Research Paper

Promoting Public Participation in the Renewal of Historic Districts through Virtual Reality

A Case Study of ju'er Hutong, Bejing

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Abstract

Historic districts, as the core carriers of cultural heritage, embody rich historical memory and cultural value. Public participation is an essential element in the renewal and renovation of these districts. However, how to encourage the public to engage in the design process in a more immersive way remains an urgent topic for further exploration. Virtual reality (VR) and other immersive interactive technologies represent a new milestone in how we interact with our environment, fundamentally reshaping the ways in which we construct and perceive our relationship with reality. By offering the public a unique and immersive interactive experience, VR has attracted widespread attention in the field of landscape practice.
This study aims to explore an immersive public participation model that leverages VR technology to promote in-depth community involvement in the renewal design of historic districts, thereby enhancing local cultural preservation and community interaction. Using Ju'er Hutong in Beijing as a case study, the research proposed two different landscape renovation schemes and developed 2D and 3D models of both schemes using AutoCAD and SketchUp. Scheme 1 features a traditional historical style that emphasizes continuity of cultural context, while Scheme 2 integrates modern streetscape elements, highlighting innovation and functional improvement.Through VR headsets and mobile devices (MDS), both schemes were presented to residents, with a total of 55 participants completing the VR experience and follow-up questionnaire. The results indicate that VR technology significantly enhanced residents' enthusiasm for participation and their understanding of the design proposals. Most residents considered Scheme 1 to be more effective in terms of cultural preservation within the historic district. In the questionnaire, 47 participants strongly agreed that "VR technology helps improve public participation during the design stage." Based on residents' feedback, the design team further optimized and refined the proposed scheme. The study demonstrates that VR technology provides residents with immersive opportunities to engage in the renewal of historic districts, contributing to the cultural relevance of the design and improving public satisfaction. This VR-based immersive participation model shows great potential for wider application, offering valuable references for future historic district renewal projects.

Keywords

virtual reality, historic districts, public participation, immersive technology

1. Introduction

As the cultural heritage of a city, historic districts are visible and expressive residues of urban history, carriers of culture, and anchors of place attachment and identity for residents(Lewicka, 2008). However, historic districts

are facing multiple challenges, such as low efficiency in terms of land use, obsolete facilities, futile functions, and status of disrepair (Yung et al., 2017). In trying to revitalize the historic districts, many cities are implementing the regeneration of historic districts to achieve optimal space utilization and functional transformation with minimum heritage disruption. The central question is how to make the regeneration scheme historically suitable and resident-friendly.

Through public engagement, design solutions can be improved to better address people's needs and maintain local characteristics (Barnes et al., 2007). However, existing engagement practices are oriented to two-dimensional representations, paper-based questionnaires and public meetings. They are not sufficiently robust to support both understanding and presentation. Residents' understanding of a project is limited by the two-dimension paper-based representations. It is difficult for them to imagine the design solution and the impacts in their neighbourhood (Jensen and Maslesa, 2015) . As a consequence, local residents tend to show a lower level of appreciation of the revitalised district (Adger et al., 2013). With a lower degree of engagement, local cultural significance can be undermined. People's sense of place is weakened. In revitalising historic neighbourhoods, the conventional sustainability approach focuses on environmental impacts and heritage preservation. However, sustainability is broader and involves a range of environmental, economic, and social issues. To be more sustainable in the long-term, besides better physical functionality, upgrading of built environments needs to preserve local culture and encourage social activities in the place. Residents' sense of the neighbourhood should not be reduced, but maintained or strengthened (Coeterier, 2002).

