AGILE: GIScience Series, 4, 24, 2023. https://doi.org/10.5194/agile-giss-4-24-2023
Proceedings of the 26th AGILE Conference on Geographic Information Science, 2023.
Editors: P. van Oosterom, H. Ploeger, A. Mansourian, S. Scheider, R. Lemmens, and B. van Loenen.
This contribution underwent peer review based on a full paper submission.

Designing healthy public spaces: A participatory approach through immersive virtual reality

Suzan Evers[1], Gamze Z. Dane[1], Pauline E. W. van den Berg[1], Alexander K. A. J. Klippel[2], Timon Verduijn[2], Theo A. Arentze[1]

[1] Department of the Built Environment, Eindhoven University of Technology, Eindhoven, The Netherlands
[2] Laboratory for Geoinformation Science and Remote Sensing, Wageningen University and Research, Wageningen, The Netherlands

Correspondence: Suzan Evers (s.evers@tue.nl)

Abstract. Participatory design approaches are increasingly used to involve citizens in the decision-making processes to actively address their preferences. Participatory design techniques dealing with urban issues often depend on digitally produced still-images. However, still-images lack immersion and explanation, which can negatively influence non-experts' understanding of the implications of different design decisions. Use of still-images also reduce active participation of non-experts in the design process of their environments. To address these shortcomings, the Immersive Virtual Reality (IVR) application 'CoHeSIVE' is developed and tested for designing healthy public spaces. It includes an innovative methodology to incorporate intuitive design decisions based on inflicted adjustments in a simulated environment. The application automatically generates new design scenarios by combining different pre-composed design elements based on people's selection. This is done to understand and discuss preferences of individuals and groups for new, not yet existing scenarios. Results from a pilot test, concerning the redesign of a plaza, indicated that participants can interpret and design urban forms through the application. Furthermore, participants felt that the interface and features were easy and useful to alter the base scenario into a new design scenario by selecting preferred elements. These results show the capability of the application to initiate a conversation between citizens and designers towards meaningful design outcomes. A set of guidelines for implementing the instrument for urban research is suggested in order to standardize its use and allow the application to be a base for methodological improvements to be further developed regarding multi-user support and as serious game instrument.

Keywords. urban design, immersive virtual reality, public space, participation, health

1 Introduction

Over the past decades, a shift has taken place towards participatory urban design approaches. It represents a move away from design and decision-making as the task of individual experts towards using the collective creativity of a team with stakeholders from different backgrounds and interests (Steen, 2013). The role of governments evolves from administrator to collaborator and for citizens from residents to co-creators (Foth, 2017). Participatory practices originated in the 1960's and 70's with the rising criticism on the disconnection between experts' technical rationality and people's everyday needs (Arnstein, 1969; Shapely, 2011). Over time, scholars have recognized the benefits of citizen participation. Participatory design can foster collaboration and creativity (Kunze et al., 2011), increase the chance of successful project implementation through citizen commitment and ownership (Evans-Cowley and Hollander, 2010; Karasti, 2014; Reed, 2008; Urton and Murray, 2021) and result in projects that are well-suited to community needs and well-being (Frediani and Boana, 2012; Toukola and Ahola, 2022).

Co-design is a particular type of participatory design approach whereby expert designers and laymen can work together in collective creative ways throughout the design process to achieve a shared design goal (Sanders and Stappers, 2008). Wates et al. (2014) divided the urban design process into steps, ranging from initiation to maintenance. Inclusion of citizens in each step of the process is favoured for the development of a high-quality urban public space (Žlender et al., 2021). Stakeholders can negotiate the project's value creation, have common understanding and mitigate major uncertainties resulting from lack of information (Liu et al, 2019; Williams et al., 2019). However, in traditional urban design practices citizens have limited scope to take part actively in the design initiation and generation stage (Chowdhury and Schnabel, 2020). The process faces numerous challenges, such as the limitation in the number of participants, the lack of representativeness and especially the lack of shared motivation and (perceptual) understanding (Gordon et al., 2017; Krek, 2005; Tenbrink et al., 2014). Hence, most of the participatory approaches are limited to consultation that, although legitimate and informative, regularly leads to narrow involvement of the public, absence of meaningful deliberation, and limited influence of participants in decisions (Calderon, 2020; Faliu et al., 2018).

