Virtual reality and traditional design methods in the Egyptian context

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Abstract: Urban planning and design research reveal the significance of virtual reality (VR) as a visualization tool in exploring user experience. This article used two public spaces of two Egyptian universities as a case study on the efficiency of VR in understanding user experiences. We randomly examine the urban studies literature to identify the essential elements that should be conveyed. Using a conventional method and a VR headset, 150 participants viewed the design and answered a questionnaire. From the descriptive and analytical analysis of the results, the findings reflect the participants' perspective when comparing the virtual reality method with the traditional way. The results also demonstrate that VR improves understanding of users' experiences while moving through urban forms. The concluding remarks shed light on how the VR tool can be used to understand urban planning and designs.

1. INTRODUCTION

Information communication technologies (ICTs) have become more involved in our daily lives. The 2030 Agenda for sustainable development demonstrated that ICT had become a tool to encourage socio-economic development [1]. Hence, it is significant to combine the new technologies and methods used in civic participation [2]–[5]to encourage citizens to participate in urban development. Research conducted many initiatives to discover a technological technique to improve the urban participatory process. The visualization techniques generated the most exciting responses [4].

Many alternative methods are available for investigating the gap between users' and designers' preferences. A solution to this gap is proposed in previous studies about European and US cities [14], [16], [17]. Grounded research orients the knowledge toward investigating the users' preferences from one side and designers' thinking and acting on the other [18]–[20]. However, it is interesting whether the gap between these two sides still holds.

This research tackles the challenge in Egypt's urban spaces that become no longer attractive to the people and does not fit their needs after the growth of digital technologies. Moreover, there is a miscommunication between citizens and urban designers. The designer still uses old techniques to represent urban ideas, such as two-dimensional plans, maps, and three-dimensional simulated images. These tools are ineffective in transferring the design ideas to the users, and it's difficult for them to understand the design from these techniques, especially for users with no educational background or outside the architecture field. So, the urban spaces are designed based on the previous design experience or according to the architect's analysis and understanding of the user's needs and behavior. Leaving decision-making to the designers alone would have many consequences; therefore, a partnership between them is necessary. The current research aims to minimize the gap between participants and designers in the design process. The purpose here is threefold. This study aims first to use novel urban design communication methods adapted to the new social, technological, and spatial context in which we live. Second, this paper investigates the effectiveness of the VR method in understanding the implementation of urban design in Cairo. Third, this study examines the efficacy of VR compared to traditional methods to determine if VR complements or substitutes the conventional approach.

2. THEORETICAL BACKGROUND

Previous literature has shown that the participatory process applies the citizen-centric approach. It is one of the significant features in achieving a successful sustainable urban development[18]–[20], and it also plays a vital role in creating smart cities, as it allows users to feel more involved in developing their country[2], [19]. Additionally, it improves the transparency democratic decision-making process[2], [3], [19], [21]. Therefore, this process can help the organizations to cope with the problems, know about residents 'welfare and thoughts[2], and create more creative and new concepts, to improve urban quality[20].

Several questions regarding the contribution of VR methods to the design of public spaces remain to be addressed. Integrating VR into the planning process has many benefits. It increases the overall quantity quality and allows the diversity of participation, as it attracts the younger generations to participate in the planning projects[5], [22]. VR has been verified as an appropriate technical means to improve public motivation and satisfaction in urban decision-making [23]–[25]. Moreover, a study suggests that VR could be more effective on women than on men in enhancing their participation[26].

VR offers participants a high level of involvement, translocation, concentration and presence than laptops [27], as the participants no longer look via a screen but become part of the virtual world[28], as they are surrounded by data in 3-dimensional (3D) models[8], [27]. Therefore, it allows partakers to see in an immersive way the changes and actions that occur in the environment [4] and enable them to give comments and ideas for modifications [22], [27].

The VR method improves memory recall as it helps the participants to remember more elements of the proposed design than people who viewed the design on computer screens [22], [27], [29]. Moreover, memory recall increased by 50% from 2D video to 3D IVR [22]. However, immersion was not effective regarding the recall accuracy, as there was no difference in the recall accuracy between the two devices [27].

