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ARTICLE



Investigating the use of visualization to improve public participation in infrastructure projects: how are digital approaches used and what value do they bring?

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ABSTRACT

Using digital visualization models is suggested as a way of overcoming known barriers in public participation processes. Through a survey conducted among professional practitioners in the Norwegian infrastructure industry, different visualization models were compared in order to determine how they may lead to change in understanding and engagement among the public. The results indicated that digital visualization models were believed to lead to a statistically significant increase in people's understanding and engagement compared to traditional visualization models. In spite of this indication, it was traditional visualization models that were most commonly used to disseminate information about infrastructure projects to the public. The results also revealed that practitioners believed that 3D models in particular led to better understanding and increased engagement compared to virtual and augmented reality models; however, the latter models had seldom been used in infrastructure projects, and many of the respondents were not familiar with these visualizations. The results suggest that an increase in the use of digital visualizations could be beneficial. Additionally, more frequent, formal, and structured evaluation of the use of visualization should be done in order to ensure that the visualizations used meet specific project objectives.

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Introduction

A core value of all modern democracies is to allow citizens to have an influence on the decisions affecting their daily lives. To achieve this, it is important that citizens have different arenas where they can participate and influence the decisions made by politicians and other decision-makers. In a planning context, public participation is a way to give citizens a certain measure of influence and power over the projects that are being planned in their local community. In Norway, the Planning and Building Act states the following: 'Anyone who presents a planning proposal shall facilitate public participation. The municipality shall make sure that this requirement is met in planning processes carried out by other public bodies or private bodies' (Plan- og bygningsloven, 2008).

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Public participation is important to ensure well-informed decisions, engagement and ownership of both democratic and community-based development (KMD, 2014). Although public participation has been a legal requirement in Norway since it was introduced in the Planning and Building Act in 1985, many have argued that the practice is far from satisfactory (Ringholm et al., 2018).

There are numerous barriers that have hindered well-implemented public participation. Münster et al. (2017) examined over one hundred articles addressing public participation and summarized four main barriers found there: few participants, a biased sample of the population, process deficits, and communication issues. Similar barriers have been found specifically in a Norwegian planning context. Ringholm et al. (2018) noted that citizens described the planning process as inaccessible and lacking transparency. Further, citizens taking part in public participation processes seldom consist of a representative sample of the population, resulting in the dominance of a limited number of opinions (Klausen et al., 2013).

Over the past few decades, a digital revolution has taken place, which in turn has led to new ways of storing and communicating information. In the field of planning and urban development, digitalization has been largely realized through continually evolving Building Information Models (BIM) and Geographical Information Systems (GIS). Simply stated, BIM and GIS can be understood as platforms that allow for gathering, storing, and exchanging information. This way of handling information has led to a more seamless information flow and new ways of collaborating among the professionals planning, designing, and constructing public infrastructure projects. The same technology can also influence the dissemination of project information through the generation of digital visualizations that can actively be used in communication with stakeholders and the public. Hanzl (2007) notes that this technology can be used to reduce barriers associated with non-professionals viewing technical information and allow for remote participation through information-sharing online. Thus, these digital technologies can potentially contribute to the elimination of certain barriers hindering well-implemented public participation.

Several studies have shown that communication through digital visualization models can bring value to the public. Visualizations have been described as the only common language to which all participants, both technical and non-technical, can relate (King et al., 1989). Further, Al-Kodmany (1999) concluded the following over two decades ago: ‘Visualization through digital technology provided a common language for all participants. The tools helped empower residents to plan and design for the future of their community.’

Technology has evolved greatly since Al-Kodmany’s conclusion; as a result, new ways of visualizing project information are becoming more common. Computer tools are the current state of practice for generating 3D models, and these tools are in constant development. Virtual reality (VR) and augmented reality (AR) are ways of viewing project information based on realistic 3D models. Through using VR technology, one can experience the planned measures in a modelled environment imitating the physical world, while AR models superimpose modelled project information over the actual physical environment. These technological trends have been suggested as a way of further overcoming barriers related to public participation, and researchers that have investigated the use of these technologies in planning processes have found promising results.

For example, the use of VR has led to an increase in the amount of helpful and positive feedback from the public (Lai et al., 2011), a better understanding of building volumes (Dannevig et al., 2009), and a higher level of public engagement (Van Leeuwen et al., 2018). AR is found to improve communication (Broschart & Zeile, 2014; Meza et al., 2015) and public acceptance of project implementation (Grassi et al., 2016). Researchers have concluded that there is no 'all-in-one' visualization method for all purposes (Appleton & Lovett, 2009; Warren-Kretzschmar, 2011). Hence, it is important to evaluate the use of digital visualizations in order to determine the kind of visualization that should be used in different contexts. While the abovementioned studies utilized structured evaluation of the different visualizations, Laurian and Shaw (2009) have argued that evaluation of public participation is generally insufficient; consequently, a more formal and structured assessment of public participation is needed in order to avoid failed participation processes.