To facilitate the participatory approaches in urban design, researchers have focused on ways to increase equal interactions and engagement between participating parties by improving the methods and tools that facilitate each urban design process. Traditionally, urban design methods rely on verbal design representations, digitally produced images or three-dimensional artefacts (Bannon et al, 2018). However, these techniques provide a static and often rudimentary representation of the environment (Shr et al., 2019). As a result, the lack of ability to perceive the design and understand the implications of different decisions hinder non-expert citizens in the feeling of control and increased influence in the decision-making process. According to recent empirical findings, digital tools can assist the co-design process by improving communication efficiency, transferring knowledge, enhancing non-professionals understanding and engaging more participants to offer their opinions (Jutraz and Zupancic, 2015; Toukola and Ahola, 2022).

The emergence of main-stream Virtual Reality (VR) technologies have changed how environmental processes are communicated and perceived (Birenboim et al., 2021; Klippel et al., 2021). Users experience the same agency as in the physical world and perceive and interact with digital objects by performing gestures that are natural to them. Consequently, designers and citizens ground their understanding not exclusively in data and traditional techniques but in embodied experiences. Extending VR to Immersive-VR (IVR), provides the user with a real-time interaction with the design and therefore ensures, to some extent, a real sense of presence. Hence, it has been argued that as participants are more engaged with the environment provided in IVR, it activates their perception, cognition, and emotion, and participants therefore can make choices that better resemble their stated preference while allowing control over the experimental conditions (Chowdhury and Hanegraaf, 2022; Mokas et al., 2021; Mourtadis and Hassan, 2020).

To date, research on how the use of (I)VR tools for urban design can involve citizens as collaborators to the design process is only limited. Most examples show how computer tools may be used for visualizing the new development and not for a constructive process of continuous public participation (Faliu et al., 2018; Hanzl, 2007). Therefore, through an experimental study, we aim to investigate how an IVR tool can be developed and used for participatory design of healthy public spaces. The research considers a central public plaza in Eindhoven, where a large-scale regeneration project will transform the station area into a highly densified urban mix-used area. Within this scope, the paper reports on insights from users on the developed application for preferences, user requirements and features.

2 Materials and Method

2.1 IVR participation tool

An Immersive Virtual Reality (IVR) prototype application, called CoHeSIVE, is developed for designing healthy public spaces. The application includes an innovative methodology to incorporate intuitive design decisions from co-designers. The IVR interface is scripted in game-engine software 'Unity3D'. It allows the users to adapt a given base level scenario according to their preferences by altering the attribute profile. Base level design scenarios are pre-composed with different physical design attribute combinations. Based on the review of the descriptions from a participatory workshop among experts and citizens and the literature (Kim et al., 2020; Liao et al., 2022; Mehta, 2014; van Vliet et al., 2020; Zhou et al., 2022), the developed application contains the seven most substantial attributes (that are suitable for IVR) and their corresponding levels (Table 1). Given the number of attributes and their levels, a total of 108 possible design scenarios can be made by the user. Users experience the virtual environments through a Head-Mounted Display (HDM). Using the controllers in combination with controller buttons, it is also possible to switch between a bird-eye and an egocentric eye-level viewpoint. Examples of a bird-eye and an egocentric perspective are shown in figure 1 and 2. The application automatically generates a new design scenario each time the user selects an alternative level for a particular attribute. A selection panel per attribute is shown sequentially, see figure 2. The user may not be satisfied with the result, based on his or her preference for a healthy environment, and again change levels of particular attributes, where the system regenerates a new design until the user is satisfied with the design. The application can run standalone or as a real-time collaboration platform via screen casting for better design decisions in the earlier stages of the design process, by means of an interactive design or for the assessment of multiple design possibilities in the virtual space.

Table 1. Attribute table

Attribute	Attribute levels		
	Base level	Level 2	Level 3
Tree presence	Few	Many	
Tree composition	Spread	Clustered	
Benches	Few	Many	
Grass coverage	None	Small	Large
Building height	High	Medium	
Lampposts	Few	Many	
Fountain	No	Yes	

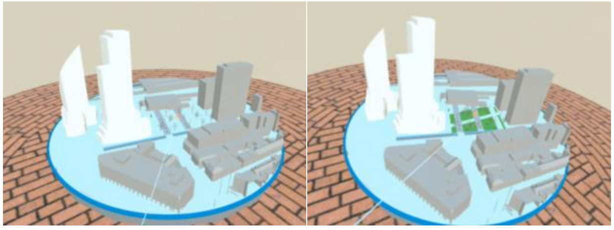

Figure 1. Simulated environment from the bird-eye perspective; a) default base scenario and b) example of designed scenario