In a study held by Kim (2005), he identifies that the 3D simulation tool delivers better data to the participants in most questions than the 2D method. He affirms that the only questions that show no difference between the two methods are; the ground slope changes, main location entrance, different species of the tree, location of water features, and benches [30]. Another study sustains that estimating the approximate measurements of the elements expressed by the traditional methods was more accurate than the VR method [31].

A study works on the perceived visual quality between VR, AR, and traditional methods. The findings indicate that the recognition of the color and texture was better in the VR method than in a conventional way. Also, VR and AR introduce the colours and textures more realistic and vividly [32].

A previous study found that the level of public interaction increased by the IVR simulations, as the number of comments and questions made by the participants after viewing the proposals by 3D IVR increased by 271% and 55%, respectively, as compared to 2D video. Additionally, the emotional responses increased by 60% from 2D video to 3D IVR. Many participants documented that the IVR had a better ability to allow them to engage with their surroundings, understand the human scale, and facilitate navigability of the design proposals than the traditional methods [22].

Calderon-Hernandez et al. (2019) perform a comparative analysis between the 2-dimensional and VR methods of the same structure to measure the academic performance of the users in two ways[33]. A previous case study measures the effectiveness of using the VR method in the public participation process in redesigning public parks and compares it to the point of the 2D method[25]. A study examined the VR method in the architectural competition's evaluations of urban mobility[15], [34]. VR was read as a teaching method in the courses related to urban design[24].

Jiang et al. (2017) developed a study using additional sensory stimuli to the online VR simulation of Piazza Vittoria in Naples, Italy. They allowed participants to examine the urban sound environment, thus creating a natural, immersive environment and encouraging public participation[35]. An earlier experiment created a bridge crossing a highway in Ghent, Belgium, using a VR tool to determine how sound and visuals affected humans[36]. The analysis of these previous studies indicates that VR presented a more engaging and interactive environment and improved the understanding of an architectural project.

A further question is whether the traditional methods investigate the pros and cons of conventional and VR methods in the design process of public spaces in Egypt. This study offers a test VR in the Egyptian context and answers the research question. A systematic and theoretical analysis is required to investigate the difference between the two methods in urban literature.

3. METHODS AND MATERIALS

To achieve the research goals, primary and secondary data were collected from various sources. The preliminary

data follows the quantitative approach collected from the questionnaire; to compare the participant's responses after using the traditional and virtual reality methods. The secondary data was collected through different types of documents and earlier researchers. Moreover, the results follow the descriptive and analytical approaches.

Questionnaire[1] was designed using the interface powered by Google Forms. It consists of four parts. The first part is the personal information. The second part aims to measure the quality of the visual presentation of the design in terms of the colour and texture of the material. The third part measures participants' level of understandability of the invention, their sense of place, and their level of interaction. Finally, the fourth part aims to measure participants' cognition. While in the survey taken after viewing the design with a VR headset, there is an extended part to identify which visualization method is preferred by participants when presenting the plans to motivate public participation in the urban process to improve the cooperative work between planners and users.

The questionnaire was started from the 26th of September 2021 to the 26th of October 2021. The sample size has been calculated using the following equation[37]:

$$(1) n = \frac{z^2 p(1-P)}{d^2}$$

Where:
n is the sample size,
d is the adequate margin of error,
Z is the level of confidence which is most often equal to 95% and 1.96, and
P is the estimated number of the population.

This research used a random sampling size. This type has the greatest freedom from bias. Moreover, the arbitrary sampling size gives an equal probability of

inclusion in the sample for the population [38]. Therefore, the survey targeted participants from different disciplines. The experiment was held in the faculty of `medicine at Ain Shams University, in the HeliolidoClub, Modern University for Technology and Information (MTI), and in the Egyptian Atomic Energy Authority (EAEA).

A total number of 150 participants took part in the experiment. We divided them into two groups to prevent biases and to have an accurate result. Each group was exposed to two different designs and two other

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[1]The questionnaire questions can be reached using the link: https://forms.gle/vgkDJUFirbHjn4yJ6,
https://forms.gle/qA5SkX58z4vE1BKD9

presentation methods (Table 1). The research was composed of 67 males and 83 females. There were 65 architects (30 males and 35 females) and 85 from other disciplines (37 males and 48 females).