In recent years, the emergence of immersive technologies such as virtual reality (VR) and augmented reality (AR) has revolutionized public participation in design. VR, in particular, enables the visualization of intangible designs in three dimensions and facilitates the conversion of architectural drawings into immersive environments, providing users with immediate and firsthand feedback on interior designs, layouts, and material choices (Paes et al., 2017). This study suggests a designer-led approach for enhancing the preservation of intangible cultural heritage (ICH) through adaptive reuse of historic districts, harnessing the potential of public feedback and the capabilities of immersive technologies for public engagement. Through virtual reality demonstrations, designers can bridge the knowledge gap between themselves and the public by providing experiential and visual feedback in a more accessible and understandable format. Incorporating public feedback into the adaptive reuse of historic districts is crucial, as it fosters a culture of place, enhances a sense of belonging, and ultimately contributes to the authenticity and sustainability of such projects.

1.1. Sustainable historic district renovation

The renovation of historic districts is sustainable is an important criterion for measuring the quality of the renovation (Bottero et al., 2020). Therefore, relevant empirical content was summarised into a questionnaire and evaluation matrix based on the influencing factors of sustainable communities. Scholars emphasize that sustainable urban goals involve improving livability through accessible infrastructure and public services, such as walkable open spaces and community facilities (Wang et al., 2022). The accessibility of such activity spaces is an important guarantee of quality of life (Liu et al., 2025). By interacting with the built spaces through walking, people can raise the level of sustainable neighbourhoods by fully utilising the resources of the neighbourhood.

Physically, livable communities require walkable infrastructure and quality amenities (Lang et al., 2019). From the social dimension, quality of life, human health, subjective well-being, social equity, sense of place and security, and social connectedness are important indicators of socially sustainable communities (Yıldız et al., 2020). Previous studies have found that providing social facilities such as cultural services, cafes, entertainment venues, and community plazas in urban renewal districts can promote social cohesion and job opportunities for local people, as well as increase their well-being, sense of pride, and cultural identity (Yung et al., 2017).

Community-based engagement can build social cohesion, conserve culture and authenticity, and foster inclusiveness (Huang et al., 2025). However, community voices remain limited in urban renewal and the transformation of community needs into design outcomes is challenging (Zhuang et al., 2019). Thus, the framework must integrate physical, social, and cultural dimensions within the engagement process.

1.2. The application of virtual reality technology in historic districts

Virtual reality is gaining more attraction as a tool in urban and architectural design projects, especially for design representation, visualization, and public engagement (Wu et al., 2010). Urban simulation, for example, offers great potential for employing virtual technologies in a planning process to democratize the participation of community members who are typically not experts in planning practice (Najafi et al., 2023). Building upon these advancements, this paper explores VR integration for historic district revitalisation processes. More specifically. virtual environments provide a comprehensive platform for built environment information fusion, as well as a means of presenting human factors in fusion with urban environment data. In such an environment, the addition of data points. such as walking paths, occupancy counts, and energy use data, can be graphically displayed on the same referential space and support architectural design, urban planning, and human factors engineering (Heydarian et al., 2015). With the aim of supporting built environment professionals' spatial perception, introducing a virtual environment to project stakeholders can immerse them in a visualisation that represents a real-world environment and enables visualisation on the same coordinate system for collaborative design (Wu et al., 2010). This novel approach to representation is key when adding the socio-technical dimension to data collection for projects in historic areas involving several stakeholders, including local authorities, researchers, the public, and designers(Cascetta et al., 2015).

At the collaboration level, VR has an immense potential to improve communications within societies (Monahan et al., 2008). Immersive visualization could be a powerful tool for facilitating communication among various stakeholders and may overcome the challenges of traditional public outreach events such as the lack of communicability (Maffei et al., 2016). Several studies have addressed how VR can aid urban planners in redesigning city spaces. Meenar et al. argue that introducing immersive, multi-sensory technologies such as VR, could act as a supplement to existing public engagement techniques, and offer planners and decision-makers another opportunity for inclusive, people-oriented approaches (Meenar and Kitson, 2020). Adeel et al. highlight that the user experience of built environments depends on multiple street-level characteristics, therefore, an effective visualisation using VR at the urban scale should accommodate these characteristics (Adeel et al., 2021).

