Development of a Virtual Reality Walking Tour for Culinary Heritage Exploration in Lawang Rangga Gading, Bogor City

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Abstract

The rising interest in preserving Indonesia's cultural heritage, especially within Bogor City, is driving the adoption of innovative methods in tourism. The COVID-19 pandemic accelerated the development of virtual tourism, enabling experiences through digital platforms, including in ecotourism for environmental preservation and inclusivity. This study introduces a virtual reality (VR) walking tour to preserve and promote Bogor's historical and cultural sites, focusing on Lawang Rangga Gading, a revitalized culinary hub. The research incorporates 360-degree immersive video techniques and interaction design principles to deliver an engaging experience. Key design features include narrative development based on local history, scene navigation, and gamification using the Octalysis framework to enhance user engagement. In conclusion, this study successfully demonstrates the potential of VR walking tours to preserve and promote Bogor's cultural heritage, specifically in Lawang Rangga Gading. User testing using the System Usability Scale (SUS) reveals an average score of 62.3, which indicates that the system falls within the marginal acceptability range. The marginal category is defined as scores above 50. There are several areas for improvement: enhancing learnability, providing more intuitive navigation to reduce the need for technical assistance, and improving system clarity.

Keywords: heritage, virtual reality, virtual walking tour

Abstrak

Meningkatnya minat dalam melestarikan warisan budaya Indonesia, khususnya di wilayah Kota Bogor, mendorong adopsi metode inovatif dalam sektor pariwisata. Pandemi COVID-19 telah mempercepat perkembangan pariwisata virtual, memungkinkan pengalaman wisata melalui platform digital, termasuk dalam ekowisata untuk pelestarian lingkungan dan inklusivitas. Penelitian ini memperkenalkan tur jalan kaki berbasis realitas virtual (VR) sebagai upaya untuk melestarikan dan mempromosikan situs-situs sejarah dan budaya di Bogor, dengan fokus pada Lawang Rangga Gading, sebuah kawasan kuliner yang telah direvitalisasi. Penelitian ini mengintegrasikan teknik video imersif 360 derajat dan prinsip desain interaksi guna menghadirkan pengalaman yang menarik bagi pengguna. Fitur utama dari desain ini mencakup pengembangan narasi berdasarkan sejarah lokal, navigasi antar adegan, serta gamifikasi dengan menggunakan kerangka kerja Octalysis untuk meningkatkan keterlibatan pengguna. Sebagai kesimpulan, studi ini berhasil menunjukkan potensi penggunaan tur jalan kaki berbasis VR dalam upaya pelestarian dan promosi warisan budaya Bogor, khususnya di kawasan Lawang Rangga Gading. Pengujian pengguna dengan menggunakan System Usability Scale (SUS) menghasilkan skor rata-rata sebesar 62,3, yang menunjukkan bahwa sistem berada dalam kategori kelayakan marginal. Kategori marginal didefinisikan sebagai skor di atas 50. Namun, terdapat beberapa aspek yang perlu ditingkatkan, yaitu: peningkatan kemudahan pembelajaran (learnability), penyediaan navigasi yang lebih intuitif untuk mengurangi kebutuhan bantuan teknis, serta peningkatan kejelasan sistem.

Kata Kunci: *tur jalan kaki virtual, virtual reality, warisan*

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INTRODUCTION

The increasing interest in preserving historical and cultural sites in Indonesia, especially in Bogor City, has become a significant focus, along with the need to maintain the nation's cultural heritage and history. The COVID-19 pandemic significantly transformed the tourism industry, including in Indonesia, with the emergence of virtual tourism. Virtual tourism enables travel experiences from home through platforms such as Zoom, Google Maps/Earth, and short videos (Kinseng *et al*. 2022; Wei, 2019). In addition to the economic aspect, preserving nature and biodiversity has driven virtual ecotourism research, such as responding to declining wildlife populations and ethical issues in animal captivity (Burns and Benz-Schwarzburg 2023; Muhammad *et al*. 2021). With its inclusive nature, virtual ecotourism provides a solution for people with disabilities who cannot visit tourist sites, fostering a more empathetic and considerate approach to the tourism industry (Fennel 2021; Asfarian *et al.* 2023). It also helps reduce the carbon footprint of travel (De-la-Cruz-Diaz *et al*. 2022; Pavlidis *et al*. 2022).