Fig1: Some pictures of BUE that were presented to the participants using the traditional method

Group A consist of 71 participants; the urban space design of The British University in Egypt (BUE) is presented to them with the traditional method(Fig. 1), and then the urban space design of Ain shams University is presented to them with the 3D VR headset. Moreover, 66 were aged 20 to 25, 51 participants were aged 26 to 35, and 33 were above 35. While Group B consisted of 79 participants, the presentation methods were switched, as they viewed the Ain shams urban space in the traditional way

Fig. 2, and BUE urban space with the VR headset. After each presentation method, the participants were asked to answer the survey so that each participant answered questionnaire twice.

Fig 2 : Some pictures of Ain Shams University that were presented to the participants (traditional method)

TABLE 1: Classification of groups

Respondent Group	No. of participants	Design	Method
Group A	71	BUE	Traditional
		ASU	3D VR headset
Group B	79	ASU	Traditional
		BUE	3D VR headset

4. RESULTS

At the end of the study, we delivered two questionnaires from the 150 participants after viewing the designs using the traditional method (Group 1) and the VR headset method (Group 2). Then the data was collected from the two groups and analysed by correlation matrix using the SPSS to determine whether there was a difference between the two techniques. The correlation matrix revealed that there is a significant positive correlation between the two methods in the questions that related to the quality of the visual presentation and some questions that related to the level of understanding, such as the boundary of the site, ground slope changes, sizes of the buildings, heights of the existing buildings, and locations of the main entrance of the buildings.

Moreover, The locations of pedestrian entrances to the place, the number of stories of surrounding buildings, trees, species of trees, and the sites of green areas. Additionally, the questions that measure the sensitivity of the place by the approximate measurements of urban space and the width of the pedestrian path. Finally, the question measures the level of interaction of the participants, and the statement measures the efficiency of the techniques. This positive correlation means no difference in these points between the two presentation methods.

There are eight questions out of 25 questions that are selected to be statistically analysed. These questions didn't show a significant correlation difference between the two techniques. This means that the two presentation methods differ in understanding these points. These questions are related to the level of understanding of the ground slope changes in the site, the place of water features and benches and how the space looks in reality. Moreover, the question that measures the area's sensitivityindicates the approximate measurements of the courts and flower box size. Additionally, the questions measure memory recall, free recall and recall accuracy.

The results in Fig. 1indicate that viewing the design through the VR method is better for understanding the location of the water features (Q.15), benches (Q.16), and how the space looks in reality (Q.17). While the traditional method is better in understanding the changes of the slopes in the ground (Q.6).Comparing the responses of the users in the two approaches, using student t-test for evaluating the significant difference (two-tailed) which obtained below the standard threshold of 0.05. The results show asubstantial difference in Q.15, 16, and 17.

Examining the results of the questions that measure the user's sense of the place by asking about the approximate sizes of the benches and flower box. (Table 2) illustrate that the results in Q.19 show no difference between the two techniques. However, Q.20 indicates that the traditional method is better than the VR method in identifying the approximate size of the flower box. By applying the student T-test to find if there is any significant difference between the two methods or not, we found that there is a substantial difference in the Q.20.
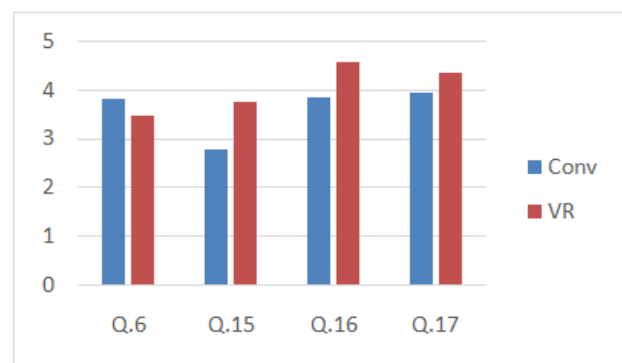
Fig3: Results of the two methods

TABLE2: The percentage of the estimated dimensions

	Traditional method			VR method		
	Near real	Far away	Not identified	Near real	Far away	Not identified
Benches (Q.19)	48%	35%	16%	48%	30%	21%
Flower box (Q.20)	60%	20%	20%	34%	32%	34%

To measure the participants' cognition levels, we used two different ways. First(Q.23) was the free recall, where participants were asked to write down the elements they remembered from the design. The results statistically and by counting the number of factors listed by the participants revealed that those who viewed the design through the VR method remembered more features and details than those who used the conventional method. The second (Q.24) was recall accuracy, measured by showing participants seven pictures and asking them to choose what they thought existed in the design. Fig.5shows that the number of participants who got the four images right increased in the group with the VR method. Comparing results using the student T-test indicates a significant difference in free recall and recall accuracy. This affirms that the VR method increased the participants' cognition

level in the planning scenarios compared to the conventional method.

