# IMMERSIVE VIRTUAL REALITY IN LANDSCAPE PLANNING

TELLEF DANNEVIG, JOSTEIN AKRE THORVALDSEN
*Asplan Viak AS, Kjørboveien 12, 1337 Sandvika, Norway*
*tellef.dannevig@asplanviak.no*
*jostein.thorvaldsen@asplanviak.no*

AND

RAMZI HASSAN
*Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Sciences, Norway*
*ramzi.hassan@umb.no*

**Abstract.** In Norway there has been an increased focus on participatory planning the latter years. The public is now supposed to be included in the planning process. The documents which the public have access to usually consists of the project`s technical drawings. In some cases, the documents include perspective drawing or computer rendering supplied by the stakeholder. Most affected parties are non professional in terms of planning, and have little or no experience dealing with the plans. Therefore, the information they rely on most cases is the perspective images, which easily can be manipulated. A system that enables all parties engaged in the planning process to visualize planning scenarios in a much realistic way is therefore needed. Virtual Reality is a tool that enables the viewer to move freely in a three dimensional digital environment. In this virtual world, different levels of interactivity can be added. The Norwegian University of Life Sciences (UMB) has recently installed a new immersive Virtual Reality system based on the idea of ConCave theatre. This research study is making use of the new ConCave theatre in order to test whether VR can be used as an enhancement of the communication process between professionals and amateurs and between professionals. By presenting digital models of different level of detail to two subject groups consisting of students with planning background and two groups without such experience we first investigated perception in an immersive VR-environment.

## 1. Introduction

The Norwegian planning law (PLBL 1985, 16) states that all affected parties should have the possibility to participate in the planning process, and the planning authorities are also given the imposition to actively spread information. The aim is to make the public aware of different plan outlines, and to keep these available at the planning authorities' office. The term participatory planning has often been ambiguously interpreted, but one general definition of what the activity should include has been stated by Holsen (2000); "It should be an activity where the public has got the right to actively participate in the planning process, and in different ways be included in the planning processes, more than just the participation that can be said to exist in the representative democracy." It should also be clarified that there is a distinct difference between the dialogue occurring when the public are given the opportunity to comment on plan proposals developed by the authorities, and the true participation where the public are allowed to be involved in the actual development of the plan (Aslaksen 1995).

In the work prior to the introduction of the 1985 law, we can read that the main reason for this focus on participation was the consideration for a more efficient society planning. It was believed that making the public able to understand and accept the decision would lead to a more efficient accomplishment (Holsen 1996).

It can be discussed if the current practise really gives the pubic the feeling of participating. Large social groups will not have the experience needed to predict the outcome of the plans they now have the right to see. The right to participation is also limited in the law to parties that are directly affected by the outcome of the plan. In many cases larger groups of people will have interest in the outcome than those that are included in the participation process today. We believe that a more widespread involvement of the public can improve the planning process as well as the accomplishment of the plan if the communication between the different parties is improved, because decision makers then will be provided with the needed knowledge before action (Pløger 2002).

## 2. Method

Our main aim is to test whether VR based on a ConCave setting can be used as an enhancement of the communication process between professionals and amateurs and between professionals.

## 2.1. AIM AND OBJECTIVES

### *2.1.1. Ås building project; VR compared to commonly used visualizations*

In order to investigate whether VR can be an enhancement to the traditional presentation techniques we were using an actual building project in Ås, Norway. We presented two subject groups with a traditional presentation of the project, and two groups with a Virtual Reality presentation in order to compare the results from each.

- Does virtual reality improve the understanding of a project compared to the present techniques?
- Which of the two presentation techniques leads to the most positive reactions to the project?
- Which presentation technique inspires the participants the most into participating in the local planning process?

## 2.2. SURVEY SUBJECTS

Our subjects were local students that knew the modeled areas well. Half of these students were studying planning at the third year or above, and therefore had experience in working with technical drawings with a high level of abstraction. The other half was students from several other fields, and did not have this experience. We got the participants to sign up for the survey by using e-mail, phone and posters at Campus. This resulted in 80 subjects signing up and 69 showing during the two days of research.

## 2.3. PROCEDURE

Our presentations were conducted by presenting four different groups with two different presentations during two days in May 2007. On Thursday May 24th one group consisting of planners and one group consisting of non planners were presented with the technical drawings for the Ås building project. The next day two new groups consisting of the same two segments were presented with the VR-model of the Ås building project.