Virtual ecotourism has the potential to significantly influence sustainable behavior (Lange and Truyens 2022; Barrera-Hernández 2020). However, the design of virtual tourism systems, particularly in Indonesia, often prioritizes function over the essential interactions between humans, computers, and nature (Vella *et al*. 2023; Orru *et al*. 2019). History, culture, and nature-themed tour activities, including walking tours, are gaining growing popularity in society (Aoki and Yoshimizu 2015; Musthofa and Arif 2020). These activities, where the organizer and participants walk together along a themed route, provide a unique and popular way to explore a place's history, culture, and nature.

This type of tour model has not been applied in virtual reality, so this study attempts to introduce a new interaction in virtual walking tours. Virtual reality and other extended reality technologies represent a potential future direction for cultural heritage preservation (Harisanty *et al*. 2024). This study aims to develop and evaluate a Virtual Reality Walking Tour as a tool to maintain and promote historical and cultural sites in Bogor City. In this early research, we removed the role of the tour guide and focused on the fundamental interactions necessary for the user to interact with the virtual reality system.

In this research, we selected Lawang Rangga Gading as a project site, a revitalized culinary center in the Suryakencana area of Bogor that was launched in March 2023 through a collaboration between the Bogor City Government and Grab. The project transformed a once dilapidated street into a vibrant food hub featuring traditional foods such as lomie, batagor, soto mie, es podeng, and laksa. This center contributes to the growth of local tourism and strengthens Bogor's culinary economy. Historically, Suryakencana, where Lawang Rangga Gading is located, holds cultural significance as a former trading route and is a key area in preserving Bogor's heritage (Hasibuan *et al*. 2017).

METHODOLOGY

The development methodology for this project (Fig. 1) is adapted from the design approach outlined by Argyriou *et al*. (2020) for 360 immersive video applications. The process begins with a site visit and content capture, where multimedia elements are collected in Lawang Rangga Gading to form the foundation of the virtual environment. The development is divided into experience design and interaction design processes. In the first process, narrative development and virtual scenes are created to guide users through the storyline and immersive visuals of the walking tour. In the second process, navigation and gamification are designed to facilitate intuitive and engaging interaction in the virtual environment. The result of these two processes is then implemented into the VR system. Finally, we tested the system using the System Usability Scale (SUS), and used the feedback to refine and optimize it.

The site visit for the VR project was conducted in September and October 2024. Content capture was done using the Insta360 X4 camera with a 72-megapixel image resolution and 8K video quality at 30fps. We captured the overall scene of the Lawang Rangga Gading Alley, including the landmark scenes and close-up images of the vendors and the food they sell,

representing the culinary atmosphere. The narrative development highlights the culinary scene's cultural and historical aspects based on various sources. Then, audio materials based on the narrative were created to support the storytelling. The virtual scenes showcase the overall environment and specific points of interest that serve as the main highlights of the tour.

In the interaction design, navigation is based on restricted walking movement in the real world. Scene transitions are handled through a navigation menu that responds to the user's movement. The activities in the scenes are gamified using the octalysis gamification framework (Chou 2019), which is recommended by Mohanty and Christopher (2023), incorporating elements of development and accomplishment with points and scores from quizzes, and unpredictability and curiosity through visual storytelling and MiniQuest. Lastly, we tested the virtual reality walking tour system using the system usability scale (Bangor *et al*. 2008; Vlachogianni and Tselios 2022) translated into Indonesian (Sharfina and Santoso 2016).
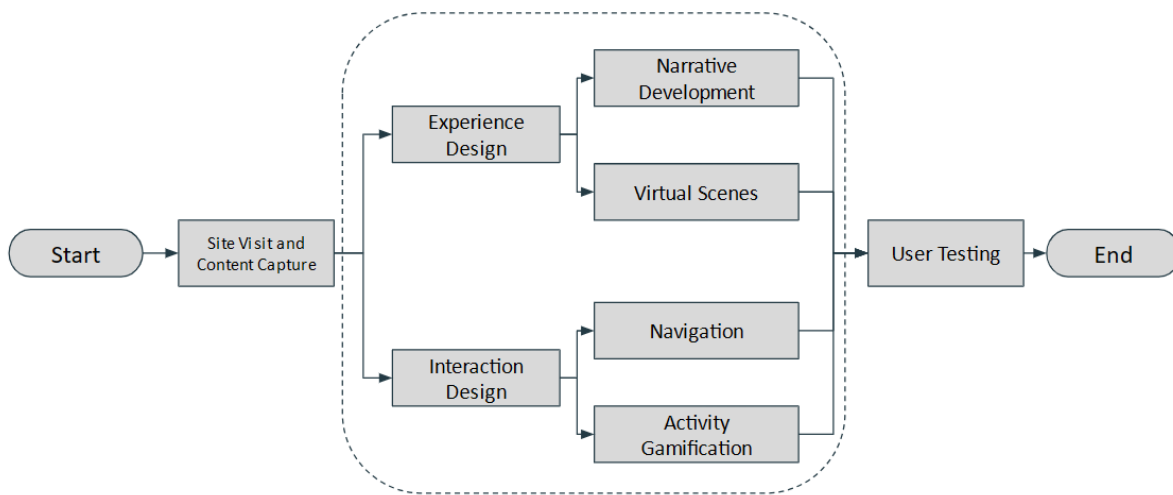