In terms of interactive scope, VR can work at micro (building and district), meso (neighborhood), and macro (urban) levels (Wu et al., 2010). In terms of interactive content, VR could be used for planning simulations, aesthetic judgment, behavioral analysis, and environmental assessment (Ruotolo et al., 2013). Its participatory value extends from spontaneous engagement to structured interviews (Hu, 2004). Beyond information dissemination, VR empowers stakeholders, increasing public awareness and agency in historic district restoration.

2. Methodology

This paper describes a process leading to the design of the public participation methods for historical landscape data collection with VR (Figure 1(a)) , componenting four collecting: the theoretical foundation, landscape renovation design and representation, data collection, and evaluation analysis. Based on the case of Ju'er Hutong in Beijing, the paper presents two landscape design alternatives emerging from surveys with local residents. These representational methods were used for modeling and importing the landscape alternatives into an interactive VR environment for public use. At the data collection stage, local residents were invited to experience the VR environment and provide feedback (i.e., physical legibility, cultural preservation, and renovation endorsement) via a questionnaire. The feedback data were analyzed using statistical methods and other qualitative methods. Finally, the performance of the method was assessed, and future optimization was

discussed.

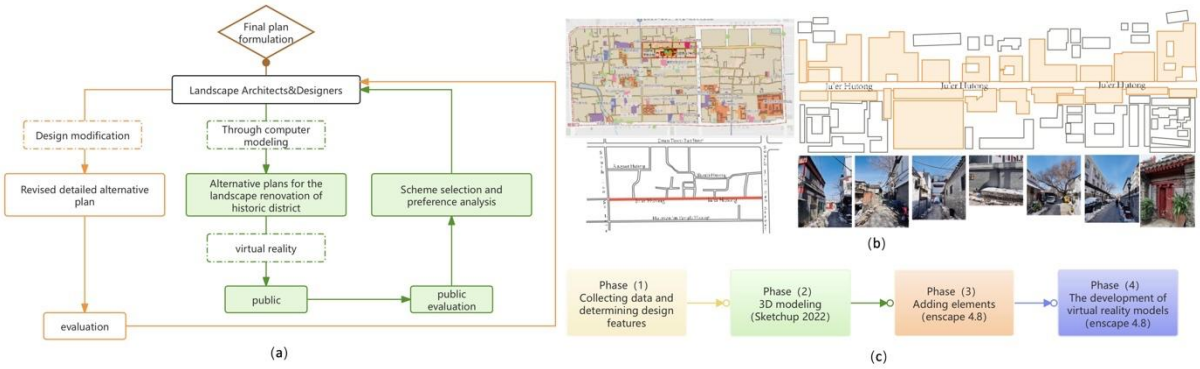


Figure 1. (a) Methods for evaluation and decision-making processes. (c) Case location and current site conditions. (c) The four steps in creating a landscape design model.