Figure 2. Simulated environment from eye-level perspective with user interface to select; a) attribute panel and b) attribute level

2.2 Data and Software Availability

A virtual plaza was created with the use of the software ‘SketchUp 2022’, ‘Blender’ and ‘Unity3D’. The baseline design of the plaza was created in SketchUp, simulating the future station plaza of downtown Eindhoven. Arbitrary details that were not related to the attributes were excluded as much as possible to show an abstract representation of the surrounding plaza. For example, the buildings do not include coloured or textured facades. In addition, animated and sensory features are not present. Attributes were imported from 3D BAG database and SketchUp models available in the 3D Warehouse repository. The application made in Unity3D is exported as ‘apk’ file for the Oculus Quest for hardware.

2.3 Immersive experiment

An immersive experiment set-up is developed to leverage citizens and designers to participate together in an urban design discussion to understand individual’s preferences for new, not yet existing design scenarios and corresponding design implications. A workshop was held at the end of November 2022 to test and collect data on the prototype of the CoHeSIVE app on its features and user requirements. A total of nineteen participants participated, including graduate students and academics, VR developers, representatives of the municipality of Eindhoven and project developers in the case study area. The session started with an introduction of the project. Participants received a clear and standardized explanation to learn how to use the equipment. In addition, they were informed about potential risks involved using the technology, such as fatigue and nausea. The experiment followed by giving a design task to the participants (e.g. design the plaza), participants were briefed that their attribute selection is about a healthy pubic space design, meaning that their choices should be able to nudge them to do healthy activities or create an environment where they can relax. Participants could alternately try-out the pilot tool with an Oculus VR headset. After the try-out, a survey was handed out per participant to self-report the experiences and give feedback on CoHeSIVE app. The workshop was concluded with a plenary discussion on the suitability and suggested improvements on the features and user requirements for the further development of the application. The gathered data on user requirements are used for descriptive analyses to validate the so-far developed application.

3 Results

This section describes the experiences of participants with regard to the user requirements and features of CoHeSIVE app. The participants varied in terms of their previous experience with an IVR technology (55% is a frequent or regular user). Despite these differences, the participants overall hardly experienced negative consequences from using the VR headsets. Furthermore, the consequences that were reported were not perceived as extreme.

Overall, 84% of the participants think this pilot application can enable citizens to design an urban area/plaza. It was reported that the application is promising for the design and decision-making processes, determining place-specific attribute levels and understanding design implications (compared to 2D). However, to co-design healthy environments, the application should be able to integrate design trade-offs and notifications for the impacts of attribute choices on health and wellbeing. Table 2 lists the given suggestions to improve the user interface, the simulated world and the collaboration process. The suggestions are categorized on importance, based on the plenary discussion and the number of participants that indicated the same or similar suggestions.

Table 2. List of suggestions for 'CoHeSIVE' app features

Suggested improvement	F	I
Increase size of selection panel	UI	3
Addition of multiple viewpoints	UI	3
Addition of 'guideline'-menu	UI	2
Addition of 'attribute overview'-menu	UI	2
Addition of teleport button between viewpoints	UI	2
Allow movement of immersed participant (e.g., walking)	UI	2
Addition of 'no-preference' option	UI	1
Addition of 'save scenario' option	UI	1
Addition of AR or 360 degree pictures	IC	2
Enable tracking techniques (e.g., eye movement, emotional responses)	IC	1
Addition of materials and textures (e.g., building facades)	DS	4
Increase amount of attributes and attribute levels	DS	4
Addition of animated features (e.g., sitting and walking persons)	DS	3
Addition of weather conditions (e.g., sunshade)	DS	2
Addition of time changes (e.g., day, night)	DS	2
Support of multi-user in IVR	CP	4
Addition of pointer to help screen mirroring conversation	CP	1

Note: **F**eature (UI: User Interface; IC: Immersive Character, DS: Design Simulated world; CP: Collaboration Process); **I**mportance (1 = slightly, 4 = highly)

3.1 User interface (UI)

The overall feelings of participants on the user interface were 'positive', 'useful' and 'fun'. Figure 3 visualizes interactions of participants with the IVR tool. The overall feelings of participants on CoHeSIVE app were positive. Furthermore, 84% of the participants reported that they found the interface easy to use, of whom 17% even reported very easy. In addition, half the participants indicated that they did not need assistance or help with technical issues. The problems that were encountered by few participants, included difficulties to read because of the size of the text and buttons, blurry visuals, and challenging use of controllers.