Figure 1 Development method for the proposed virtual reality walking tour system

RESULTS AND DISCUSSION
The Development of the Proposed VR Walking Tour

Nine Points of Interest (POI) were captured using the 360-degree camera labeled for this lab, as shown in Fig. 2. The figure also shows the navigation between **the POIs**, which will be modeled in the VR system. 360-degree images of landmarks and close-up shots of food vendors were taken, as shown in Figure 3. Landmarks include culturally or historically significant locations such as the entrance and interior sections of Lawang Rangga Gading, as well as notable spots like LS Gymnastics Studio, Kopitiam, and the Kesatuan Institute of Economics. Close-ups highlight food vendors' offerings, featuring traditional Indonesian snacks and dishes such as onde-onde, tahu bakso, nasi uduk, and oncom varieties. Table 1 provides detailed information on the POIs. Meanwhile, Table 2 provides an example of a narrative description of each POI.
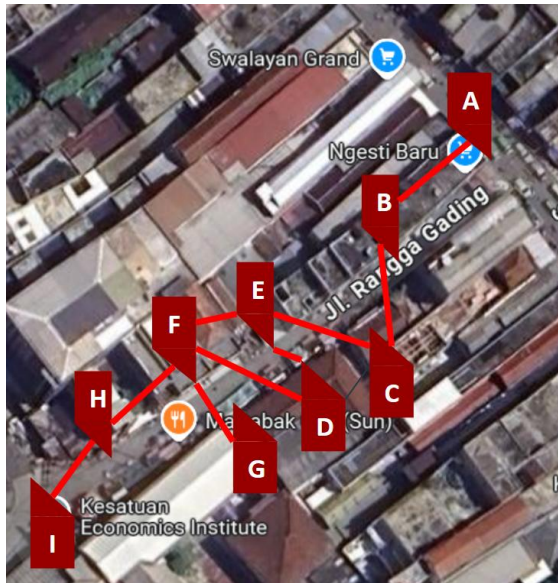
Figure 2 A map shows the location of the content captured in Lawang Rangga Gading. The red line indicates the navigation between scenes enabled in the virtual reality walking tour.

Figure 3 Example of (a) landmark panoramic image and (b) close-up content of vendors.

Table 1 The point of interest taken in the site visit

PoIs ID	Name
A	Landmark: Entrance to Lawang Rangga Gading
B	Landmark: Inside Lawang Rangga Gading - 1
C	Landmark: Inside Lawang Rangga Gading - 2
D	Close-Up: Food vendors 1: wafel, onde-onde, bakpao, susu kacang ijo, mochi, keripik singkong balado, kue cucur, tahu bakso, kue sus, nagasari, dadar gulung, kue talam, pisang keju
E	Landmark: In Front of LS Gymnastic Studio
F	Landmark: In Front of Futiam (Kopitiam)
G	Close-Up: Food vendors 2: oncom merah, oncom hitam, risol, otak otak, bakwan, tahu isi, nasi uduk
H	Landmark: Inside Lawang Rangga Gading - 3
I	Landmark: Kesatuan Economics Institute