2.1. Juer Hutong Case Study

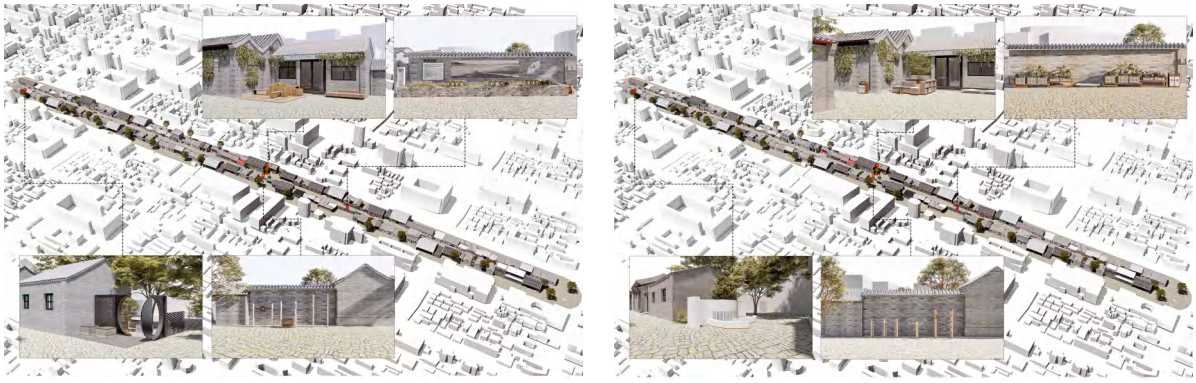
Juer Hutong is a traditional alleyway located in the Xicheng District, Beijing. It is situated in the core area of the old city of Beijing (Figure 1(b)). The urban context in this area is well-preserved, with abundant historic and cultural resources in the neighbourhood. It is also a typical residential hutong. Juer Hutong was just one of many hutongs that were traditionally used as residential neighbourhoods in Beijing. At that time, as part of the house remodelling scheme of the Beijing Municipal Government, a section of Juer Hutong was selected as a pilot project for remodelling. In this context, Professor Wu Liangyong, a leading architect and urban planner, provided a well-known concept of "New Courtyard House", which proposed an alternative that could serve as a compromise by carrying out a non-destructive type of renovation that would improve the conditions of old city houses without, at the same time, putting the social lives of residents at risk. He suggested that instead of building new houses in new neighbourhoods, the restoration of the old city should take place while preserving the existing neighbourhood structure. This means providing a better environment by improving infrastructure, landscaping and common facilities, while preserving the original layout of courtyard houses.

2.2. Model building for alternative landscape design schemes

Based on the characteristics of hutongs, courtyards, and local landscape features, the first step of the modelling process was to determine the modelling objectives and strategies (Figure 1(c)).Based on the findings of a previous study, we selected Jujuner Hutong as our remodelling site, making two alternative design proposals.

Scheme One (Figure 2(a)): Traditional Continuity. As the literal meaning implies, this design approach places greater emphasis on the urban texture and scale of traditional architecture. As Wu Liangyong advocates, there is no ‘absolute’ tradition; the new is implicit in the old (Wu, 2018). This approach attempts to continue the use of traditional materials, such as timber, gray bricks and tiles, taking these symbols of traditional culture.

On the contrary, Scheme Two(Figure 2(b)) emphasizes a ‘‘modern-day symbiosis’’ and utilizes the concept of ‘‘New Courtyard House’’ in suggesting that contemporary inner-city communities should retain their vibrancy by responding to the present. Physically, the design scheme includes more dynamic architectural forms and color tones, with a more contemporary layout of public plazas, meandering through pedestrian streets, a variety of new fitness elements and contemporary furniture creating attractive spaces for social exchange.



(a) (b)

Figure 2. (a) Scheme One: "Continuation of Traditional Culture". (b) Scheme Two: "Integration with Modern Streetscape".

The implementation followed four stages: (a) identifying design goals corresponding to the courtyards and alleys (Fig. 1c). (b) Developing schematics and a 3D model using the street layout, lighting and furniture elements in a software named SketchUp. (c) Rendering the design to be more photorealistic by further developing site materials and shadows using a professional software named Enscape render. (d) Creating a 360° panorama using a VR plugin. In this way, two design schemes were integrated into one file providing landscape views arranged in an interactive scene. The resulting file was uploaded to a designated website, allowing for the exploration of the site using a smartphone.

2.3. Construction of the Virtual Reality Scenarios



(a) (b)

Figure 3. Virtual reality scene (a) Scheme One: Direction of "Traditional Cultural Continuity" (b) Scheme Two: Direction of "Modern Functional Renewal".

In order to allow the participants to familiarise themselves with the alternative design proposals, a VR interactive experience with 360° panoramas was developed (Figure 3). The 3D models were designed using SketchUp 2020®, while the real-time rendering software, Enscape 4.8, was used to achieve a realistic environment with appropriate depth, lighting, and textures. Residents explored the virtual environment and visualised the potential form and spatial features of a neighbourhood in an immersive way before responding to a set of exploring questions. In such a way, residents evaluated their surroundings within an immersive environment

beyond the traditional approach using paper sketches, resulting in more meaningful and representative feedback (Merenda et al., 2018). Then, the research team evaluated the most appealing design features.