*2.3.1. Analogue presentation*

We needed the subjects` response to an actual building project when exposed to traditional technical drawings and perspective images commonly used in planning today. The problem with this was that we had invited all the subjects to participate in a study concerning Virtual Reality, and they would naturally have expectations exceeding looking at paper copies of a project. We thought that the subjects would understand that the analogue presentation they got of the building project were supposed to be compared to a VR-presentation, and therefore they would believe that the "correct" answers in this study were answers that showed that this presentation gave them less understanding of the project. The way we decided to solve this was to fool the participants into believing that the presentation was not related to our study, and that we had been hired by Ås Municipality to get students` opinion on the development of Ås. Based on the oral comments we got after finishing the test the participant believed us.

In order to retrieve the subjects` perception of the project two questionnaires was used. Part 1 was handed out along with the perspective images of the project, and Part 2 along with the technical drawings. Before Part 2 was handed out, Part 1 was handed in, but they kept the perspective images, so that during Part 2 they had both technical drawings and perspective images to base their opinions on. This was done to both collect information about what would be the publics` first impression of a project, and what would be their opinion after studying plans. Perspective images are what will be printed in newspapers and on posters, and are therefore the presentations most people rely on when making up their opinion of a project.

This analogue presentation we got from the planning authorities in Ås, and it is the base for the decision-making in this project. In most cases the drawings would, however, be accompanied by a written or oral presentation by the stakeholder (Lange 2005). Therefore compared to the actual decision makers our subjects received less information. However the information they received was identical to the information the public have a right to see according to the Norwegian planning law. This first group therefore had the same grounds for having an opinion about the project as the general public has in this actual case.

*2.3.2. Virtual Reality presentation*

At the last day of testing, both groups were handed out stereoscopic glasses right from the start. In order to achieve the same setting as when performing the analogue presentation we needed to make also these subjects believe that their results would be provided to the planners of Ås. We told the subjects that Ås Municipal had hired us to make a model of the local development and to collect opinions about it. Also these groups presented with this lie

seemed to believe it. The subjects were first taken on a virtual tour around the proposed buildings, both flying in the air and walking on street level. After a predefined trip they were asked if they wanted to observe from additional viewpoints. If there were any requests, we moved to the desired position. After moving around freely in the virtual environment, the projection was turned off, and a questionnaire was handed out asking the same questions as answered by the other groups. The form was collected after 6 minutes, and a round of oral commenting were performed.

## 2.4. QUESTIONNAIRES

When retrieving input from the subjects we decided to measure opinions by using a Likert scale ranging from 1 to 5. The subjects were to assign a value representing their opinion on different matters in the model or drawings. A Likert scale is usually treated as an ordinal scale (Wikipedia 2007), because the difference between the numbers may be perceived differently by different persons.

## 2.5. ANALYSIS

In order to analyze the answers from our questionnaire, we used both Microsoft Excel for arranging the results and providing us with descriptive statistics, and SigmaStat for the more advanced statistical analysis. When working on the results we were in many cases basing our discussion on descriptive statistics as the average and mean of the groups, but in most cases inferential statistics (Trochim 2006) were obtained by using Spearman`s Rank Correlation test or a Mann-Whitney test. The Spearman test is a suiting tool for analyzing paired data to find correlation between them. In order to describe this correlation the Spearman`s rank correlation coefficient was used due to the ordinal data from our testing. Whenever there is a positive correlation ($1>P>0$), the two variables are increasing together, while a negative correlation ($-1<P<0$) describes a situation where one variable is increasing when the other is decreasing Altman (1991). Mann-Whitney on the other hand can be used in cases where we are not dealing with paired data, and we want to investigate whether one of two datasets tend to be higher than the other. This is done by comparing the medians as well as the spread of the data (Hart 2001).

## 2.6. RESULTS

### *2.6.1. Understanding volumes*

To try and figure out how well the groups presented with different presentations understand the planned development, we asked them to

estimate the height of two buildings. One of the buildings is an existing building commonly known as the “Bunnpris”-building, while the other is the estimated tallest building of the new project. The Bunnpris-building is 10 meters tall, while the new project is 19 meters at its tallest. The traditional presentation groups were first asked to estimate the height when presented with the perspective still images. These images were all from an aerial view, and made it hard to make the correct estimates. However when the first form was handed in, they received all the technical drawings in a 1:1000 scale. They were also informed that there were rulers to be found under their seats. The groups presented only with a VR-presentation were asked to make the estimations after the presentation was over. The results from the height estimations can be seen in (Figure 1 – 4).