Table 2 Example of a narrative description of each POI

PoIs ID	Narrative Description
A	"After being inaugurated in 2023, Lawang Rangga Gading has now become a must-visit culinary destination in Bogor. Starting from batagor, soto mie, and es doger, the dishes served at this culinary centre are very diverse. Not only that, with the presence of attractive booths and colourful murals, Lawang Rangga Gading not only pampers the tongue but also pampers the eyes. The existence of Lawang Rangga Gading not only revives this area but also contributes to the economic growth of Bogor City and is a source of pride for the local community."
B	"In the Lawang Rangga Gading area, Surya Kencana, Bogor, culinary lovers can find a variety of favorite snacks, including cimol, potato sticks, and appetizing crispy otak-otak. Cimol, a snack made from tapioca flour, has a unique chewy texture with a coating of spicy sweet or salty savory seasoning that perfectly penetrates every bite. In addition, potato sticks come with pieces of potato that are fried until crispy, producing a crunchy sensation that is addictive. Meanwhile, crispy otak-otak is also a favorite with a distinctive fish flavor coated in crispy flour, creating a perfect combination of savory and crispy texture. Lawang Rangga Gading is a culinary spot that must be visited by anyone who wants to enjoy authentic local flavors."
D	"Balado cassava chips are one of the snacks that always attract the attention of spicy food lovers. Made from selected cassava that is thinly sliced and fried until crispy, these chips are then coated with a special spicy, sweet, and slightly sour balado seasoning. Each bite offers a strong and appetizing blend of flavors, perfect for relaxing or as a typical Bogor souvenir. The savory and spicy taste of these balado cassava chips makes it hard for anyone to stop chewing. For visitors who are on a culinary tour in the Surya Kencana area, tasting this legendary snack is an experience that should not be missed!"
E	"Es doger and es podeng are the favorites for visitors who want to refresh themselves in the midst of culinary tourism activities. Es doger, a typical drink with a striking pink color, consists of a mixture of coconut milk, sticky rice tape, pieces of young coconut, and added with fresh, sweet shaved ice. Added with red syrup and sprinkled with black sticky rice, each spoonful provides a sweet and legit sensation that pampers the tongue. In

PoIs ID	Narrative Description
	addition, there is es podeng which is no less delicious, with avocado, pearl, and white bread fillings drizzled with shaved ice and sweetened condensed milk, creating a rich blend of flavors. Both are iconic drinks that are perfect for refreshing the day and adding to the authentic culinary experience at Surya Kencana."
G	"Black oncom is a typical Indonesian fermented food made from peanut dregs. Unlike red oncom, black oncom has a darker color and a slightly denser texture. The taste of black oncom tends to be more savory and slightly bitter, making it a cooking ingredient with a unique flavor profile."
H	"At Lawang Rangga Gading, Surya Kencana, Bogor, doclang is one of the signature dishes that must be tried by fans of traditional cuisine. Doclang, often called "Bogor's signature vegetable ketupat," consists of pieces of lontong or ketupat served with fried tofu, boiled potatoes, and eggs. The distinctive feature of doclang is the thick peanut sauce, which has a sweet and savory taste with a touch of spicy that fits perfectly. Of course, doclang is served with crackers as a complement that adds a crunchy texture to every bite. With its tempting peanut aroma, doclang offers an authentic and filling local culinary experience, making it a favorite for tourists visiting Surya Kencana to sample the rich flavors of Bogor."
I	"At Lawang Rangga Gading, Surya Kencana, Bogor, cakue is a favorite snack that always attracts the attention of culinary lovers. Cakue, or often called "cahkwe", comes from ancient Chinese culture and was originally created as a symbol of protest. It is said that cakue represents the figure of Qin Hui, a Song dynasty official who was considered a traitor, so he was cut and fried as a symbol of punishment. Now, at Surya Kencana, cakue appears as a snack that is crispy on the outside and soft on the inside served with a special sauce that combines sweet, salty, and slightly sour flavors. This sauce is absorbed into every bite, creating a perfect combination with the savory taste of cakue. With a long history and authentic taste, cakue at Surya Kencana is a must-have for a traditional culinary experience rich in meaning and flavor."

We integrated the content into a VR system using Unity 3D and its VR project template. We chose Unity 3D as the development platform for its versatility and robust features, which enable us to deploy the system as a non-VR mobile application. We built the program specifically for the Meta Quest 2 VR headset, selecting it for its affordability compared to other headsets and its inclusion of two hand controllers for interacting with immersive content. We enhanced the system using additional VR libraries, including Open XR, Oculus XR, the XR Interaction Toolkit Package, and SideQuest. For multimedia design, we incorporated resources such as Flaticon and Vlog Music. Several screenshots of the developed VR system are shown in Fig. 4.

