes to ideal order of exposure the users seem to agree with each other. Most users agreed on the fact that the starting point for the exposure should move from abstract to more detailed, in other words - plan view to virtual reality. A combination of the different visualisation techniques, like the plan view and 3D world would be preferred. A photo collage of the plan view and the perspective images might be positive to expose to the users first and then the animated video.

5.2.3 Improvements
Most users thought that more than one visualisation technique were needed to get an idea of the proposed plan of the park. If the public consultation is held for a crowd of people, some users gave the suggestion to show the movie instead of using VE and/or VR. This because the latter techniques are more time consuming.

Many users said that the perspective images with some text would be good to start with as a presentation for a public consultation, followed by the animated video and finally VR for the people that are the most interested.

6. Analysis
In this section analysis of the data will be presented together with related search to answer the two research questions, which are as followed:

1. What visualisation technique is better suited when presenting a design proposal at a public consultation?
2. With an increasing degree of fidelity, is there a breaking point where the user can form a general understanding of the proposed design? If so, does the rest of the information then become excessive?

6.1 Best suited visualisation technique
The first question, regarding what visualisation technique is better suited when presenting a design proposal in a public consultation setting, is somewhat tricky to answer in a brief way. It seems like there is no best practice. We would argue that it is relative depending on the object that is being showcased as well as the context. Most of the users suggested that going from an abstract to a more detailed level would be preferred when taking part of the proposed design. Even though the plan view was the most disliked visualisation technique many users would not dismiss it entirely. This was because it gave an overview of the park and showed its geographic location with information that the other visualisation techniques, to a varying degree, were lacking. A possible improvement to the plan view would be to use an aerial photograph instead of a map to get the surrounding context. This suggestion was
supported by some users and opposed by others. It would put the proposed design in the correct setting but it could also remove focus from the design itself. The users who opposed to the suggestion said that the plan view would then probably be too cluttered. We acknowledge the opposing users doubt and we believe that the decision to use an aerial photography or a map has to be made on a case by case basis since it will depend a lot on how complex and/or cluttered the surrounding environment is.

A combination between different visualisation techniques was suggested by the users. For example, the plan view bundled with the perspective images would be preferred. This could solve the problem of context being lost when only looking at the perspective images. Most users preferred virtual reality even though many of them experienced nausea, due to motion sickness, and a blurry image, due to low performance from the HMD hardware.

To further add to the spatial understanding and general experience props were asked for in all of the 3D-visualisations. Most of the users thought that the animated video, VE and VR could all benefit from adding life to the techniques which would show how the park could be used when built. Adding people who were walking around, sitting in the swings or sunbathing as well as everyday items would give the 3D worlds a more lifelike touch and help with the spatial understanding since they become reference cues for scale and depth cues for size as well as interposition. It should be noted that none of the users saw this option as mandatory or essential to understand size but it would be a nice detail.

To answer the first research question, it seems like there is no single best technique to be used but a combination of several seems to be the superior alternative. Based on the results of this study and the related research we have created a general combination and order of exposure of visualisation techniques for a public consultation, see figure 4. The combination of plan view bundled with perspective images should be presented first to set the geographic context to give a quick and broad sense of understanding. The animated video should follow up to give a systematic guided tour of the area and it should put emphasis on key points in the design. This part is where the general presentation should end and the people attending the public consultation should be able to ask questions and make comments. VR should be saved for the ones who have an extra interest in the design and they should have to wait until the general presentation is over to use it.

Figure 4. Suggested order of exposure for public consultations.

This approach starts very wide and gives the overall picture and then keeps narrowing down until a detailed level is reached with VE or VR. Saving them until the very end is primarily chosen due to the extra costs and time consuming nature of the techniques. Only one person can use a VE or VR station at the time if the free control is used, which is beneficial. This proposed setup of a public consultation regards the planned public meeting which is supervised by architects and urban planners. For the unsupervised public consultations,
which are available at city halls and libraries, the same order of exposure would be preferable and the problem with a large amount of people and limited access to VE/VR equipment would not be as severe. This is due to the fact that people could visit the unsupervised public consultation at any time.

One user requested a mix of the animated video and VR, a VR experience with a predefined walk-through. This approach would make it possible for several people to get the depth cue benefits of VR at the same time but the free navigation would still be absent. It is an interesting suggestion and it could be created to mimic a real life situation, e.g. a bus ride or a guided tour. At the time of writing and probably a couple of years ahead there is a massive hype around VR since a lot of the consumer versions of the HMDs are currently being released. This might lead to that people attending the public consultation wants to try out the brand new technology but in a couple of years when VR is more normalized the above stated approach should be viable.