Research regarding the use of digital visualization models in public participation processes has thus far been largely concerned with the fields of architecture, landscape architecture, and environmental engineering. To date, no studies were found which presented quantitative data on the value of digital visualization models in public participation processes of infrastructure projects. Such data allows for making informed decisions when considerations are made whether or not to invest in digital visualization implementation. There also exists a wide span of different visualizations. Subsequently, there is a need to compare these visualizations and gather knowledge about the extent to which they meet specific project objectives regarding public participation. In a Norwegian context, it is unknown to what extent digital visualizations are used in infrastructure projects and whether digital visualizations are being evaluated to determine how they contribute to public participation. Investigating this issue is the first step in gaining a better understanding of the use of digital visualizations in public participation processes.

The research objective of this study has been to understand how visualizations can lead to better public participation processes in infrastructure projects. This process includes understanding how visualization models are currently being used in Norwegian infrastructure planning processes as well as understanding how communicating with the public through digital visualization models differs from traditional visualization models. Additionally, this research considers how digital visualization models are currently being evaluated in public participation processes.

The comparison between digital and traditional (paper-based) visualization models specifically focuses on understanding project information, as well as engagement and participation in the planning process. As mentioned previously, communication issues due to poor understanding of project information among laypeople and low participation are some of the main challenges in public participation processes (Münster et al., 2017). Further, engaging the public and communicating planning information are found to be the central evaluation criteria utilized when evaluating digital visualization models (Warren-Kretzschmar, 2011).

Method

The research objectives are largely addressed through a nationwide survey among professionals in the Norwegian architecture, engineering, and construction (AEC)

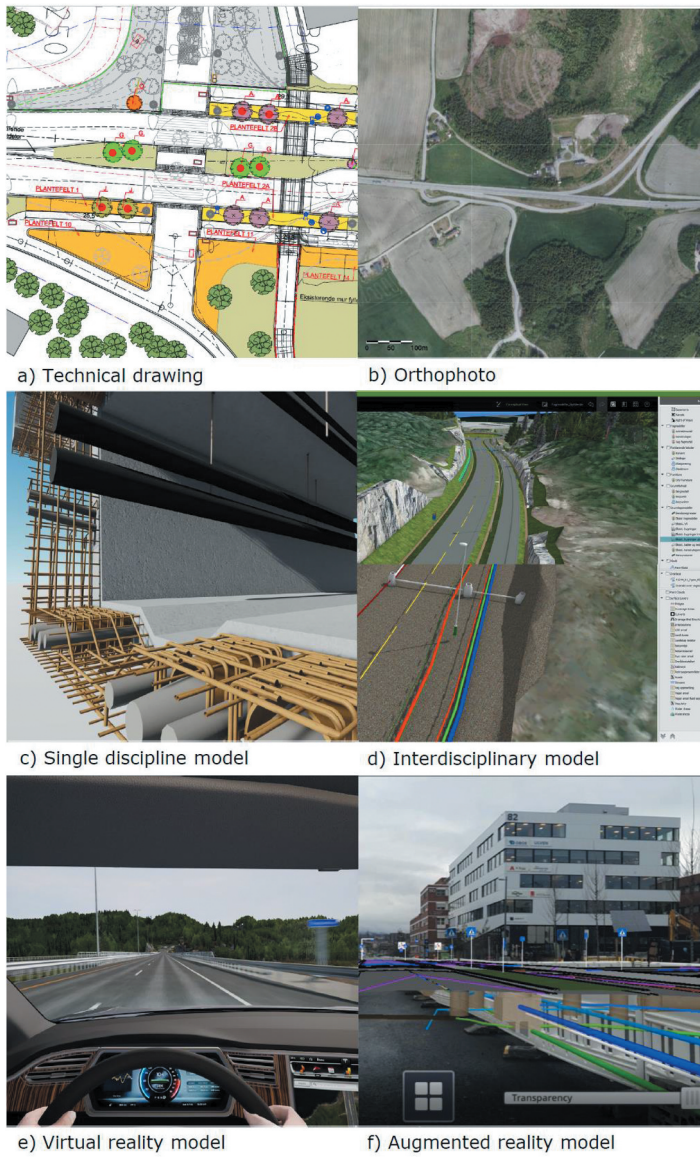


Figure 1. Examples of traditional and digital visualizations (images provided by Norconsult AS).

industry. Informal interviews with industry professionals were completed prior to the survey's development in order to gain a better understanding of both the current situation and new trends with respect to using visualization models when working with infrastructure projects.