More specifically, 67% of the participants reported that they found it easy to change the attribute profile. A total of seventeen designs were developed and submitted by the participants in this pilot. There were eleven different designs created. However, the differences in the designs were minimal, as there was consensus on main preferences (Table 3).

72% of the participants preferred to design the area by selecting amongst the given options, as was tested, over the possibility to design the VR environment freely themselves. Participants reported that selecting amongst options is easier, more controlled and enables efficient discussion and expectation management. 22% of the participants think that combining the existing method with the possibility to design the VR environment themselves (e.g., to make small adjustment freely in a created scenario) would improve the application.

Figure 3. Participants reacting and interacting with the VR headsets

Table 3. Selected attribute level

Attribute	Selected attribute levels (%)			
	Base level	Main preference	Second preference	Third preference
Tree presence	Few	Many (82.4%)	Few (17.6%)	
Tree composition	Spread	Spread (82.4%)	Clustered (17.6%)	
Benches	Few	Many (82.4%)	Few (17.6%)	
Grass coverage	None	Small (47.1%)	Large (47.1%)	None (5.9%)
Building height	High	Medium (76.5%)	High (23.5%)	
Lampposts	Few	Many (88.2%)	Few (11.8%)	
Fountain	No	Yes (88.2%)	No (11.8%)	

3.2 Immersive character (IC)

During the experiment, 89% of the participants felt they were interacting with the immersive environment, either due to the immediate change of attributes, feeling of presence or the realistic corresponding while moving. However, one participant mentioned that s/he was unsure if this interaction was more than by just using a computer (2D). Moreover, another indicated that the immersive character limits the interaction to have face-to-face discussion between users and designers.

During the experiment other virtual tools (i.e., an AR application and 360 degree photos) were also presented to participants. These tools were developed for other purposes such as medical education, biology education. They were presented in order to explain participants possible other capabilities of the technologies used. Based on that, two participants suggested to use aspects of AR or 360 degrees photos to discuss and brainstorm prior to or after the use of the provided 'CoHeSIVE' app, so the developed application can be used specifically for exploring the design possibilities in a more informed way. Two other participants indicated that the VR should enable tracking techniques, to measure eye and head movements or emotional responses of participants. These type of data can then be used to explore how participants' attention to certain objects in IVR influenced their choices.

3.3 Design of the simulated world (DS)

Two thirds of the participants found the visual information, such as building facades, not enough to understand the environment. Moreover, 39% indicated the visual information did not guide them for the design and decision-making process. The main problems encountered with the environment related to the abstract forms, neutral colours and a too small bird-eye overview to see details of changes.

Half of the participants reported that they could clearly see the difference between the attribute levels, especially for the water and greenery elements. The other half reported that for some of the attributes (i.e., building height and lamp posts) the differences were not impactful or difficult to find. 61% of the participants indicated that there could be more attributes and, or attribute levels.

3.4 Collaboration process (CP)

During the experiment the possibility to design together was not tested. However, participants could indicate if it was easy to communicate while being immersed (72% agreed), see figure 4. There were no reports made that stated they felt this was uneasy. Furthermore, participants were asked what should be added to the application in terms of facilitating co-design. Half of the participants indicated that the CoHeSIVE app should support multiple users being in the same environment. Other suggestions were; finding an optimum of the input designs which can be discussed by the participants or provide a pointer in the VR so when pointing to or selecting an option a non-immersed participant can follow the reasoning through a screen. An example of screen casting can be seen in figure 5.

Even though collaboration was not tested, one third of the participants stated that the pilot looks promising with regard to public participation. Participants reasoned that the CoHeSIVE app would greatly increase acceptance of (healthy) plans by citizens.