Fröst & Warren (2000) argues that virtual reality runs the risk of being just an expensive tool for showcasing building projects if not used in a meaningful context. Similarly, during the test session one of the users repeatedly pointed out that advanced techniques such as VR or VE was perceived to be excessive when looking at the proposed plan for the park used as the object in this study. The users suggested that virtual reality instead ought to be used when showcasing more complex objects and environments, e.g. a building and how it affects the surroundings. We would argue that it is the design showcased that should affect the choosing of visualisation technique(s) together with time and budget constraints. Furthermore, the archtect could choose visualisation techniques depending on what sort of feedback is wanted. If general feedback is desired the perspective image could be a good choice and if it is detailed feedback that is wanted VR might be a better choice, see figure 5. It should however be pointed out that this is somewhat speculative since we do not have enough support in our data and related research to determine that it is this way.

The users who felt that they could locate themselves geographically and possessed local knowledge of the area also seemed to need less fidelity to generate a solid understanding of the park. They could rely on their previous experience of the area to see how the park would fit in its surroundings and to comment on it. The order of exposure to the visualisation techniques does not seem to affect this aspect and all of the users thought that they had a good understanding of the park after watching the animated video.

“[t]he design] felt very much Umeå [the town].” – User 4

This could mean that the choosing of visualisation techniques should also depend upon how well known the area is. We could argue for different visualisation techniques depending on if e.g. the area is concerning a rebuilding of a central part of a town, which would be a well-known place, or if it is a grove that is going to be turned into a residential area, which is a less known place. This is however speculations, partly based on the data.
6.2 The breaking point

The second research question regarding fidelity and whether or not there is a breaking point where the user can form a general understanding of the space and if some of the information is excessive will be discussed below.

According to Schnabel (2004) the distance between imagination and realization is reduced when viewing architecture designs as 3D visualisations. This seemed to be the case for some of the users. One of the users experienced that the real size of objects was easier to perceive when using virtual reality as a visualisation technique. The user said that in order to determine size and distance it had to guess when using the other visualisation techniques. After experiencing VR the same user said that:

“My preconceptions of how large everything is, are not as strong. You have a general thought of how the objects will look but you do not need it...I'm not allowed to interpret as much on my own which I did before.” - User 6

With VR the user stated that he did not have to imagine size and depth in the same way since he experienced that he could see and comprehend the real size of objects. The user was experiencing the depth cues size, interposition and motion parallax all at the same time with VR and extra emphasis was put on the size cue.

A higher degree of fidelity can according to Campell & Wells (1994) give the viewer a deeper understanding of what it is looking at. This seems to be corresponding with the experience of the users in this study. When some of the users were exploring the park using VR or VE they started commenting on details like surface structures, how the railing was shaped and so on. A deeper level of understanding had been achieved. The other visualisation techniques did not bring this level of detailed understanding. A question which arose during the study was if this level of detail was something that the general public is interested in. Is it relevant to show details of handrails, material choices and so on to all visitors at a public consultation by using techniques such as VE or VR? In turn, who can decide for whom some information is excessive or not? All of the users that participated in this study agreed that it is not possible to get too much information about the proposed design from the visualisation techniques. Furthermore, the users did not comment or talk about the park in the same way when using the different visualisation techniques. This is because everybody views things differently, have different perspectives, prior knowledge and so forth.

6.2.1 Different levels of understanding

It does seem like the higher fidelity techniques allows for a deeper understanding and thus more detailed feedback. This knowledge could be used in a public consultation process where the level of feedback wanted or needed would dictate which visualisation techniques should be used. With this in mind we argue that there is not a specific breaking point in where the extra fidelity becomes excessive. However, it seems like there is a breaking point where the level of detail in the feedback increases. From the results of the study we can see that the lower fidelity visualisation techniques (plan view and perspective images) provides a more general understanding and the higher fidelity techniques (VE and VR) brings a detailed understanding. The animated video which is located in the middle of the fidelity stair bridges
the gap between the two sides but it still belongs with the lower fidelity techniques since the
detailed understanding is not as good as with VE and VR. Figure 5 is an expanded version of
Figure 1 and shows the breaking point as well as the level of understanding.