During these informal interviews, current visualization methods were identified. Visualization methods were divided into two categories: traditional and digital. Traditional visualization methods were categorized into three groups, including maps/orthophotos, illustrations/sketches, and technical drawings. These are 2D representations that are typically presented in printed form. Further, in this study digital visualization

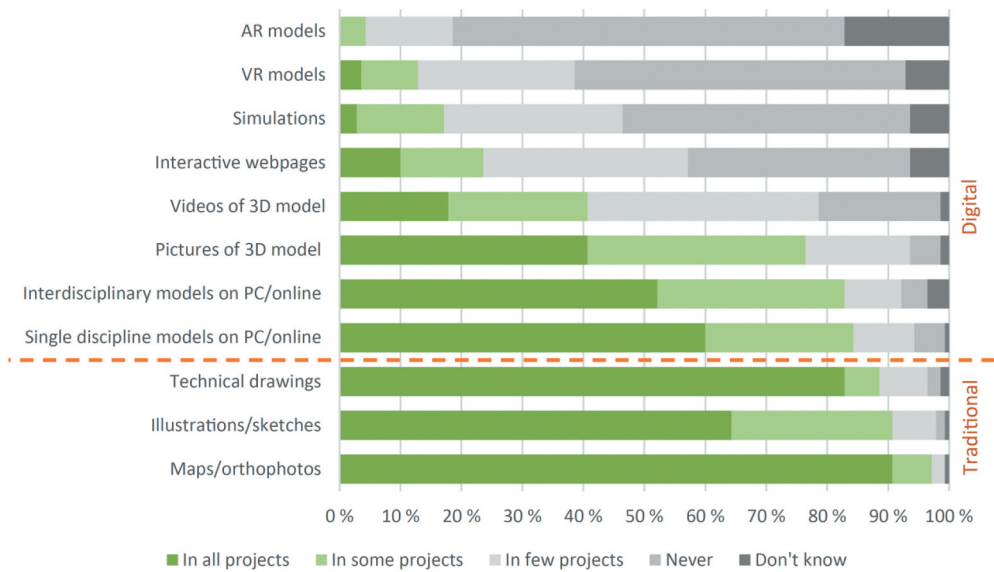


Figure 2. Frequency of use of different visualization methods (n = 140).

models are understood as digital 3D models generated by one or more computer programs. These digital visualizations can be presented in several ways. The 3D models can be displayed on a 2D screen (computer screen, smartphone, tablet) as an interactive model built into the existing environment, for both a single discipline (e.g. only a road model) and as an interdisciplinary model (e.g. both a road model and drainage systems model). Pictures and videos can also be created from the 3D models to be used as visualizations. Other forms of digital presentation include webpages, where project information – including maps, models, images, and possibilities for providing comments – are presented in a digital and interactive way, and simulations which depict operations on future infrastructure. Finally, the 3D models can be further developed with VR/AR technology and presented using devices such as VR and AR glasses. [Figure 1](#) shows examples of several of these traditional and digital visualizations.

Survey

The online survey consisted of several parts. In the first part, background questions were asked to map respondents' type of employer, title, and professional experience. In the second part, these respondents provided information about how often they used different visualization models and in what context this was done. Then the respondents were asked their opinion about rating to what extent the different visualization models would lead to understanding and engagement among stakeholders and the public. The rating was done on a five-point Likert scale and allowed for making comparisons between different visualization models. The questions were formulated like the following example: "To what extent do you experience that traditional visualization methods lead to a better understanding of what a project will look like?" Finally, the respondents were asked to

describe in what manner and how often the use of visualization models within the public participation process were evaluated.

The survey was disseminated through known industry contacts via email and social media channels specific to the industry; subsequently, 140 responses were received in the spring of 2020.

Analysis

In addition to using descriptive statistics, the Wilcoxon Signed-Rank Test was used to compare digital and traditional visualization models. This test is a non-parametric alternative to a paired sample t-test (Lowry, 2020). The null hypothesis for the test stated that the means of two samples were equal. The test was used to determine whether the means, which were based on the different visualization methods' ratings, differed significantly from one another.

Results

Demographic of the sample

As previously stated, there were 140 respondents to the survey. All respondents who started the survey completed it. The sample was quite evenly distributed between respondents employed by clients (for example, the Norwegian Public Road Administration) and those employed by consulting firms. Most respondents worked in management roles or as designers/engineers; however, 20 respondents (14%) primarily worked as a BIM coordinator or similar. The majority of respondents worked with road projects; thus, the results of the study most closely mirror the current road project situation as opposed to general transport infrastructure projects. The years of work experience held by the respondents varied from 1 to 40 years, with an average of 11.3 years and a median of 8 years.