Figure 4. Conversation among non-immersed and immersed participants

Figure 5. Screen casting of immersed oculus

4 Discussion and Future work

The findings of this study clearly show that the general opinion of participants on usability of the prototype is promising. It was confirmed by the responses of the users that the implementation of this application can be used as a method to incorporate the opinions of end-users and help the decision-making process for a suitable design. Thus, 'CoHeSIVE' app allows citizens and designers to communicate in the design process s. In addition, each individual 'design' of the plaza is saved and stored and can be used to determine an amalgamated solution based on the average decisions. CoHeSIVE app as an IVR solution is an alternative and supplement to the traditional tools rather than as their substitute. Its usability should be explored and tested compared to the other digital and traditional tools. Next to that, due to the limited sample size, the user opinions do not represent the whole community. More research is needed to understand better which type of tools align with individuals preferences covering certain user groups, certain type of activities and a certain stage of the co-design process.

For this it would be important to improve the 'CoHeSIVE' tool for standardized application. Future experiments will be related with the study on visual fidelity, to find the balance between abstracting arbitrary details and a (photo-) realistic virtual environment. Furthermore, implementing animated or sensory features will enhance the understanding for a real-life situation, as it would give an indication of how the created design could be used. Moreover, being able to change the time and weather conditions, would make designing with attributes as 'building height' (sun blocking) and 'lampposts' (night visibility) more useful. In addition, future proposals will focus on the creation of a collaborative tool that can support virtual co-presence and co-location for a multi-user usage. Consequently, it is needed to provide multiple fixed view-points, so participants can communicate simultaneously based on different viewpoints. At last, the current pilot application does not allow to make trade-offs in the design. There are no constraints of resources, which means that utopias can be created with 'the more attributes, the merrier'. These utopias can in the real situation become unrealistic, for example based on financial limitations or other obligatory functions in the area (e.g., parking places). Developing CoHeSIVE app into a serious game application could enable participants to make trade-offs between attributes and attribute levels. This would create awareness on the constraints or limits a designer has to deal with.

5 Conclusion

To conclude, the current study investigated with a qualitative research the user requirements and features that are needed for a developed IVR application "CoHeSIVE". The study confirms that participants can interpret and design urban forms through the application. Furthermore, it showed the capability of the application to initiate a conversation between citizens and designers towards meaningful design outcomes. Accordingly, the CoHeSIVE app will not only enable understanding individuals' preferences, it can in the future become also a new form of a design-decision making platform where co-designers (non-experts and designers) can fully learn about the spatial (and possibly non-spatial) implications of planning and design decisions in a shared virtual environment. All in all, continuing this promising tool creates an opportunity to reshape the urban design process by improving interactions and information exchanges among urban designers and citizens, which are central in the move towards more healthy and liveable cities.

Acknowledgements: This study is part of the CoHeSIVE project (Co-design Healthy Public Spaces with Immersive Virtual Environments). This seed-fund project is funded by the alliance TU/e, WUR, UU, UMC Utrecht. Participants' consent was taken and the consent form was approved by the TU/e ethical board.

Author contribution: All authors have read and agreed to the published version of the manuscript.

References

Arnstein, S. R.: A Ladder of Citizen Participation. Journal of the American Planning Association, 35:4, 216–224, https://doi.org/10.1080/01944366908977225, 1969.

Bannon, L., Bardzell, J., and Bodker, S.: Reimagining participatory design, Interactions, 26:1, 26-32, https://doi.org/10.1145/3292015, 2018.

Birenboim, A., Ben-Nun Bloom, P., Levit, H., and Omer, I.: The Study of Walking, Walkability and Wellbeing in Immersive Virtual Environments, International Journal of Environmental Research and Public Health, 18:2, 364, https://doi.org/10.3390/ijerph18020364, 2021.

Calderon, C.: Unearthing the political: differences, conflicts and power in participatory urban design, Journal of Urban Design, 25:1, 50-64, https://doi.org/10.1080/13574809.2019.1677146, 2020.

Chowdhury, S. and Hanegraaf, J.: Co-presence in remote VR co-design, in: Proceedings of the 27th International Conference of the Association for Computer Aided Architectural Design Research in Asia (CAADRIA), 2, 465-474, https://doi.org./10.52842/conf.caadria.2022.2.465, 2022.

Chowdhury, S. and Schnabel, M. A.: Virtual environments as medium for laypeople to communicate and collaborate in urban design, Architectural Science Review, 63:5, 451-464, https://doi.org/10.1080/00038628.2020.1806031, 2020.

Evans-Cowley, J. and Hollander, J.: The New Generation of Public Participation: Internet-based Participation Tools, Planning Practice & Research, 25:3, 397–408, https://doi.org/10.1080/02697459.2010.503432, 2010.