2.4.Data Collection and Analysis

In the study area, a total of 55 residents were recruited to participate in the survey, all of whom joined voluntarily with full informed consent. Participants came from diverse occupations and social backgrounds to ensure variability within the sample. Prior to the formal experiment, the research team provided technical training on the operation of the VR equipment, preventing confusion caused by unfamiliarity with the technology and ensuring that participants' feedback reflected genuine experiential judgment(Kwon, 2019). During the VR experience and questionnaire completion process, researchers recorded the time each participant spent on the virtual operation and the submission of the questionnaire for subsequent analysis.

In the data processing and analysis stage, two analytical frameworks were developed to separately address public participant data and expert evaluation data, ensuring that the findings could be examined from both user-oriented and professional perspectives. Public data were derived primarily from questionnaires completed by residents after the VR immersive experience. The questionnaire consisted of 27 items grouped into four sections: (a) personal information, (b) VR experience, (c) participation willingness, and (d) scheme preference. Responses were measured using a five-point Likert scale, where 1 indicated "strongly disagree" and 5 indicated "strongly agree." The structure and detailed items of the questionnaire are presented in Table 1.

Table 1. Resident Questionnaire

category	question	NO.	option
personal Information	gender		Male/Female
	Age		<35/36-50/51-65/>65
	Housing tenure		Owner/Tenant
	Household registration type		Local/Nonlocal
	Length of residence		<3/4-6/7-10/>10
	Education level		Primary school and below/Middle school/university or above
virtual reality experience	I feel immersed in the VR environment.	a1	1-5
	The scene details and lighting make the environment feel realistic.	a2	1-5
	I experience dizziness or nausea during the VR session.	a3	1-5
	Navigation and interaction are easy to learn.	a4	1-5
	I prefer	a5	Smooth movement (continuous movement) / teleportation (point-and-jump)
Resident participation	VR helps me better understand the design and provide feedback.	b1	1-5
	I feel that my opinions may influence subsequent design optimization.	b2	1-5
	VR increases my willingness to participate in discussion/voting.	b3	1-5
Proposal 1	Navigation is clear, and it is difficult to get lost.	c1	1-5
	The scheme enhances community interaction.	c2	1-5
	The scheme improves everyday livability.	c3	1-5
	The scheme respects and expresses local culture.	c4	1-5
	I am willing to support the implementation of this scheme.	c5	1-5
Proposal 2	VR increases my willingness to participate in discussion/voting.	d1	1-5
	Navigation is clear, and it is difficult to get lost.	d2	1-5
	The scheme enhances community interaction.	d3	1-5
	The scheme improves everyday livability.	d4	1-5
	The scheme respects and expresses local culture.	d5	1-5
Relative preference	Overall, I prefer		Proposal 1/Proposal 2/Cannot decide
	Preference intensity (relative strength of preference for Proposal 2 over Proposal 1)		(-3 to +3)
open-ended question	What else you wish to add?		

Similar to public questionnaires, descriptive statistics and weight analysis of semi-structured expert questionnaires were conducted in SPSS to illustrate experts' valuations and concerns of the evaluation indicators (Table 2). The expert evaluation results were then cross-compared with those of the public to address potential public biases and to further analyze the potential of virtual reality in enabling public participation from a professional perspective. Finally, the statistical results of the two questionnaires were analyzed and compared, extracting a multi-disciplinary evaluation of the two renovation alternatives, and discussing the potential and limitations of public participation enabled by virtual reality in the context of historic district renewal.