Current use of visualization models

The respondents were asked to rate how often they used different visualization methods in infrastructure projects. Their responses showed that traditional visualization models were more frequently used compared to digital visualization models, as seen in [Figure 2](#).

Maps/orthophotos and technical drawings were the most frequently used methods, as over 80% of respondents reported utilizing them in all projects. Among the digital methods, single discipline models and interdisciplinary models were most used, having over 50% of the respondents report that they used these models in all projects. On the contrary, VR models, AR models, simulations, and interactive webpages were seldom used. In fact, AR models were the only visualization method that no one reported using in all projects, although these models were reported as being used on occasion.

The informal interviews with industry representatives at the study's outset indicated that most of the VR and AR models' implementation work was done by individuals with a particular interest in the technology, and this technology had not yet been broadly accepted. The same was said about interactive webpages, often based on GIS data. The

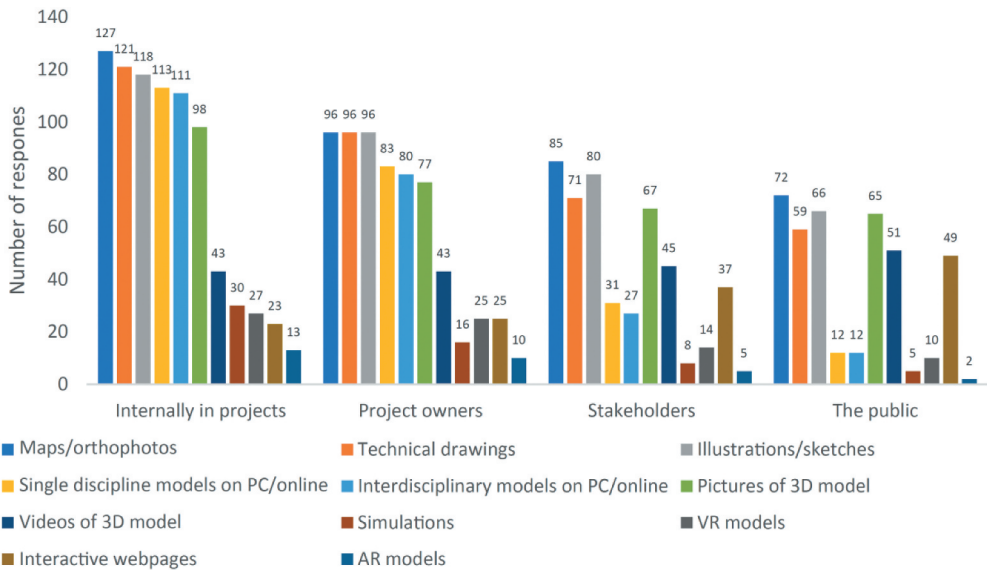


Figure 3. Use of visualizations with different partakers in the planning process (n = 140).

development of these visualization methods was most often implemented in larger projects where the project owners were willing to invest in developing technology.

Respondents were also asked with whom they used these visualizations, as seen in Figures 3 and 4. These figures display the same data in different ways: Figure 3 highlights with whom the visualization provides communication, and Figure 4 highlights the comparison between various visualization methods. The respondents were asked to differentiate between the use of visualizations internally in projects, with project owners, with stakeholders, and with the general public. In this study, stakeholders are understood as participants in the planning process that are directly affected by a project and thus have an interest in the project's outcome (e.g. municipalities, businesses, landowners etc.). The general public is understood as other people who are directly or indirectly affected by the project (e.g. neighbors, NGOs etc.).

There are numerous points to be noted in the two figures. For instance, traditional visualization methods are most often utilized internally in projects; they are also commonly used with project owners and stakeholders (Figure 3). They are also utilized with the public, but not necessarily as the dominant method. Single discipline and interdisciplinary models are frequently used internally and with project owners. However, their usage frequency clearly drops with stakeholders and the public (Figure 4b). Videos of 3D models and interactive webpages are the only methods that are more frequently used externally compared to internally (Figure 4c). Although the most immersive visualization methods – VR models, AR models, and simulations – are used more internally than externally, this is done with a low overall frequency (Figure 4d).