Figure 4 Screenshots of the developed VR system

Testing Using System Usability Scale

The testing process was conducted using the System Usability Scale (SUS) method. The SUS method is a questionnaire comprising ten statements, which are then scored based on respondents' responses on a Likert scale. n this process, 16 respondents were selected, all of whom were IPB University undergraduate students who were not born and raised in Bogor and had varying levels of knowledge regarding VR technology, cultural tours, and Indonesian culinary.

Based on the results of the tester form, 75% of all respondents had never tried any VR devices, with the remaining respondents using VR less than once a month. Of all the respondents who had used VR, all of them only use it for entertainment, with 40% using it for 1-2 hours and the rest using it for less than 1 hour per session. As for cultural tours, 81.3% of respondents reported prior knowledge of them. In total, 62.5% of the respondents had

participated in cultural tours, with most of them participating 1-2 times per year. Of all the respondents, only 2 people had previously experienced a virtual cultural tour.

The SUS score (Table 3) reveals that the developed system has a marginal-high acceptability range (an average score of 62.3), according to Bangor *et al*. (2008). This score indicates that while the system is functional, there is a gap in meeting user expectations fully. These findings indicate that while the system is usable, it would benefit from targeted refinements to address user frustrations and inconsistencies, with the aim of achieving a higher usability score.

The SUS results highlight the strengths of the developed system. For frequency of use (Question 1), 12 out of 16 participants indicated that they would use the system frequently. Regarding ease of use (Question 3), 13 participants agreed that the system is sufficiently user-friendly. Lastly, 14 participants agreed that the developed system is well-integrated (Question 5). On the other hand, there are three areas of improvement. Half the participants reported needing technical assistance when using the system (question 4). Secondly, only 6 participants were confident using the VR application (Question 9). Finally, 12 participants stated that they needed to learn many aspects of the system before being able to use it easily (Question 10), indicating a need for improved learnability and better user guidance. Figure 5 shows the testing session along with the post-testing interview.
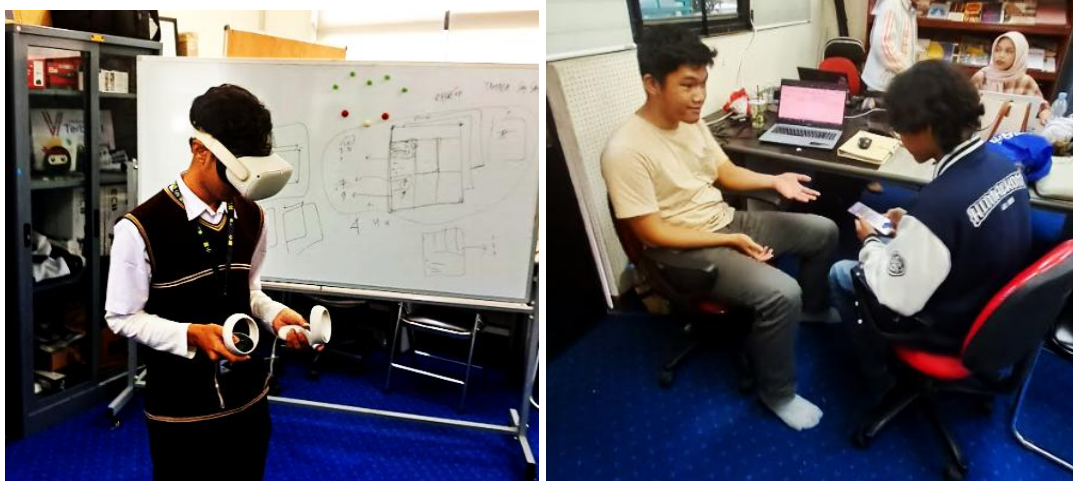