Results display a significant correlation in the conventional group between gender and questions that measure the perceived quality of the visual presentation (Q.2 to Q.4)and the questions that recognize the level of understanding of the design (Q.5, Q.7 to Q.10, Q.13, 14, 16, 17). Additionally, the questions measure the sense of the place (Q.18, 19), the level of interaction, and the efficiency of the techniques (Q.22, 25,respectively).The females were superior to males in all questions except Q.18 and Q.22. However, there was no significant correlation between gender and these questions when the users viewed the designs through virtual reality. Still, there was a slight difference between the responses of the females and males, where the males were better.
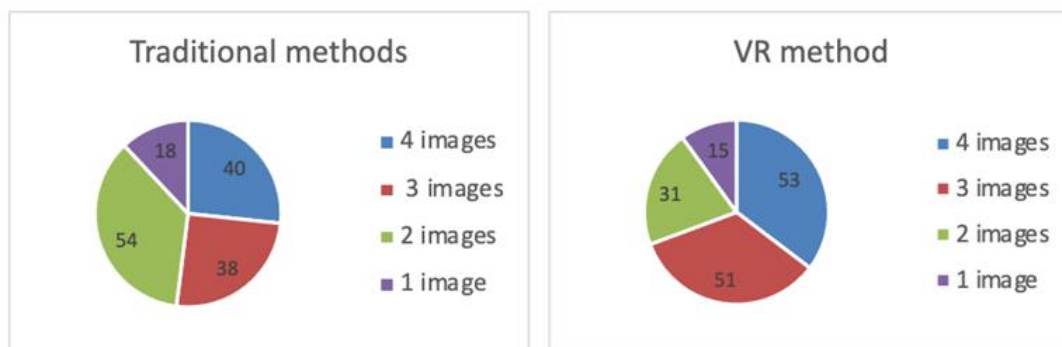

Fig4: Recall the accuracy of the participants in the two methods

In the present study, we found that in Q.10, there was no significant correlation with age in the traditional method group. In contrast, in the virtual reality group, there was a significant correlation with age, where the younger participants were more understanding than the adults. On the other hand, Q.15 and Q.20 show a significant correlation with age in the traditional method group. In contrast, there was no correlation with age in the group VR method. There was a slight difference between responses; the participants from age 20 to 35 responded better in the VR than the participants above 35. In Q.15, people of all ages were more understanding of the VR method, while in Q.20, participantswere nearer to the approximate measurements from the traditional method.

Analysing the responses by positions (architects and others), we observed that in the traditional method group ,there was a significant correlation between posts and Q.2 in the section measuring the visual quality and some questions in the part that measures the level of people's understanding of the design (Q.5, 9, 10, and Q.12 to 14), Q.19 and Q.25. However, there was no significant correlation between these questions and positions in the

virtual reality environment. On the other hand, there was no significant correlation between classes and Q.6, Q.15, and Q.18 in the traditional method. At the same time, there was a substantial correlation in people's responses to the VR method. The finding illustrates that the others responded better than the architects in all the questions except Q.18 and 19,which asked about the dimensions.

5. DISCUSSION

Scanning relevant literature revealed that broad attention had been increased to virtual reality (VR) methods in the urban design [6]. VR is a device for visualisation and communication [7] that brings the digital environment and the users together [8]. It is defined as a simulation environment created by devices and computers that lets humans visualise and cooperate with computers and data, gives them the feeling of being mentally immersed and present in the simulation as if they are in the actual world [6], [8], [9].

Several pieces of research paid attention to the software, methods, and techniques of VR to investigate public places [10], [11]. Group of research focuses on the

ecological systems and [11] infrastructure, while others tackle the visualization laboratory [12] and design process using technology [13], [14]. However, a limited number of studies have focused on VR and users' preferences and how those preferences could affect the decision-making process of urban space design [15]. Besides, no study has yielded our knowledge investigating the users' preferences for VR in Egypt's public spaces.