Specifically addressing visualizations used with the public, the results indicate that pictures and videos of 3D models and interactive webpages, in addition to traditional visualization models, are frequently used (Figure 3). Interviews with professionals

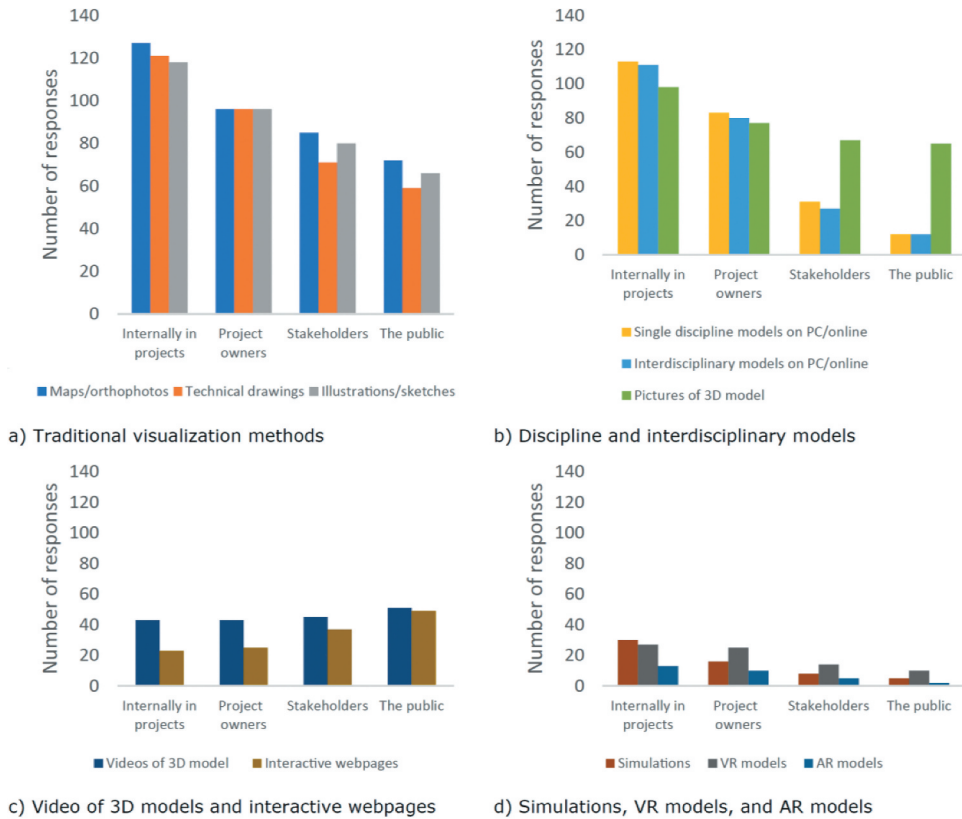


Figure 4. Use of visualizations with different partakers in the planning process (n = 140) – comparison of methods.

working in the industry also indicated that 3D models and webpages are becoming a standard way of presenting projects to the public. Additionally, representatives from the Norwegian Public Roads Administration have stated that pictures or videos of 3D models are used in all their projects.

Out of 140 respondents, only 12 (or fewer) had used either simulations, single discipline, interdisciplinary, VR, or AR models with the public in the past three months. During the interviews, professionals working with the implementation of VR/AR models in infrastructure projects spoke enthusiastically about the potential in these technologies to be an effective communication tool with the public. However, in spite of this, the data shows that VR/AR are not frequently being used.

Differences in communication with the public through digital and traditional visualization models

Looking specifically at communication with the public, the following results consider respondents who have experience in public participation (n = 131). When considering

communication with the public from a perspective of public participation, *understanding* and *engagement* were focused on, as seen in the four questions asked. The respondents were asked to what extent, on a scale of 1 to 5, they experience that traditional, 3D, and VR/AR visualization methods lead to the following:

- Q1 – A better understanding of how the current situation will change (*understanding*)
- Q2 – A better understanding of what measures/projects may look like (*understanding*)
- Q3 – A greater desire to join the public participation process (*engagement*)
- Q4 – A greater engagement in the project (*engagement*)

A rating of 1 represents ‘to a very small extent’ and a rating of 5 represents ‘to a very large extent’. The results are presented in [Tables 1 and 2](#), where [Table 1](#) focuses on *understanding*, and [Table 2](#) on *engagement*. In the descriptive statistics within these tables, one can see the numbers of respondents, mean, and standard deviation. The number of respondents vary because those who answered ‘don’t know’ are excluded from the presented data and the analysis.

The results from Wilcoxon Signed Ranks Tests are also presented in [Tables 1 and 2](#). The null hypothesis for the statistical test is that the means of two compared samples are equal. The Z-value can be used to determine how certain one can be that the mean of the evaluations of one visualization method is different from that of another method. The more Z differs from zero, the more certain one can be of a statistical difference, and hence a correct rejection of the null hypothesis. An asymptotic significant level (p-value) ≤ 0.05 is set as a criterion of statistically significant difference of the means. For instance, if

Table 1. Evaluation and comparison of understanding with respect to the different visualization methods.