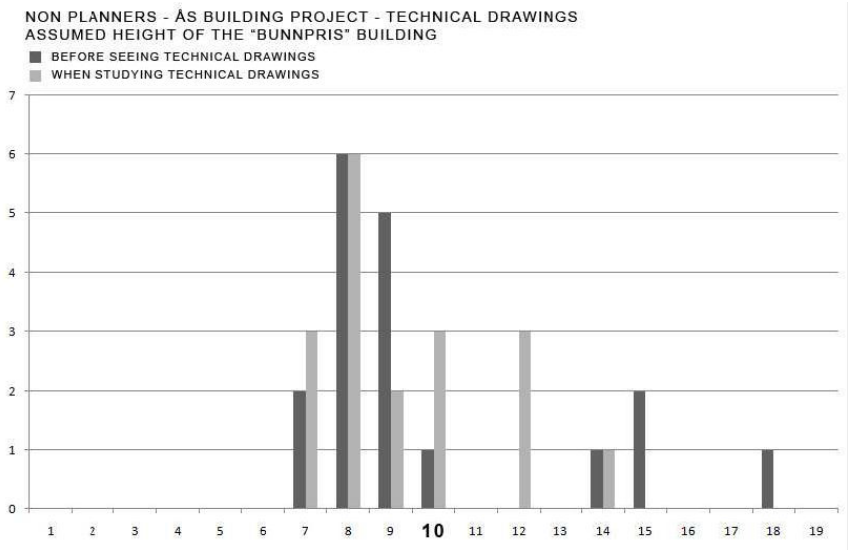


*Figure 1*

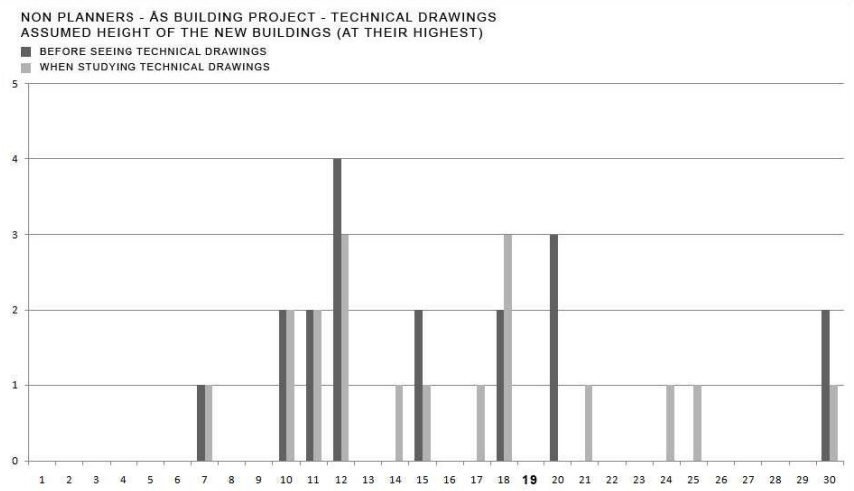


*Figure 2*

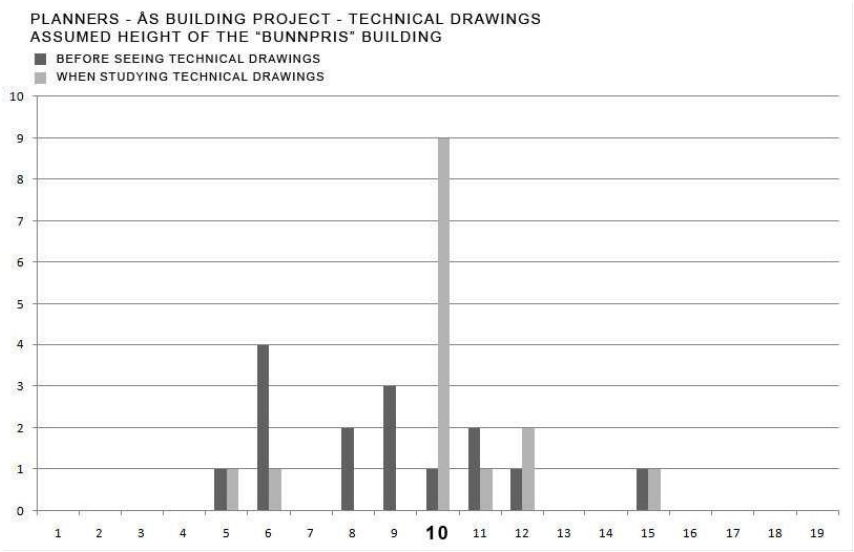


*Figure 3*

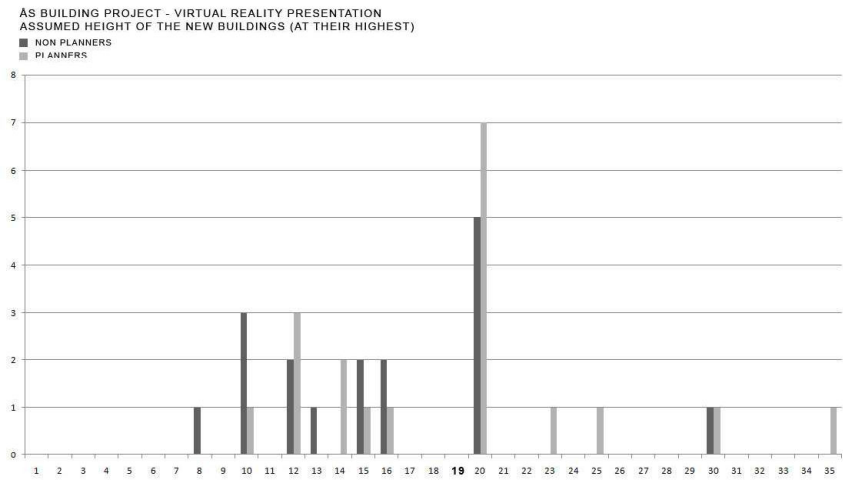


*Figure 4*

*Figure 5,* Presentation at Virtual Reality Lab for groups

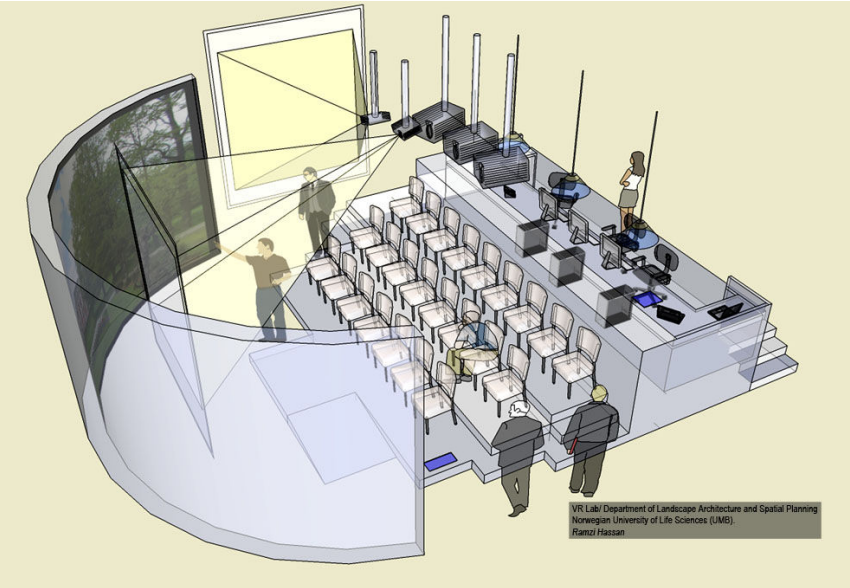


*Figure 6,* The Virtual Reality Lab at UMB


*Figure 7,* Virtual Reality Lab at UMB, preparations before the presentation

*Figure 8,* Screenshot from the VR-model for Aas project.

*2.6.2. Stated understanding*

In addition to the testing of how well the respondents understood the volumes, we asked them to quantify their understanding of the project. When comparing the results from both groups seeing VR and technical plans (part 2), the difference in the median values is greater than would be expected by chance. There is a statistically significant difference (P = 0,002) according to Mann-Whitney Rank Sum Test. It means that the understanding was on a higher level for the ones gaining the VR-presentation.