Table 2. Questionnaire for Architecture Professionals

category	question	NO.	option
Personal Information	Profession		architect / urban planner / landscape architect / cultural heritage conservation expert / other
	Years of professional experience		1–5 years / 6–10 years / 11–20 years / more than 20 years
	Previously involved in historic district or cultural heritage conservation projects		yes / no
virtual reality experience	VR can enhance the depth of public understanding of design proposals.	e1	1-5
	VR experience can facilitate effective communication between designers and residents.	e2	1-5
	Immersive VR experiences enable the public to express their preferences more clearly.	e3	1-5
	VR technology helps balance professional design perspectives and public opinions.	e4	1-5
	VR tools should be widely adopted in future historic district renewal processes.	e5	1-5

3. Evaluation results and design plan development

The results indicated that the use of VR technology was a positive factor that enhanced resident engagement and understanding of design concepts.

3.1. Basic Information of Participants

In March 2025, Ju'er Hutong residents participated in a VR experiment and questionnaire survey. The participants' general information was summarized. Specifically, 55 participants were involved in this research, including 26 males and 29 females, with a relatively even gender. Regarding age, 25 participants were aged 51-65, 20 were aged 36-50, and only 2 were under 35, with the elderly group slotting higher. In terms of home ownership status, 29 reported ownership while 26 rented a house. At the education level, the majority of respondents received secondary education, which might influence the results.

3.2. Virtua reality experience

The study investigated participants' virtual reality experience, as summarized in Table 4. Among the respondents, ten individuals had never used VR technology prior to the experiment. Regarding the mode of navigation within the VR system, 83.64% of participants preferred smooth, continuous movement. They reported that this mode provided a stronger sense of realism and reduced discomfort or motion sickness during the experience. These findings highlight the importance of incorporating user preferences and perceptual comfort when designing VR-based experiential environments.

Table 3. Virtual Reality Experience Preferences

Category	Option	Frequency	Percentage(%)
Have you experienced VR before?	yes	10	18.1
	no	45	81.9
Virtual Reality Experience Preference	Smooth Movement (Continuous Movement)	46	83.64
	Point-to-Point (Click and Instant Movement)	9	16.36

In this study, we also examined participants' perceptions of the realism of the virtual reality scenes used during the evaluation process. As shown in Table 5, respondents generally considered the VR environment to be clear and easy to understand. This finding suggests that the use of immersive technology in design and planning can enhance residents' comprehension of proposed schemes. Consequently, VR technology was well received by participants and is expected to improve the effectiveness of evaluating future redevelopment proposals.

Regarding scene realism, some participants indicated that there remained room for improvement. Although VR was perceived as capable of adequately simulating the design concepts, respondents noted that certain aspects—particularly the refinement of visual details and the overall sense of immersion—could be further optimized. Enhancing these elements would help strengthen users' feeling of being fully embedded within the virtual environment.

Table 4. Virtual Reality Experience Rating Statistics

Item	1Point	2Points	3Points	4Points	5Points	Average Score	Standard Deviation
VR scene is realistic	0 (0.00%)	0 (0.00%)	14 (25.45%)	22 (40%)	19 (34.55%)	4.091	0.776
The details and lighting of the scene make it feel realistic	5 (9.09%)	5 (9.09%)	11 (20%)	17 (30.91%)	17 (30.91%)	3.655	1.265
I feel discomfort or dizziness during the VR experience	21 (38.18%)	18 (32.73%)	7 (12.73%)	5 (9.09%)	4 (7.27%)	2.145	1.239
Navigation and operation are easy to learn	3 (5.45%)	7 (12.73%)	6 (10.91%)	26 (47.27%)	13 (23.64%)	3.709	1.133

3.3.Evaluation of the Alternative Design Proposals

An overall analysis of the survey data reveals a clear preference pattern among participants regarding the two design proposals. Specifically, 54.55% of respondents selected Scheme one as their preferred final option, while 30.91% favored Scheme two, and 14.55% indicated that they were unable to make a definitive choice. This distribution demonstrates that the majority of residents showed a stronger inclination toward Scheme one, suggesting that it aligns more closely with public needs and enjoys higher levels of acceptance in terms of overall experience and cultural identity.