Faliu, B., Siarheyeva, A., Lou, R., and Merienne, F.: Design and Prototyping of an Interactive Virtual Environment to Foster Citizen Participation and Creativity in Urban Design, in: Advances in Information Systems Development, edited by Andersson et al., Springer International Publishing: Cham, 55–78, https://doi.org/10.1007/978-3-030-22993-1_4, 2019.

Foth, M.: Participation, Co-Creation, and Public Space. The Journal of Public Space2, 4, 21–36, https://doi.org/10.5204/jps.v2i4.139, 2017.

Frediani, A. A., and Boano, C.: Processes for Just Products: The Capability Space of Participatory Design, in: The Capability Approach, Technology and Design, edited by Oosterlaken, I. and van den Hoven, J., Springer: London, 203–222, https://doi.org/ 10.1007/978-94-007-3879-9_12, 2012.

Gordon, E., Schirra, S., and Hollander, J.: Immersive Planning: A Conceptual Model for Designing Public Participation with New Technologies, Environment and Planning B: Planning and Design, 38:3, 505–519, https://doi.org/ 10.1068/b37013, 2011.

Hanzl, M.: Information technology as a tool for public participation in urban planning: a review of experiments and potentials. Design Studies, 28:3, 289–307, https://doi.org/10.1016/j.destud.2007.02.003, 2007.

Jutraz, A., and Zupancic, T.: Virtual worlds as support tools for public engagement in urban design, in: Planning support systems and smart cities, edited by: Geertman et al., Springer International Publishing: Cham, Lecture Notes in Geoinformation and Cartography, https://doi.org/10.1007/978-3-319-18368-8_21, 2015.

Karasti, H.: Infrastructuring in participatory design, in: Proceedings of the Participatory Design Conference - PDC '14, 141–150, https://doi.org/10.1145/2661435.2661450, 2014.

Kim, S., Kim, J., and Kim, B.: Immersive Virtual Reality-Aided Conjoint Analysis of Urban Square Preference by Living Environment, Sustainability 2020, 12:16, 6440, https://doi.org/10.3390/su12166440, 2020.

Klippel, A., Sajjadi, P., Zhao, J., Wallgrün, J. O., Huang, J., and Bagher, M. M.: Embodied Digital Twins for Environmental Applications, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., V-4-2021, 193–200, https://doi.org/10.5194/isprs-annals-V-4-2021-193-2021, 2021.

Krek, A.: Rational ignorance of the citizens in public participatory planning, in: Proceedings of the 10th Symposium on Information-and Communication Technologies (ICT), Urban Planning and Spatial Development and Impacts of ICT on Physical Space, CORP: Vienna, 5, 420, 2005.

Kunze, A., Halatsch, J., Vanegas, C., Jacobi, M. M., Turkienicz, B., and Schmitt, G: A Conceptual Participatory Design Framework for Urban Planning, in: Proceedings of eCAADe 2011, Respecting Fragile Places: Ljubljana, 895–903, https://doi.org/10.52842/conf.ecaade.2011.895, 2011.

Liao, B., van der Berg, P.E.W., van Wesemael, P.J.V., and Arentze, T.A.: Individuals' perception of walkability: Results of a conjoint experiment using videos of virtual environments, Cities, 125, 103650, https://doi.org/10.1016/j.cities.2022.103650, 2022.

Liu, Y., van Marrewijk, A., Houwing, E.J., and Hertogh, M.: The co-creation of values- in-use at the front end of infrastructure development programs, International Journal of Project Management., 37:5, 684–695, https://doi.org/10.1016/J.IJPROMAN.2019.01.013, 2019.

Mehta, V.: Evaluating Public Space, Journal of Urban Design, 19:1, 53-88. https://doi.org/ 10.1080/13574809.2013.854698, 2014.

Mokas, I., Lizin, S., Brijs, T., Witters, N., and Malina, R.: Can immersive virtual reality increase respondents' certainty in discrete choice experiments? A comparison with traditional presentation formats, Journal of Environmental Economics and Management, 109, 102509, https://doi.org/10.1016/j.jeem.2021.102509, 2021.

Mouratidis, K., and Hassan, R.: Contemporary versus traditional styles in architecture and public space: A virtual reality study with 360-degree videos, Cities, 97, 102499, https://doi.org/10.1016/j.cities.2019.102499, 2020.