*2.6.3. Enough information*

When comparing the results from both groups seeing VR and technical plans (part 2), the difference in the median values is not great enough to exclude the possibility that the difference is due to random sampling variability. There is not a statistically significant difference (P= 0,916) according to Mann-Whitney Rank Sum Test.

*2.6.4. Stated positiveness*

From the two presentations conducted on planning students, we get the average of 3,11 on the Virtual Reality presentation, and 3,58 on the traditional presentation when asked how positive they are to the project. The same numbers from the non planners are 3,41 and 3,72. As we now are not

interested in separating the two segments, we will merge the answers from both planners and non planners. The VR-presentation will then have an average of 3,25 with a median of 3, and the traditional presentation will have an average of 3,56 with a median of 4. When comparing the results from both groups seeing VR and technical plans (part 2), the difference in the median values is not great enough to exclude the possibility that the difference is due to random sampling variability. There is not a statistically significant difference (P = 0,162) according to Mann-Whitney Rank Sum Test.

When comparing the results from both groups seeing VR and technical plans (part 1), the difference in the median values is not great enough to exclude the possibility that the difference is due to random sampling variability. There is not a statistically significant difference (P = 0,856) according to Mann-Whitney Rank Sum Test.

As mentioned by Perkins and Barnhart (2005) the issue of engaging the public in the planning process is one of the main obstacles in achieving participation in planning processes. We asked the subjects to rank their engagement in the local development both before and after they participated in the project. This was of course a leading question, but as we asked the same question to all groups, we can still compare increase or decrease between the groups to find whether a presentation technique is more inspiring than the other. When comparing the results from both groups seeing VR and technical plans, the difference in the median values is not great enough to exclude the possibility that the difference is due to random sampling variability. There is not a statistically significant difference (P= 0,720) according to Mann-Whitney Rank Sum Test.

## 2.7. DISCUSSION

### *2.7.1. Does virtual reality improve the understanding of a project compared to the present techniques?*

- *Perspective images and Technical Plans*

Both planners and non planners are in general estimating the new building mass to be lower than it actually is based on the perspective images provided by the stakeholder. On the 19 meters tall proposed building the estimates are ranging from 7 – 23 meters among planners, and 7 – 30 meters among non planners, making an average of 14,9 and 15,7 meters. These estimates show that the subjects in general perceive the building to be lower than what is the case, and that the extreme values are significantly wrong. These results alone however do not tell us much more than that people does not get a realistic enough perception of height from the images provided. What is more interesting is to test how well the architect succeeds in presenting the height of the proposed buildings compared to the already

existing buildings. The “Bunnpris”-building is 10 meters tall, which both groups fairly accurately estimated. The planners also in this case had a lower average than the non planners, and estimated the building to be 8,7 meters compared to 9,9 of the other group. That both groups are failing to estimate the correct heights is an expected result, but what is more interesting to look at is the relationship between the estimates of the existing and planned building. The correct heights are as mentioned 10 meters and 19 meters, making the correct ratio number 1,9. Non planners had an average ratio number of 1,56 with extreme values from 0,9 to 2,2, while the planners had a closer average of 1,7 with extreme values from 1,25 to 2,33. Neither of the groups can be said to have come very close to the correct ratio, and we will therefore conclude that a presentation consisting of only still images from an aerial view is not sufficient in communicating future building heights.

In the second part of this case drawings with a 1:1000 scale were handed out, and considering that they had rulers available it should have been easy to perform the correct measurements. However, when observing the results, almost none of the non planners seem to have performed these measurements. We expected there to be someone that did not understand how to use a ruler to measure a drawing at a given scale, but that so few people got the heights right is a surprise. One person even believed that the ratio was 1 at this point, and a few more had ratios down to 1,2 - 1,4 (correct ratio; 1,9). This tells of an even lower understanding of plans than we had hoped to expect. Even though the planners did better in measuring the heights, some did still not get it right at this point. All subjects in the experiment had at least three years of planning experience at university level, and should have been well familiar with measuring the dimensions of a proposed project. When the technical plans were studied, only about half of the subjects seemed to make use of the ruler, even when specifically told that it was to be found under their seats. They were also located in the same room as the people using their rulers, and still they did not think of using it themselves. Even though few of the respondents estimated the correct height, the average ratio of the estimations of the planners are very close to the correct of 1,9. The non planners also came a little closer at this attempt ending up with a ratio of 1,7.