Regarding the first part of the questionnaire that measures the quality of visual representation of the two methods, the correlation matrix indicates that there was no difference between the two methods, in contradiction to Gang et al. (2020)[32].The results of the research provide that the understanding of the location of water features and benches was superior in the VR method, in opposition to the effects of Kim (2005) [30], that identified that there is no difference between the two methods in these two points, this may be for the modifications of the technologies. The understanding of the changes in the ground slope in the design was a better understanding of the traditional method. This indicates that the stairs and ramps were more apparent in the conventional method, as the VR method can make some distortion, which results in previous research effects by Kim (2005) [30].

The level of imagination of how the urban space looks increased in the VR method; this may be due to the high level of immersion the VR headsets gives to the participants. Regarding the questions that measure the user's sense of the place, the estimation of the approximate measurements was more accurate in the traditional method than the VR method, in line with Gomez et al. (2021)[31]. This can affirm that the traditional method was more precise than the VR method or was affected by the limited functions of the VR headset used in this study. Our results show no difference between the two methods in the level of interaction and this outcome in contrast to M. Meenar and J. Kitson(2020) [22].

The findings confirm what was expressed by other researchers [22], [27], [29], that the free memory recall shows a significant difference between the VR method and the traditional method, as the number of objects remembered by the participants increased in the group who experienced the design through VR method. This means that the VR method provides the participants with a high level of immersion that improves the mental process, the sense of presence, and space perception. This indicates that this method was more precise and vivid, as mentioned in the literature review. However, the results of

the recall accuracy did not agree with Van Leeuwen et al. (2018) [27], as our results show a significant difference in recall accuracy.

Analysing the results by gender in the VR group displays a slight difference between males and females, where males were better at understanding the design through the VR method than females. This is opposite to the findings of Zhu et al.(2020) [26].These results may be due to the characteristic differences in the use of technologies, where the males are more attracted to the new technologies than the females. The younger participants better understood the design of the VR method than the adults.This returns to the fact that the younger participants were born in the digital age and are adapted to the technology and gaming approaches. At the same time, the adults lacked experience in using the new techniques corresponding to [5], [22].

Comparing the positions illustrates that the others responded better to the VR technique than the architects. This may be due to computer-aided design (CAD) and 3DMAx being the primary technological tool of architects. In contrast, the VR tool nowadays has become a fun tool in many gaming applications that people use. Moreover, the architects responded better than others to the questions about the approximate dimensions, so the architects had more knowledge of the dimensions of the elements in urban space.

Because the authors were unaware of the crowd sourcing approaches to investigate the gap between the traditional and VR methods, we decided to use a survey tool using Google Forms. The limitations of the present study naturally include the balanced distribution of the sample size among females (83) and males (67) to compare the effects of gender on our results effectively. The unbalanced samples were also recognised by their ages, with a high presence of responses from 20–25year-olds. An obvious challenge with this research method is that the VR headset used in this study only lets you see. Urban and landscape architects need a multi-sensory process to be more accurate.

6. CONCLUSION

The relevance of virtual reality (VR) as a visualisation tool in participatory processes has been discovered via urban planning and design research. The effectiveness of virtual reality in understanding urban spaces was investigated in this research utilising two case studies of urban areas. This research conducted a 150-person survey launched in many places. Using a traditional approach and a VR headset, the survey participant saw the design

and then completed a questionnaire prepared following the literature research to determine the main parts that should be conveyed via the presentation methods.

As a result of enabling individuals to recall and envisage more things from the design, the final comments provided further insight into how virtual reality might be utilised in urban planning and design in general. When comparing the virtual reality approach with the conventional method, the findings represent the participants' opinions on the matter, according to the descriptive and analytical examination of the data. The results also suggest that virtual reality facilitates understanding urban structures, but it cannot substitute the traditional method. Both VR and traditional methods can be used in the urban participatory process.

The contributions here should be of broad interest to urban design, ethnography, and computer science. The first main contribution proposed in this field is investigating the gap between users' preferences and the design actions previously taken to overlock the users' needs.