Figure 5 The testing session with post-testing interview

Table 3 The system usability scale results ($N = 16$) with overall SUS score

Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS Score
1	5	4	4	4	4	2	4	3	2	4	55.0
2	4	2	5	2	4	3	4	2	4	4	70.0
3	3	3	3	3	3	3	3	3	3	3	50.0
4	4	3	4	1	4	2	2	4	3	4	57.5
5	4	2	5	3	4	2	5	2	4	3	75.0
6	4	3	3	4	4	4	4	2	4	4	55.0
7	4	1	5	3	3	3	4	4	3	5	57.5
8	1	1	5	4	4	2	5	2	2	3	62.5
9	3	2	4	3	4	2	5	2	5	4	70.0
10	5	4	2	5	5	2	2	3	2	5	42.5
11	5	2	4	4	5	1	4	1	4	5	72.5
12	5	2	4	4	4	2	5	2	3	5	65.0
13	4	3	4	5	5	1	4	3	2	5	55.0
14	3	3	4	1	5	2	3	3	3	5	60.0

Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS Score
15	5	1	5	2	5	2	5	1	5	1	95.0
16	5	3	5	4	4	2	3	4	3	5	55.0
Med.	4	2.5	4	3.5	4	2	4	2.5	3	4	
Modus	4	3	4	4	4	2	4	2	3	4	
									Average		62.3
									Minimum		42.5
									Maximum		95.0
									Standard Deviation		12.3

Several participants reported a need for more confidence when using the program due to limited experience with VR technology. Participant 16 noted, "*Flexibility in using the device is important to avoid rushing, and the instructions provided by the assistant should be more focused and clear.*" Furthermore, most participants felt overwhelmed by the specific new tasks [e.g., navigating a virtual environment and interacting with virtual objects] they had to complete in the testing, especially if it was their initial experience with the VR system. Participant 8 recommended, "*A manual related to the use of controls, adjustable pop-up information sizes, and improvements in image and video quality would be beneficial.*"

From the median analysis, the odd-numbered questions (positive) show good results with the highest median of 4.0 (Q1, Q3, Q5, Q7) and the lowest median of 3.0 (Q9), indicating that the system is generally easy to use but still requires improvement in certain features. The even-numbered questions (negative) have the lowest median of 2.0 (Q6), indicating minimal issues, but the highest median of 3.5 (Q4) suggests some perceived difficulties that need to be addressed. Improvement efforts should focus on enhancing the positive aspects identified in Q9 and reducing negative perceptions in Q4.

Based on mode analysis, the positive questions have the highest mode of 5 (Q1, Q3, Q5, Q7), reflecting strong positive user feedback, while the lowest mode of 3 (Q9) suggests room for improvement in specific features. On the other hand, negative questions show the lowest mode of 1 (Q2, Q6, Q8), indicating minimal issues, but the highest mode of 4 (Q4) highlights notable user challenges. Efforts should focus on enhancing positive perceptions in Q9 and addressing negative feedback in Q4 to improve overall user experience.

Table 4 The scale frequency of each SUS question

No	Question	Scale Frequency				
		1	2	3	4	5
Q1	I think that I would like to use this system frequently.	1	0	3	6	6
Q2	I found the system unnecessarily complex.	0	1	2	7	6
Q3	I thought the system was easy to use.	0	0	2	9	5
Q4	I think that I would need the support of a technical person to be able to use this system.	0	2	3	6	5
Q5	I found the various functions in this system were well integrated.	0	4	6	4	2
Q6	I thought there was too much inconsistency in this system.	3	5	6	2	0
Q7	I would imagine that most people would learn to use this system very quickly.	2	2	4	6	2
Q8	I found the system very cumbersome to use.	2	10	3	1	0
Q9	I felt very confident using the system.	2	6	5	3	0
Q10	I needed to learn a lot of things before I could get going with this system.	1	0	3	5	7

CONCLUSION

In conclusion, this study successfully demonstrates the use of VR walking tours to preserve and promote Bogor's cultural heritage, specifically in Lawang Rangga Gading. User testing using the SUS reveals an average score of 62.3, which indicates that the developed system has a marginal-high acceptability range. Based on median and mode analysis, the application demonstrates strong usability in aspects related to Q1, Q3, Q5, and Q7, as reflected by high median and mode values. However, Q9 reveals a need for improvement in specific features, while Q4 highlights user challenges with navigation or complexity. Enhancing Q9 and addressing negative perceptions in Q4 are crucial to improving the overall user experience. In summary there are several areas for improvement: increasing learnability, providing more straightforward navigation to reduce technical assistance, and improving system clarity.

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