- *Virtual Reality Presentation*

We did not expect the subjects during the VR-presentation to estimate the correct heights, because they did not have any tools available to perform any exact measurements. Neither did they have the presentation in front of them when performing the estimates. What we hoped to find out however was that the ratio between the two buildings were perceived more accurately when they had the possibility of free movement and a street level view

point. The planners estimated the tallest new building to be everything between 10 and 35 meters, while the non planners were estimating between 8 and 30 meters. These estimates led to the averages of 18,8 and 15,7. In the case of the "Bunnpris"-building planners estimated between 6 and 15 meters, and winded up with an average of 9,8, while the non planners assumed from 3 to 11 meters with an average of 7,7. In both these two groups the estimates are ranging between some pretty extreme values, but a closer look at the numbers reveals a clustering around the accurate numbers of 10 and 19. As mentioned it is not whether the actual estimates are correct or not that is interesting in this study, but how accurately they estimate the ratio between the two buildings. In this case the average ratio of the planners were dead on the correct of 1,9, while the non planners were a little above with an average of 2,0. This is even more accurate results than when the other two groups had the possibility of measuring technical drawings. This is however not the results we consider it natural to compare the VR-test with. The technical drawings are in a scale, and therefore the subjects should have been able to figure out the correct ratio. Both the VR presentation and the perspective drawings are meant as illustrations, so it is the results from these tests that are interesting to compare. For planners we then get the ratio of 1,7 compared to the VR-results of 1,9. Non planners got an even bigger gap of 1,6 and 2,0. This implies that the Virtual Reality presentation gave the audience a more realistic view of the volumes of the proposed project compared to the existing buildings. The understanding of a project of course goes beyond understanding the heights of the buildings, but the variable of volume is probably the easiest to test whether people understand or not. It is also the variable that the planning authorities have the greatest control over in Norway. Even though there is a paragraph in the Norwegian Planning Law that enables the authorities to stop a project on aesthetic grounds (PLBL 74 – 2), this is very rarely used. What is very common in processes like this however is to very precisely regulate building heights and volumes. However we still asked questions to clarify how well the subjects themselves felt that they understood the development. Their statement can of course be affected by the fact that they believe that they understand it even though they don't, but still we might get an indication which of the groups feel the least confused. The accuracy in communicating the relationship between existing and proposed buildings seems better when using Virtual Reality than still images. We also wanted to check how well the subjects felt they understood the development, and to what extent they felt that they had received enough information to make up an opinion. When performing the Mann-Whitney test on the level of understanding stated by the respondents themselves, we found that there is a significant difference. The subjects provided with the VR-presentation clearly feel that they understand the development better than the subjects of the traditional

presentation. The possibility of the participants having misunderstood the project, and therefore feel that they understand the project even though they don't, may have interfered with the result. However the results from the volume estimation already discussed indicates that this is not so. We have already concluded that VR provided the most accurate visualization when comparing new buildings to the existing, and now we see that the participants themselves feel more convinced that they understand the development. Therefore we believe we can assume that virtual reality is a more suiting tool than analogue presentations when it comes to making both lay people and professionals understand the visual impact of a proposed project. Interesting to note is that when receiving the technical drawings, many respondents feel that they get a better grounds for making up an opinion, but their overall understanding of the project is decreasing. In other words when getting more information, they understand less. This could have been caused by lack of correlation between the plans and the perspectives, making the outcome very confusing to predict, but when asked specifically about this correlation only one person answers that something is wrong. Another thing interesting point is that it is the planners that seem to become the most confused about the information in the technical drawings. The average understanding amongst planners in part 1 was at 4,2 points on the five point scale, but this average declined to 3,47 when studying part 2, making the understanding 0,73 points lower. Among non planners the decline is only 0,06 points, which makes it hard to conclude that this group is in general increasingly confused. What we can conclude is that none of the groups feel any more certain about the outcome of the project at this point, even though they now have a much more realistic impression of the building volumes.

*2.7.2. Which of the two presentation techniques leads to the most positive reactions to the project?*

As we can see from the results, there is a decline from the traditional display compared to the VR presentation. However when applying a Mann Whitney Rank Sum test, the results proved to not be statistically significant. We can therefore not conclude either way when it comes to the participants stated positivity of the project. Also when it comes to the question of whether the planned project will fit well into the existing surroundings or not, the results don't differ significantly enough to conclude either way. We can therefore assume for now that the reactions of building proposals presented in virtual reality can be as positive as the traditional displays. This will probably differ between projects, but perhaps this project seemed equally positive from both the aerial view provided by the architect and from all the viewpoints of the VR-presentation.