Building on the research limitations, this research suggests using a crowdsourcing approach to investigate broader users of VR and traditional methods. Besides, examining other contexts and comparing the results to the Egyptian cases can validate the present research results and offer new insight into the effect of the case study condition on using conventional methods.

ACKNOWLEDGEMENT

Declarations

The current work applies compliance with ethical standards in the following:

- **Disclosure of potential conflicts of interest:** The authors of the present study declare that they have no conflicts of interest.
- **Research Involving Human Participants and or Animals:** There is no research involving animals. Regarding survey, the researchers of the current study used volunteer participants (150 participants) Spring 2021.
- **Data collection and analysis:** The authors confirm that the results presented in this study were mainly prepared for this research during the years 2020 and 2021. There is no similarity in research design or results that could be found between any previous research conducted by the authors of the present work or anybody else.
- **Ethics Statement:** Approval for the study was not required in accordance with local/national legislation. The authors of this research confirmed that an informed consent statement is provided for the 150 students who showed up willing to engage in our ethnographic research. The identity of these participants is kept confidential. All volunteer participants indicated their desire to participate in this research before completing the survey form, and we have verified that this is the case. As a result, informed permission was gained from each and every participant in the research.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the present authors affiliated to Ain Shams University. The authors also confirm that Ain Shams University does not establish Institutional Review Board (IRB) at the moment of conducting the current study.

Availability of data and materials

All data were provided in this manuscript. Besides, the survey results can be found in the following link https://drive.google.com/file/d/15RbuWngEdAHadYndIzT2KH5JyqYQSTlO/view?usp=sharing.

Competing interests

The authors confirm that there is no conflict of interest

Funding

Authors' contributions

AE, the first author, has conceptualized the research idea and conducted the research meted. AE the second author has write the research findings conclusions and reviewed the entire text. SA has analyzed the data and reviewed the results and the entire text. All authors have approved the data and the research findings.

REFERENCES

[1] S. E. Bibri and J. Krogstie, "A scholarly backcasting approach to a novel model for smart, sustainable cities of the future: strategic problem orientation," *City, Territ. Archit.*, vol. 6, no. 1, 2019, doi: 10.1186/s40410-019-0102-3.

[2] N. Afzalan, T. W. Sanchez, and J. Evans-Cowley, "Creating smarter cities: Considerations for selecting online participatory tools," *Cities*, vol. 67, no. May, pp. 21–30, 2017, doi: 10.1016/j.cities.2017.04.002.

[3] P. Neirotti, A. De Marco, A. C. Cagliano, G. Mangano, and F. Scorrano, "Current trends in smart city initiatives: Some stylized facts," *Cities*, vol. 38, pp. 25–36, 2014, doi: 10.1016/j.cities.2013.12.010.

[4] M. Sanchez-Sepulveda, D. Fonseca, J. Franquesa, and E. Redondo, "Virtual interactive innovations applied for digital urban transformations. Mixed approach," *Futur. Gener. Comput. Syst.*, vol. 91, pp. 371–381, 2019, doi: 10.1016/j.future.2018.08.016.

[5] G. Stauskis, "Development of methods and practices of virtual reality as a tool for participatory urban planning: a case study of Vilnius City as an example for improving environmental, social and energy sustainability," *Energy. Sustain. Soc.*, vol. 4, no. 1, pp. 1–13, 2014, doi: 10.1186/2192-0567-4-7.

[6] Z. Li, Y. N. Cheng, and Y. Y. Yuan, "Research on the application of virtual reality technology in landscape design teaching," *Kuram ve Uygulamada Egit. Bilim.*, vol. 18, no. 5, pp. 1400–1410, 2018, doi: 10.12738/estp.2018.5.037.

[7] D. Hill, B. H. George, and T. Johnson, "How virtual reality impacts the landscape architecture design process during the phases of analysis and concept development at the master planning scale," *J. Digit. Landsc. Archit.*, vol. 2019, no. 4, pp. 266–274, 2019, doi: 10.14627/537663029.

[8] A. Shakibamanesh, "Improving results of urban design research by enhancing advanced semiexperiments in virtual environments TT - ," *Int. J. Archit. Urban Plan.*, vol. 24, no. 2, pp. 131–141, 2014, [Online]. Available: http://ijaup.iust.ac.ir/article-1-204-en.html

[9] U. Nassar, "Green Cities : a Path to Sustainability The use of new visualization Tools to Enhance Public Participation in Riverfronts ' Landscape regeneration Case Study of Nile riverfront in Cairo," no. December, p. 2011, 2011.