Table 5. Overall Preference for the Proposals

Item	Option	Frequency	Percentage(%)
Overall Preference	Proposal 1	30	54.55
	Proposal 2	17	30.91
	Unable to Decide	8	14.55
Total		55	100

As described above, scheme One has the highest ratings with less variance compare to the other two schemes. For spatial legibility, the item "Ease of entry and home recognition" has an average rating of 3.9 in which most residents gave 4 or 5 points, indicating that the entry to the residential block is legible enough for residents to orient themselves. For sociability, results suggest that the design's potential to encourage more social interaction is appreciated by respondents (item "Improved neighbor interaction" with the highest rating of 4.0 points). The same is true about housing quality. Interestly, "Perception of cultural and historical value" received the highest mean score, of 4.1, which is an indication for the fit between the newly introduced design and the genius loci, the spirit of the place, resulting in the articulation of the neighborhood's cultural capital. This finding, therefore, reinforces the intervention which, in turn, is reflected in the mean value of "Agreement with construction" (4.09).

The results of the comparative analysis of the two proposals further confirmed the aforementioned trend (Table 6). Proposal 1 significantly outperformed Proposal 2 in four dimensions: navigation clarity, livability in daily life,

cultural representation, and implementation support. All corresponding p-values were below 0.05, indicating that these differences were statistically significant. The only dimension without a significant difference was "promoting community interaction," suggesting that the two proposals performed similarly on this indicator. In summary, Proposal 1 demonstrated more stable and prominent advantages in terms of cultural adaptability, spatial understanding, daily user experience, and public support. These advantages explain why Proposal 1 ultimately received more resident approval and was considered the superior design option.

Table 6. Comparison of participant evaluations for Scheme 1 and Scheme 2.

Indicator	Proposal	N	Average Score	Standard Deviation	T	P
Navigation clarity, easy to avoid losing direction	1	55	3.95	0.87	2.148	0.034
	2	55	3.51	1.23		
Proposal enhances community interaction	1	55	3.84	0.958	1.192	0.236
	2	55	3.6	1.116		
Proposal improves daily residential comfort	1	55	4.18	0.796	2.064	0.041
	2	55	3.78	1.197		
Proposal respects and presents local culture	1	55	4.09	0.701	2.421	0.017
	2	55	3.71	0.936		
I am willing to support the implementation of this proposal	1	55	3.99	0.64	2.118	0.036
	2	55	3.68	0.872		

3.4. Resident participation

Further analysis of the questionnaire results (Table 7) shows that 22 participants gave a score of 5 to the question "VR enhances my willingness to participate in discussions and voting" indicating that they believe VR is an effective tool for increasing public participation. Participants generally stated that the VR experience helped them better understand and experience the proposed renovation plans, stimulating their willingness to provide feedback.

From the descriptive statistics of resident participation, VR technology shows a positive role in promoting public understanding of the design and enhancing participation willingness. The average score for the statement "VR makes it easier for me to understand the design and offer suggestions" was 3.818, indicating that VR has some effect in helping residents understand the plans, but due to the dispersed distribution of scores, its effect varies among different groups. In contrast, the average score for the statement "My opinions will influence subsequent optimization" was slightly higher, indicating that the interactivity of VR enhanced residents' sense of participation in the decision-making process.

Table 7. Statistical analysis of public participation assessment

Item	1Point	2Points	3Points	4Points	5Points	Average Score	Standard Deviation
VR makes it easier for me to understand the design and provide suggestions	4 (7.27%)	2 (3.64%)	12 (21.82%)	19 (34.55%)	18 (32.73%)	3.818	1.156
I feel my opinions will affect the subsequent optimization	2 (3.64%)	5 (9.09%)	11 (20.00%)	18 (32.73%)	19 (34.55%)	3.855	1.113
VR enhances my willingness to participate in discussions and voting	1 (1.82%)	1 (1.82%)	11 (20.00%)	20 (36.36%)	22 (40.00%)	4.109	0.916

3.5.Expert Evaluation

For the architecture professionals, the study selected 4 urban planners, 4 landscape architects, 1 architect, and 1 cultural heritage expert, totaling 10 individuals. Regarding years of experience, seven participants had 1-5 years of experience, two had 6-10 years, and one had 11-20 years. The expert group mainly consisted of young and middle-aged professionals with 1-5 years of experience. All experts had participated in projects related to historical districts or cultural heritage protection, indicating that the expert group possessed relevant practical experience in this field.