*2.7.3. Which presentation technique inspires the participants the most into participating in the local planning process?*

We expected both groups to feel more engaged after viewing the presentations, both due to the lack of information they had about the project prior to our presentations, and also to the fact that our question was somewhat leading. As we can read from the results our expectations proved to be correct. This was however not what we were investigating by asking the question. We wanted to figure out whether VR can be more engaging than the commonly used displays. The Mann-Whitney analysis showed that the increase in engagement felt by the participants viewing the VR-presentation was not significantly higher than on the groups viewing the traditional presentation techniques. We can therefore conclude that in this case virtual reality did not engage the subjects enough to be superior to traditional presentations. If these analogue presentation techniques are insufficient in overcoming the second obstacle mentioned by Perkins and Barnhart (2005) we can conclude that neither virtual reality is a sufficient tool to present the information in an engaging manner.

## 3. Conclusion

The studies that now have been conducted suggest that a ConCave based Virtual Reality environment has great potential for enhancing the communication in planning processes.

When Virtual Reality is used to communicate an actual building project, we have discovered that this presentation technique has advantages compared to the traditional displays. Building volumes are more easily understood when being presented as a VR model than as technical drawings and perspective still images, and the participants also feel that they understand the project better when provided with a VR presentation. This study did not reveal any difference in how positive the development was perceived to be, or how well the audience believed the project would fit into the environment. The subjects felt more engaged in the local development after being presented with the VR presentation than before, but this was also the case with the subjects observing the analogue presentation. Therefore we cannot assume that VR is a more inspiring tool for use in public participation than the tools already in use.

## Acknowledgements

Several people have been providing us with vital assistance during the process of writing this paper. First of all we want to thank our supervisor Ramzi Hassan for

help in both the writing process and the organizing of the tests. We would also like to thank Mari Tveit and Gary Fry for being extremely helpful and patient when assisting us in the writing process, Ole Sandberg for help in the initiation phase, and Caroline Hägerhäll for helping to develop the questionnaires. Our models could not have been made without the cooperation with Vianova. They provided us with free software and the very helpful tutoring conducted by Gisle Totland, Tone Kristiansen, Camilla Dale and Torbjørn Tveiten. In order to export our models into the ConCave we received crucial help from Mathias Jäderholm from EON Reality. The technical drawings for the Ås building project were provided by Ås municipal where Erik Martinsen was very helpful at several occasions and provided us with digital maps and the technical drawings for the Ås building project. Kjetil Johansen at Astrup og Hellern AS was kind enough to give us the digital model of the same project. Last but not least we will thank all the participants at the testing. This paper would not have been possible without you!

## References

Altman D.G., 1991. *Practical Statistics for Medical Research*. Chapman & Hall, London, 285-288.

Aslaksen, F., 1995. Brukermedvirkning i planlegging, Kommuneforlaget.

Holsen, T., 1996. Medvirkning i planlegging: Planleggingsteoretisk analyse av lovgrunnlaget for medvirkning etter plan- og bygningsloven, NIBR.

Holsen, T., 2000. Medvirkning som begrep i plan- og bygningsloven. NIBR.

Lange, E., 2005. Issues and Questions for Research in Communicating with the Public through Visualizations. Trends in real-time landscape visualization and participation.

Lover, Norges, 2003. Plan- og bygningsloven (1985), Det juridiske fakultet, Universitetet Oslo

Perkins, N. and S. Barnhart (2005). Visualization and Participatory decision making.

Pløger, J. (2002). Kommunikativ planlegging og demokrati - nye perspektiver i planforskningen. NIBR.

Hart, A., 2001. Mann-Whitney test is not just a test of medians: differences in spread can be important. http://www.bmj.com/cgi/content/full/323/7309/391. (19.07.2007).

Trochim, W.M.K., 2006. Descriptive Statistics.

http://www.socialresearchmethods.net/kb/statdesc.php - (20.07.2007).

Wikipedia. (2007). "Likert scale." http://en.wikipedia.org/wiki/Likert_scale - (16.07, 2007).