To what extent in a public participation process do you experience that traditional, 3D, and VR/AR visualization methods leads to:

<i>Q1) A better understanding of how the current situation will change.</i>			
Type of visualization methods	N	Mean	Std. Deviation
Traditional	131	3.56	0.861
3D	130	4.19	0.808
VR/AR	68	3.99	0.938
Wilcoxon Signed Ranks Test			
Methods of comparison:	Z	Asymp. sig. (2-tailed)	
3D – Traditional	-5.117 ^a	0.000*	
VR/AR – Traditional	-3.054 ^a	0.002*	
VR/AR – 3D	-1.750 ^b	0.080	
<i>Q2) A better understanding of what measures may look like.</i>			
Type of visualization methods	N	Mean	Std. Deviation
Traditional	131	3.18	0.935
3D	130	4.42	0.680
VR/AR	69	4.17	0.839
Wilcoxon Signed Ranks Test			
Methods of comparison:	Z	Asymp. sig. (2-tailed)	
3D – Traditional	-8.211 ^a	0.000*	
VR/AR – Traditional	-5.232 ^a	0.000*	
VR/AR – 3D	-2.223 ^b	0.026*	

Note

^aBased on negative ranks.

^bBased on positive ranks.

* Statistically significantly different with a confidence level $\geq 95\%$.

Table 2. Evaluation and comparison of engagement with respect to the different visualization methods.

To what extent in a public participation process do you experience that traditional, 3D, and VR/AR visualization methods leads to:			
<i>Q3) A greater desire to join the public participation context</i>			
Type of visualization methods	N	Mean	Std. Deviation
Traditional	123	2.96	0.953
3D	122	3.84	0.856
VR/AR	67	3.72	0.966
Wilcoxon Signed Ranks Test			
Methods of comparison:	Z	Asymp. sig. (2-tailed)	
3D – Traditional	-6.629 ^a	0.000*	
VR/AR – Traditional	-3.843 ^a	0.000*	
VR/AR – 3D	-0.880 ^b	0.379	
<i>Q4) A greater engagement for the project</i>			
Type of visualization methods	N	Mean	Std. Deviation
Traditional	125	3.03	0.967
3D	123	3.92	0.874
VR/AR	69	3.81	1.004
Wilcoxon Signed Ranks Test			
Methods of comparison:	Z	Asymp. sig. (2-tailed)	
3D – Traditional	-6.424 ^a	0.000*	
VR/AR – Traditional	-3.908 ^a	0.000*	
VR/AR – 3D	-0.926 ^b	0.355	

Note

^aBased on negative ranks.

^bBased in positive ranks.

* Statistically significantly different with a confidence level $\geq 95\%$.

asypm. sig. ≤ 0.05 one can be at least 95% sure that the differences in means do not happen by chance; thus, they are significant.

As presented in Table 1, with respect to *understanding* and compared to traditional methods, both 3D models and VR/AR models were reported to lead to a statistically significantly better understanding among partakers in a public participation process. The largest difference was seen when respondents were asked about how the different visualization method led to a better understanding of what measures might look like in a future situation (Q2). Similarly, 3D models were also evaluated as being significantly better than VR/AR models.

The same pattern is seen when evaluating *engagement*, as shown in Table 2. Statistically speaking, both 3D models and VR/AR models were rated significantly better than traditional visualization models for both Q3 and Q4. It was also found that *understanding* was rated higher than *engagement* for all the different visualization methods.

The impression that digital visualization models lead to a greater understanding of planned measures than traditional visualization models was also addressed in interviews done prior to the survey. Many of the interviewees said that 3D models (displayed on 2D screens or VR/AR devices) were especially suitable for visualizing volumes and heights of measures. In the same interviews, it was stated that VR/AR models created a lot of engagement when used with the public, although this was not observable from the survey results.

In conclusion, 3D models and VR/AR models were evaluated significantly better than traditional visualization models for all the questions related to *understanding* and *engagement*. These results were also statistically very strong, having an asymp. sig. level

$\leq 0,002$ for all questions. While 3D models were evaluated better than VR/AR models for all questions, this difference was only statistically significant for Q2.

Current evaluation of digital visualization models

Survey respondents were asked how they evaluated digital visualization methods used in public participation processes and whether this evaluation was formally documented (in a report, evaluation form, note etc.). The evaluation methods are shown in Figure 5. The majority of respondents reported having taken part in conversations with colleagues and/or the client, stakeholders, and public regarding the use of visualizations in public participation processes. Although observations were also quite often used, more formal evaluations, such as questionnaires and interviews, were only utilized by a minority of the respondents; in fact, only 15% reported using formal evaluations.