[10] K. Mouratidis and R. Hassan, "Contemporary versus traditional styles in architecture and public space: A virtual reality study with 360-degree videos," *Cities*, vol. 97, no. June 2019, p. 102499, 2020, doi: 10.1016/j.cities.2019.102499.

[11] Y. Ma, J. Wright, S. Gopal, and N. Phillips, "Seeing the invisible: From imagined to virtual urban landscapes," *Cities*, vol. 98, no. December 2019, p. 102559, 2020, doi: 10.1016/j.cities.2019.102559.

[12] D. Fisher-Gewirtzman, "Perception of density by pedestrians on urban paths: an experiment in virtual reality," *J. Urban Des.*, vol. 23, no. 5, pp. 674–692, Sep. 2018, doi: 10.1080/13574809.2018.1444471.

[13] R. Potts, L. Jacka, and L. H. Yee, "Can we 'Catch 'em All'? An exploration of the nexus between augmented reality games, urban planning and urban design," *J. Urban Des.*, vol. 22, no. 6, pp. 866–880, Nov. 2017, doi: 10.1080/13574809.2017.1369873.

[14] B. Shannon and T. Banerjee, "Dialectic of design, rhetoric of representation," *J. Urban Des.*, vol. 22, no. 3, pp. 326–346, May 2017, doi: 10.1080/13574809.2016.1273743.

[15] H. Schrom-feiertag, F. Lorenz, G. Regal, and V. Settgast, "Augmented and Virtual Reality Applied for Innovative , Inclusive and Efficient Participatory Planning," *Proc. 7th Transp. Res. Arena TRA 2018*, pp. 1–10, 2018.

[16] N. Ellin, "Life support: Nacirema redux," *J. Urban.*, vol. 1, no. 1, pp. 47–55, 2008, doi: 10.1080/17549170801903660.

[17] H. Hata and E. Sternberg, "Framing the beholder's visual experience: an investigation of perspectival thinking for urban design," *J. Urban. Int. Res. Placemaking Urban Sustain.*, pp. 1–24, Sep. 2021, doi: 10.1080/17549175.2021.1979084.

[18] S. G. Tavares, D. Sellars, K. Dupré, and G. H. Mews, "Implementation of the New Urban Agenda on a local level: an effective community engagement methodology for human-centred urban design," *J. Urban. Int. Res. Placemaking Urban Sustain.*, pp. 1–23, Jan. 2022, doi: 10.1080/17549175.2021.2021972.

[19] S. Judge and L. Harrie, "Visualizing a Possible Future: Map Guidelines for a 3D Detailed Development Plan," *J. Geovisualization Spat. Anal.*, vol. 4, no. 1, 2020, doi: 10.1007/s41651-020-00049-4.

[20] A. Kunze, R. Burkhard, S. Gebhardt, and B. Tuncer, "Visualization and decision support tools in urban planning," *Commun. Comput. Inf. Sci.*, vol. 242 CCIS, pp. 279–298, 2012, doi: 10.1007/978-3-642-29758-8_15.

[21] M. West, O. Yildirim, A. E. Harte, A. Ramram, N. W. Fleury, and V. Carabias, "Enhancing Citizen Participation through Serious Games in Virtual Reality Mirjam West, Onur Yildirim, Aislinn E. Harte. Adam Ramram, Nicholas W. Fleury, Vicente Carabias," vol. 4, no. April, pp. 881–888, 2019.

[22] M. Meenar and J. Kitson, "Using Multi-Sensory and Multi-Dimensional Immersive Virtual Reality in Participatory Planning," *Urban Sci.*, vol. 4, no. 3, p. 34, 2020, doi: 10.3390/urbansci4030034.

[23] L. Gill and E. Lange, "Getting virtual 3D landscapes out of the lab," *Comput. Environ. Urban Syst.*, vol. 54, no. October 2015, pp. 356–362, 2015, doi: 10.1016/j.compenvurbsys.2015.09.012.