Figure 5. Expanded fidelity stair - showing the level of understanding and the breaking
point of the visualisation techniques.

This is interesting because the major thing that sets the animated video aside from VE and
VR is the lack of free navigation. The quality of the park in terms of resolution is exactly the
same for the animated video and VE whereas the HMD even has less resolution. Campell &
Wells (1994) does point out that being able navigate freely is preferred over a predefined
route so the users can choose for themselves what to look at. This was confirmed by some
users while others liked the predefined walk-through more.

The free navigation seems to bring an increased understanding due to the fact that the
user could choose which parts to inspect. Our observations also shows that the free
navigation makes users look at the objects up close and try to use the park as it is intended.
Some users tried to jump into the swings and sit on the benches to try to create a detailed
understanding of how the real life use of the park would be. This playful behaviour was more
recurring with VR and the movement was also more realistic due to the head-tracking
feature. Users were looking up and down more while using VR compared to VE, probably
since this movement comes more natural with head movements compared to inputs on the
gamepad. This added motion to the head/viewport increases the number of depth cues and
especially motion parallax and this is probably a part of why the understanding seemed to
increase.

Mohler’s study from 2007 shows that depth and spatial perception are very close or equal
when comparing VR with a real life visit to the same place. Our study seems to align with
Mohler’s results and it seems like a more realistic use of the park allows for an increased
detailed understanding. It might be that the realistic use plays an even larger role in terms of
understanding than a better looking 3D-model for the general public at a public consultation.
This is an interesting thought but since we are now sliding into the prototyping field which is
outside the scope of this study we can only speculate on why. To speculate, it might be
feasible to adapt the level of fidelity to the level of implementation depending on what sort of
information is wanted from the public consultation. Different visualisation techniques could
have different specific purposes and thus complement each other, e.g. a high fidelity
perspective image could be used to convey the look and feel and a lower fidelity VR experience could be used to show the function/implementation of a design.

The users that liked the predefined walk-through preferred it because it showed the proposed plan in a simple and systematic way. The same users also saw downsides with having someone else choosing the information that they got to see. This was for instance that they could not individually choose what to focus on, they lost details and were sceptical of the fact that an architect, for example, could show the design from its best side and thus hide flaws with the design and so forth.

6.2.2 The cumulative effect
The cumulative effect was present and the level of understanding kept increasing all the way up the expanded fidelity stair, figure 5, until VR was reached. The order of exposure did not matter as much as expected but there was a clear trend that the users who were exposed to the VE and VR before the animated video liked the video more than the other users did due to its systematic showing of the park. This is probably because VE- and VR-first users were thrown into the 3D-world without any background information about the park or the context. They had to discover everything for themselves. To be thrown in blindly was feasible with the use of this specific park since the design was not very complex but anything more complex than this very basic level of design could probably be disorienting.

The cumulative effect was increasing the general understanding of the park up until VE and VR where the understanding started to be more detail oriented, see figure 5. Most users did not get a better understanding of the park as a unit after the animated video but they did get an increased understanding for the details. All users also felt they could comment or criticize the park after watching the animated video, a few of the users felt that they could do it with the perspective images as well but those users also said that the animated video increased their sense of security to comment.

There does seem to be a breaking point where the user can form a general understanding of the space and the breaking point is the animated video. The rest of the information is however not excessive, it is just more detail oriented. Schnabel & Kavan (2001) and Fröst & Warren (2000) writes that architecture designs represented in 3D and VE are easier to understand for the layman. Our study confirms their statement and we can also further add that the animated video, in our case, is a sufficient visualisation technique to gain a general understanding and that VR is the best technique of them all if the users’ are given some context beforehand.

6.3 Experience
During the test sessions some users pointed out things that were connected to their experience of the park. Comments were made about how shadows fell, how the nearby street with cars passing by could affect the space, noise, crowds of people in the park or someone passing by on a bike and so on. Other aspects that could be interesting to look into might be the experience of the space for someone in a wheelchair, the change of seasons or just how it will look at different times during the day. Since this thesis focus on the users understanding of space and not overall experience these aspects are not something which we have looked into but still got some vague data about. It would be interesting to study further.
7. Conclusion and suggested future research

Based on our findings it is evident that there is no single best technique to be used in a public consultation setting. Rather a combination of several techniques seems to be the superior alternative. The users in this study preferred being exposed to the different techniques going from an abstract, or general, level to a detailed one. Based on this a proposed order of exposure at a public consultation was presented, starting with the plan view and perspective images bundled together, giving the context and geographical location to the viewer. This is followed by the animated video which gives a structured tour of the proposed plan. After this the public should be able to ask questions and leave comments. For the ones that have an extra interest in the design VE or VR could be offered at the end of the public consultation.