VR and AR

While VR and AR models were not addressed as a separate theme in the survey, interesting results were found when answers related to VR/AR models were analyzed. For example, Figure 6 shows how respondents rated the VR and AR technology's maturity level. As seen in the figure, the VR technology has a slightly higher mean rating (level of maturity) compared to AR technology. Furthermore, several respondents answered 'don't know', indicating that they did not have enough experience to answer the question. More respondents answered 'don't know' with respect to AR technology (41.4%), compared to VR technology (27.9%), indicating the survey sample had less experience with AR compared to VR technology.

A lack of experience with VR/AR models is also evident from the responses to other questions. When rating the visualization methods regarding *understanding* and *engagement* (shown in Tables 1 and 2), around 46% of the respondents did not know how to rate these methods. Additionally, 61.4% and 84.1% of the respondents replied 'never' or 'don't know', respectively, when asked about how often they used VR and AR models. Hence, most respondents were not very familiar with the use of VR/AR models, particularly AR models.

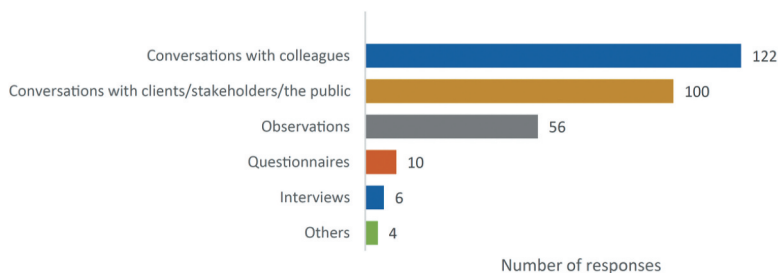


Figure 5. Evaluation methods used in public participation processes (n = 140).

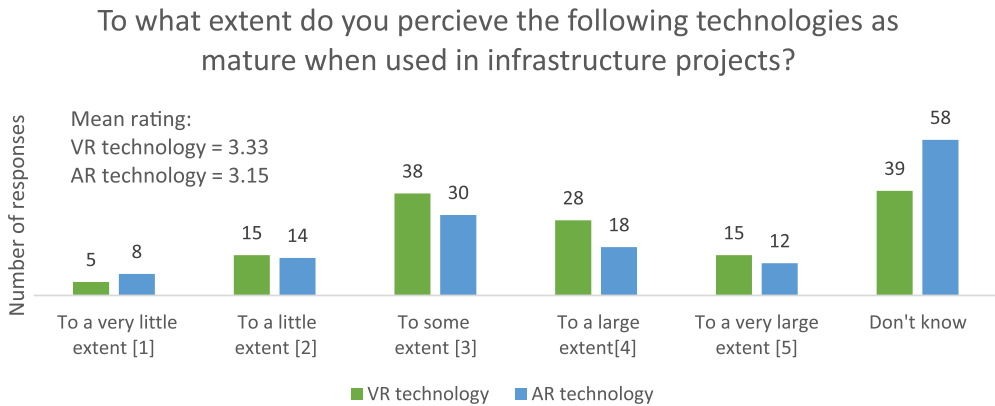


Figure 6. Maturity of VR and AR technology (n = 140).

Discussion

The research objective in this study has been to identify how digital visualizations can be used to improve public participation in infrastructure projects. This has been done by mapping the current use and evaluation of visualizations in Norwegian infrastructure projects, and by comparing professional perspectives of understanding and engagement with the public between traditional non-digital methods and digital visualizations such as 3D and VR/AR models.

As previously described, the results were obtained from a survey conducted among professionals working on infrastructure projects. Given their relevant hands-on experience, this group was well suited to supplying information about the current use of visualization models and evaluating these models' performance. Nonetheless, respondents' assessments of how visualizations that are utilized with the public in mind impact people's understanding and engagement should be understood as opinions based on experience rather than direct results from the public themselves. The survey's results reveal that respondents perceive that presenting project information through digital visualizations (3D, VR, and AR models) leads to statistically significant improved understanding and more engagement among the public compared to traditional visualizations (maps/orthophotos, illustration/sketches, and technical drawings). This conclusion is in line with previous case studies carried out in the field of landscape architecture, including Dannevig et al. (2009), who concluded that building volumes were more easily understood when presented as a VR model compared to technical drawings and perspective still images, and Van Leeuwen et al. (2018), who showed that immersive VR resulted in higher levels of engagement among the public than using 2D presentation models. At the same time, despite the statistically significant improved understanding and engagement between traditional and digital visualizations, traditional visualizations were reported as being more frequently used in communication with the public. This inconsistency might to some extent be explained by a practice of using combinations of visualizations when communicating with the public; as a result, digital methods are used in addition to traditional methods, as opposed to replacing them. It might also indicate that there is an

unexploited potential in increasing the use of digital visualizations, thereby increasing the public's level of understanding and engagement. Additionally, the level of understanding was rated higher than engagement for all visualization methods, indicating that visualizations might be a better means to communicate project information compared to creating engagement for either the participation process or the project.