Reed, M. S.: Stakeholder participation for environmental management: a literature review, Biological Conservation, 141:10, 2417–2431, https://doi.org/10.1016/j.biocon.2008.07.014, 2008.

Sanders, E. B.-N. and Stappers, P.J.: Co-creation and the New Landscapes of Design, Co-design, 4:1, 5-18, https://doi.org/10.1080/15710880701875068, 2008.

Shapely, P.: Planning, Housing and Participation in Britain; 1968–1976, Planning Perspectives, 26:1, 75–

90, https://doi.org/10.1080/02665433.2011.527550, 2011.

Shr, Y. H.. J., Ready, R., Orland, B., and Echols, S.: How do visual representations influence survey responses? Evidence from a choice experiment on landscape attributes of green infrastructure, Ecological Economics, 156, 375-386, https://doi.org/10.1016/J.ECOLECON.2018.10.015, 2019.

Steen, M.: Co-Design as a Process of Joint Inquiry and Imagination. Design Issues, 29:2, 16–28, https://doi.org/10.1162/DESI_a_00207, 2013.

Tenbrink, T., Hölscher, C., Tsigaridi, D., and Dalton, R.: Cognition and communication in architectural design, in: Montello, D.R., Grossner, K., Janelle, D.G. (eds.) Space in Mind: concepts for Spatial Learning and Education, edited by Montello et al., MIT Press: Cambridge, MA, 263–280, https://doi.org/10.7551/mitpress/9811.003.0014, 2014.

Toukola, S., and Ahola, T.: Digital tools for stakeholder participation in urban development projects, Project Leadership and Society, 3, 100053, https://doi.org/10.1016/j.plas.2022.100053, 2022.

Urton, D., and Murray, D.: Project manager's perspectives on enhancing collaboration in multidisciplinary environmental management projects, Project Leadership and Society, 2, 100008, https://doi.org/10.1016/j.plas.2021.100008, 2021.

Van Vliet, E., Dane, G., Weijs-Perrée, M., van Leeuwen, E., van Dinter, M., van den Berg, P., Borgers, A. and Chamilothori, K.: The Influence of Urban Park Attributes on User Preferences: Evaluation of Virtual Parks in an Online Stated-Choice Experiment, Int J Environ Res Public Health, 18:1, 212, https://doi.org/10.3390/ijerph18010212, 2020.

Wates, N., Brook, J., De Lange, M., De Waal, M., Salter, J.D., Campbell, C., Journeay, M.,Sheppard, S.R.J., Yeang, L.D., Jutraz, A., Zupancic, T., Slotterback, C.S., Senbel, M.,Church, S.P., Panagopoulos, T., Andrade, R. dos R., Barreira, A.P., Luigi, M., Massimiliano,M., Aniello, P., Gennaro, R., Virginia, P.R., Fonseca, D., Valls, F., Redondo, E., Villagrasa,S., Turan, S.Ö., Pulatkan, M., Beyazlı, D., Özen, B.S., Hanzl, M., Saad-Sulonen, J.C., Horelli,L., Ben-Joseph, E., Ishii, H., Underkoffler, J., Piper, B., Yeung, L., Köninger, A., Bartel, S.,Ahn, H.-C., Jacobi, M., Halatsch, J., Kunze, A., Schmitt, G., and Turkienicz, B.: The Community Planning Handbook: How People Can Shape Their Cities, Towns and Villages in Any Part of the World. Routledge, London, https://doi.org/10.4324/9781315848716, 2014.

Williams, T., Vo, H., Samset, K., and Edkins, A.: The front-end of projects: a systematic literature review and structuring, Prod. Plann. Control, 30:14, 1137–1169, https://doi.org/10.1080/09537287.2019.1594429, 2019.

Zhao, Y., van den Berg, P.E.W., Ossokina, I.V., and Arentze T.A.: Individual Momentary Experiences of Neighborhood Public Spaces: Results of a Virtual Environment Based Stated Preference Experiment, Sustainability 2020, 14:9, 4938, https://doi.org/10.3390/su14094938, 2022.

Žlender, V., Erjavec, I.S., and Marušić, B.G.: Digitally Supported Co-creation within Public Open Space Development Process: Experiences from the C3Places Project and Potential for Future Urban Practice, Planning Practice & Research, 36:3,247-267, https://doi.org/10.1080/02697459.2020.1829286, 2021.