[24] M. V. Sanchez-Sepulveda, R. Torres-Kompen, D. Fonseca, and J. Franquesa-Sanchez, "Methodologies of learning served by virtual reality: A case study in urban interventions," *Appl. Sci.*, vol. 9, no. 23, 2019, doi: 10.3390/app9235161.

[25] J. van Leeuwen, K. Hermans, A. Jan Quanjer, A. Jylhä, and H. Nijman, "Using virtual reality to increase civic participation in designing public spaces," *Proc. Eur. Conf. e-Government, ECEG*, vol. 2018-Octob, no. February, pp. 230–239, 2018.

[26] W. Zhu, S. Guo, and J. Zhao, "Planning participants ' preferential differences under immersive virtual reality and conventional representations : An experiment of street renewal," vol. 0, no. 0, pp. 1–15, 2020, doi: 10.1177/2399808320942776.

[27] J. P. Van Leeuwen, K. Hermans, A. Jylhä, A. J. Quanjer, and H. Nijman, "Effectiveness of virtual reality in participatory urban planning," *ACM Int. Conf. Proceeding Ser.*, no. November, pp. 128–136, 2018, doi: 10.1145/3284389.3284491.

[28] H. Schrom-Feiertag, M. Stubenschrott, G. Regal, T. Matyus, and S. Seer, "An Interactive and Responsive Virtual Reality Environment for Participatory Urban Planning," no. January, pp. 119–125, 2020, [Online]. Available: https://unity.com/

[29] J. Harman, R. Brown, and D. Johnson, "Improved Memory Elicitation in Virtual Reality: New Experimental Results and Insights," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 10514 LNCS, pp. 128–146, 2017, doi: 10.1007/978-3-319-67684-5_9.

[30] D. H. Kim, "Three-dimensional urban simulation for collaborative urban design," *Urban Reg. Plan.*, 2005.

[31] H. C. Gómez-Tone, J. B. Escapa, P. B. Escapa, and J. Martin-Gutierrez, "The drawing and perception of architectural spaces through immersive virtual reality," *Sustain.*, vol. 13, no. 11, pp. 1–25, 2021, doi: 10.3390/su13116223.

[32] J. G. Lee, J. O. Seo, A. Abbas, and M. Choi, "End-Users' augmented reality utilization for architectural design review," *Appl. Sci.*, vol. 10, no. 15, 2020, doi: 10.3390/APP10155363.

[33] C. Calderon-Hernandez, D. Paes, J. Irizarry, and X. Brioso, "Comparing Virtual Reality and 2-Dimensional Drawings for the Visualization of a Construction Project," *Comput. Civ. Eng. 2019 Vis. Inf. Model. Simul. - Sel. Pap. from ASCE Int. Conf. Comput. Civ. Eng. 2019*, no. June, pp. 17–24, 2019, doi: 10.1061/9780784482421.003.

[34] C. V. Lopes and C. Lindström, "Virtual cities in Urban planning: The Uppsala case study," *J. Theor. Appl. Electron. Commer. Res.*, vol. 7, no. 3, pp. 88–100, 2012, doi: 10.4067/S0718-18762012000300009.

[35] L. Jiang, M. Masullo, L. Maffei, F. Meng, and M. Vorländer, "A demonstrator tool of web-based virtual reality for participatory evaluation of urban sound environment," *Landsc. Urban Plan.*, vol. 170, no. January 2017, pp. 276–282, 2018, doi: 10.1016/j.landurbplan.2017.09.007.

[36] G. M. Echevarria Sanchez, T. Van Renterghem, K. Sun, B. De Coensel, and D. Botteldooren, "Using Virtual Reality for assessing the role of noise in the audio-visual design of an urban public space," *Landsc. Urban Plan.*, vol. 167, no. February, pp. 98–107, 2017, doi: 10.1016/j.landurbplan.2017.05.018.

[37] G. Megahed, A. Elshater, and S. M. Z. Afifi, "Competencies urban planning students need to succeed in professional practices: Lessons learned from Egypt," *Archnet-IJAR*, vol. 14, no. 2, pp. 267–287, 2020, doi: 10.1108/ARCH-02-2019-0027.

[38] H. Taherdoost, "Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research," *SSRN Electron. J.*, no. January 2016, 2018, doi: 10.2139/ssrn.3205035.