In the survey, a distinction within digital visualizations was made between 3D models and VR/AR models. The results indicated that 3D models are perceived as leading to better understanding and more engagement among the public compared to VR/AR models; however, this difference was only statistically significant for one out of four sub-questions. Additionally, findings indicate that VR and AR models were seldom utilized in infrastructure projects in general, and even less so in communication with the public. Several respondents reported not knowing how to rate VR/AR models in terms of understanding and engagement in public participation processes. Thus, the evaluation of the different visualization methods was done on different terms, as the familiarity with traditional visualizations and 3D models was much greater compared to VR/AR models. The respondents' lack of familiarity and experience with VR/AR technology is relevant information when discussing whether this technology adds any value to partakers in public participation processes. Based on these results, more information is needed to conclude whether there is a difference in general understanding and engagement when using 3D models compared to VR/AR models. At the same time, previous research has indicated that AR led to a greater understanding of project documentation among architects and engineers compared to a 3D model on PC and 3D plans on tablets (Meza et al. (2015)).

In the same above-mentioned study, all the architects interviewed saw a huge unexploited potential to using AR in communication with their clients (Meza et al., 2015). Additionally, Broschart and Zeile (2014) highlighted the potential of AR after testing four AR applications in real life environments. During this study, professionals informally interviewed in the Norwegian infrastructure industry were optimistic when discussing future possibilities of these technologies. When respondents of the survey were asked about the VR/AR technology's maturity in infrastructure projects, they most often answered that the technology was only mature to a certain extent. When added to the results showing that VR/AR technologies are not frequently used, this answer indicates that the implementation of these technologies is still in an early phase; consequently, respondents expect future developments to occur within VR/AR technology.

It was reported that the evaluation of visualizations was mostly done internally, informally, and without documentation. Indeed, only a few of the respondents formally evaluated whether these visualizations communicated desired project information and engaged stakeholders/the public. This indicates a potential for creating more structured evaluations and gathering more information on the use of visualizations in Norwegian infrastructure projects. This type of evaluation would be useful on several fronts: first, in a practical sense, those developing the visualizations for use in public participation projects would receive better feedback on whether the process for communication and information transfer functioned effectively for given visualization methods. This would in turn potentially justify the cost of developing these visualizations. At a higher level, evaluating visualizations used in public participation processes from the perspective of stakeholders/the public could provide further knowledge about current uses of digital

visualization models. Further, research could address additional aspects of the visualizations, including realism, credibility, and validity.

The results of this study indicate that both a wider use of digital visualizations and better evaluations of them can lead to improved public participation. At the same time, the study addressed neither planning phase differences nor project size and complexity. The evaluation of the different visualizations was also divided into aggregated categories. Consequently, results concerning the use and evaluation of the different types of visualizations must be seen from a general perspective. Previous research has found that there is no 'all-in-one' visualization method for all purposes (Appleton & Lovett, 2009; Warren-Kretzschmar, 2011). Hence, the results from this study should be supplemented with information on visualizations used in real life projects in order to contribute knowledge about the benefits associated with different visualizations in different project contexts. Research based on direct feedback from the public would supplement this study, which focused solely on opinions of practitioners that were based on experience rather than documented evidence from the public. Further, as highlighted, more research is needed to determine if VR/AR models specifically can lead to additional value for the public in future planning processes.

This research has concluded that digital visualizations can improve understanding and engagement within a public participation project; nevertheless, it is important to keep in mind that different visualization tools are suitable for different phases of a project and for communication with participants in the planning process. Consequently, focusing on storing and handling project information in a way that helps one easily generate different visualizations is more expedient than striving toward creating one tool that fits all. Open standardized information, as well as transparent and frequent information sharing is therefore important, and can contribute to reducing the competence and costs required to generate different kinds of visualizations. It is also important to acknowledge that generating different visualizations should not be a goal in itself; rather, visualizations, and the information associated with them, should be targeted to achieve successful project outcomes. Moreover, these visualizations should be properly evaluated so that the visualization methods which are most valuable to both the project and public are being utilized in the public participation process.

Data availability statement

Some or all data, models, and/or code that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the authors.

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