Table 8 shows the analysis results of the expert questionnaire. Overall, experts held a positive attitude towards the role of VR in design communication and public participation, but there were some differences in the degree of agreement across different dimensions. In the item "VR enhances public understanding of design proposals," the average score was 3.600, indicating that experts generally acknowledged the role of VR in improving public understanding, but there is still room for improvement. The responses were relatively concentrated and suggested positive opinions from the experts on the related questions of “VR system is useful of facilitating communication between planners and residents” (4.000) and “It is possible to participate in urban regeneration projects in the future by adopting the VR system” (4.000). It can be interpreted that experts encouraged future practice of using VR in public participation and urban regeneration. The lowest scores were found in the question of “VR scenes in this system provide a realistic feeling in terms of details and natural lighting” (2.300). In this case, experts seemed to be dissatisfied with the video rendering of the developed 3-d virtual scenes. They indicated that the system had limitations in providing realistic feeling or virtual presence.

Table 8. Statistical data based on expert assessments

Item	1Point	2Points	3Points	4Points	5Points	Average Score	Standard Deviation
VR Enhances the Public's Understanding of the Design Proposal	0	2	3	2	3	3.600	1.174
Virtual reality experiences enhance communication between designers and residents	0	1	2	3	4	4.000	0.869
Virtual reality experiences can allow the public to express their biases more clearly	0	1	3	4	2	3.700	1.022
Virtual reality technology helps to balance professional design with public opinion	0	1	5	0	4	3.700	1.159
The lighting and detail effects of the scenes in virtual reality look incredibly realistic	2	4	3	1	0	2.30	0.949
Future Historical Districts Should Incorporate VR Participation Tools	0	2	0	4	4	4.000	1.155

4. Conclusion

The research findings support the viability and relevancy of utilizing virtual reality (VR) technology in the regeneration process of historical districts and indicate several practical implications for future planning, design, management of public spaces, and the preservation of cultural heritage. Firstly, as an empowering means of participation, VR-based immersion can be integrated into the planning and design workflow of urban regeneration to foster a more exciting, open, and inclusive mode of public participation, which will allow community members to better envision the potential of their built environment and to assert their opinions about community transformation. This will help expand the technological pathway for contemporary urban governance and turn “top-down” designer-driven approaches into more interactive, “bottom-up” exchanges between designers and end-users.

The methodology described in this research for immersive public participation can be both scalable and replicable. With the same technical infrastructure, it can be adapted to support different urban renewal and regeneration projects at the neighbourhood level, especially in cases of historical restoration, landscape

transformation, or the design of public spaces that can be rapidly modelled and visualised in parametric format. As the technology and hardware of virtual reality become more accessible and production process more streamlines, it could translate into an essential part of a universal public participation tool that can easily transfer traditional planning knowledge among different states and cities.

In future research and practice, this model can also be combined with technologies such as artificial intelligence (AI)(Wang et al., 2025) and eye-tracking(Shadiev and Li, 2023) to automatically analyze users' visual attention and emotional responses, providing quantitative evidence for design evaluation. This could enable a more significant transformation from questionnaires to behaviour analysis in public engagement, strengthening the validity and reliability of the data collected. In conclusion, the study presents a verifiable paradigm for sustainable urban development. By leveraging innovative technologies, such as virtual reality, it promotes a bottom-up approach to the application of evolutionary urban planning that creates the bi-directional communication among designers, the public, and urban cultural heritage. This approach aims to empower the community through meaningful engagement, and to preserve urban heritage by embedding it into thoughtful urban restructures and community-centred design. The approach holds the potential to make a significant contribution to the evolution of the field of urban design, championing the cause of "resilience-in-action" for cultural preservation during the rapid pace of urban development.

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