Regarding the understanding of the visualisation techniques, there seems to be a breaking point after the animated video. The users went from a general understanding to a detailed understanding, there was a cumulative effect, at the increasing level of fidelity. The plan view, perspective images and the animated video provided a general understanding of the design for the users. Virtual environment and virtual reality on the other hand did not increase the general understanding but gave the users a better understanding for detail. After the animated video the breaking point came when we noticed detail oriented commentary about the proposed plan that the user gave during the test session.

Important to consider when choosing visualisation techniques for a public consultation is what kind of feedback the municipality or architect wants and/or needs. All of the users stated that they could not get too much information about the proposed plan with any of the visualisation techniques. Although the information is not excessive per se it is important to reflect upon which information is wanted. If the municipality wants general feedback from the public about a proposed plan virtual reality would not be the first choice of visualisation technique(s) for that setting, in other words, it is context dependent.

7.1 Future research

There have surfaced some future improvements to the field of architecture and urban planning visualisation as well as specific techniques. A way to improve the general publics’ possibility to leave comments on specific design features could be to mark the 3D-world itself while navigating in it in VE or VR. Some sort of paintball metaphor could work, a user would then fire paintballs at specific places to color mark them and then leave a voice recorded or written comment. The use of post-its in the 3D-world itself could also work. Another possible technology driven improvement would be to use sound recorded from the specific place to provide an even more realistic setting.

Future research which has proven to be needed after this study is primarily connected to the prototyping field. We found that differently oriented prototypes could probably be used with success depending on what information is being looked for, e.g. a high fidelity perspective image could probably sometimes be more beneficial than a lower fidelity virtual reality experience. We would like to see studies where different levels of fidelity are mixed with different visualisation techniques which would result in knowledge about which techniques and/or fidelity is suitable depending on what sort of feedback is being seeked.
References


Appendix 1: Interview guide

Structured interview

Feeling
• Do you get a sense of how the area will look once it is built? If yes, do you feel like you can form an inner mental model of what it is going to look like?
  If no, why?

Understanding
• What information do you get from the comprehensive plan? Example: do you understand where trees are going to be placed when you have been looking at the plan with visualisation technique A?
• Do you feel like some information is missing when you look at the comprehensive plan with this visualisation technique?
• Do you feel like you get the information you need from the technique to be able to comment and/or criticize it in some way?
  If yes, in what way?
  If no, why?
• (Question after 2nd exposure) Did this visualisation technique give you an increased understanding of the park compared to the previous one(s)?

Presence
• How much did you feel that you were present at the place?
  o Very much - Much - A little - Not at all

Conclusion
• What is your overall impression of the technique?

Semi-structured interview

Preferences
• Which technique do you like the best?
  o Why? (Most fun, most understanding, best overall experience etc?)
• Which technique do you like the least?
  o Why? (Least fun, least understanding, not so good overall experience etc?)
• Do you find any visualisation technique to be more than necessary (too detailed, too complicated)?
  o Which and why?
• What strengths and weaknesses did you see with visualisation technique A?
• What strengths and weaknesses did you see with visualisation technique B?
• What strengths and weaknesses did you see with visualisation technique C?
• What strengths and weaknesses did you see with visualisation technique D?
• What strengths and weaknesses did you see with visualisation technique E?

Differences
• According to you, what are the biggest differences between the different visualisation techniques?
• If all of the techniques are used, do you think there is an ideal order of exposure to the different visualisation techniques?
  o Are any redundant?
  o Would you like to experience several at the same time? (Multitask)

Improvements
• If you got to decide which visualisation technique(s) should be used at a public consultation, which would you choose? And why?
• Do you think it is good to use more than one visualisation technique at a public consultation or is it, in your opinion, better just use one of those you tested?
Plan view
Appendix 2: Visualisation techniques

Animated video / Virtual environment

Virtual reality
Appendix 3: Virtual reality in use

One of the users during the VR part of the test session. He is wearing the HMD Oculus Rift and navigating in the 3D-world through his head movements and inputs with the gamepad.