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Immersive virtual reality experience: Showcasing wadai Banjar traditional cake with hand gesture controls

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ABSTRACT

Virtual reality (VR) has revolutionized the way we engage with digital content, offering immersive environments that combine education and entertainment. This study explores the innovative application of VR to introduce Wadai Banjar, traditional cakes from the Banjar tribe in Indonesia, through a virtual environment enhanced by hand gesture interaction. Using hand-tracking technology on the Meta Quest 2 headset, users can interactively explore the making and cultural history of Wadai Banjar in a highly engaging and immersive manner. The study employs the Game Development Life Cycle (GDLC) methodology. It evaluates the experience through Playtesting, Gameflow, and assessments of telepresence, controller naturalness, and cybersickness. The findings reveal high levels of immersion, with a telepresence score of 64.46/70, controller naturalness of 62.3/70, and low cybersickness at 16/70. These results highlight VR's potential as a cultural education platform to preserve intangible heritage, particularly in engaging younger generations with the rich traditions of Indonesian cuisine. This research paves the way for future efforts to preserve cultural heritage through interactive technologies.

1. Introduction

Indonesia is recognized as a cultural superpower, with UNESCO acknowledging nearly 600 elements of intangible cultural heritage, including traditional crafts, dances, and cuisines [1]. Among these is Wadai Banjar, a unique category of traditional cakes originating from the Banjar tribe of South Kalimantan. Wadai Banjar carries rich cultural and historical significance, representing centuries-old traditions and culinary practices. Traditionally, these cakes have been an integral part of Banjar rituals, celebrations, and communal gatherings, embodying values, beliefs, and local knowledge passed down through generations. However, rapid modernization and shifts in lifestyle have created challenges in preserving this intangible cultural heritage, especially among younger generations who are increasingly disconnected from traditional practices.

A significant aspect of Banjar culture that requires preservation is the traditional Banjar cake known as wadai. The term wadai or waday translates to "cake" or "snack" in English [2]. Historically, in South Kalimantan, wadai played a role in rituals and offerings associated with animist beliefs. Over time, these beliefs diminished and evolved with the arrival of organized religions in the region, particularly in what is now South Kalimantan. With this cultural shift, the practice of using wadai in offerings ceased, aligning with religious principles regarding the permissibility (halal and haram) of certain foods and actions. Today, wadai is primarily prepared as a delicacy to be enjoyed by the community, often served during special occasions and traditional ceremonies. Among the various types, the collection known as Wadai Banjar 41 Macam holds particular historical and cultural significance as a cherished symbol of Banjar heritage. Despite its cultural value, educators and cultural

enthusiasts from the Banjar community face challenges in accessing resources and learning materials about wadai [3]. This highlights the urgent need for innovative approaches to preserve and promote the knowledge and appreciation of Wadai Banjar 41 Macam. Illustrations of Wadai Banjar 41 Macam are presented in Fig. 1.

Fig. 1. Wadai Banjar 41 Macam

Several studies have highlighted the effectiveness of Virtual Reality (VR) in cultural preservation and education. VR has become popular as a technology that allows users to experience immersive visual and audio experiences in a three-dimensional simulated environment that can be controlled by a computer [4]–[6]. The application of VR is developing widely and becoming significant in various fields, namely in education [7], professional training [8], cognitive assessment [9], mental health therapy [10], and entertainment [11]. Besides that, VR allows users to immerse themselves in a virtual environment that can replicate cultural experiences with high fidelity. The immersive quality of VR makes it an ideal tool for introducing and teaching about traditional foods like Wadai Banjar, which are deeply rooted in cultural practices and community life. Thus, VR technology is recommended in this research as a medium for introducing and learning about Wadai Banjar 41 Macam.

Several studies have demonstrated the effectiveness of immersive technologies as tools for learning and preserving Indonesian culture. For instance, a study by [12] developed a simulation application for learning to play Gamelan, a traditional Indonesian musical instrument, utilizing augmented reality (AR) technology with Leap Motion controls. The application achieved a usability score of 86.48%, highlighting its potential as an engaging learning platform. Similarly, research by [13] introduced a VR game as a medium for teaching Pencak Silat, a traditional Indonesian martial art. The evaluation revealed high user interest in learning about Pencak Silat through VR, with a Behavioral Intention to Use score of 78.61%, indicating strong user willingness to revisit the game. Additionally, the game achieved a Focused Immersion score of 77%, suggesting that users experienced significant levels of engagement and immersion while interacting with the VR environment. These studies underline the potential of immersive technologies, such as AR and VR, to effectively promote cultural education and engagement.

The difference between those studies and this research is that the virtual reality game developed to introduce Wadai Banjar in this research uses hand-gesture-based controls. Control with hand tracking refers to the feature on the Meta Quest 2 headset, which allows users to use their hands as a substitute for Touch Pro or Touch Controllers to control interactions in the virtual environment on Meta Quest 2. Hand tracking works by using an inside-out camera on the Meta Quest 2 headset, which will detect the position and orientation of the hand, as well as the user's finger configuration. Once detected,

computer vision algorithms track the user's movement and orientation, which will serve as input for the system [14].

Interacting with virtual environments using hand gestures has become an increasingly popular approach in recent years, particularly in VR applications. Hand gesture interaction in VR enhances the user experience by providing a more intuitive and natural way of interacting with virtual objects. Research has shown that hand gesture interfaces can improve user engagement and learning outcomes in VR environments [15]–[19]. By incorporating hand gestures, users can simulate the preparation and tasting of Wadai Banjar, making the experience more interactive and memorable. Besides that, when users can use their hands to control interactions in the game, it is hoped that users will feel happier playing the game and that Wadai Banjar will be easier to remember. This correlation is because the more accurate and realistic a control movement is, the more a user will feel that the interaction is natural, thus the higher spatial presence and enjoyment the user feels when playing the game [20].

The rise of the digital age has further exacerbated the decline in traditional knowledge transfer, creating an urgent need for innovative methods to engage and educate people about cultural heritage. VR has emerged as a powerful tool in cultural education, offering immersive and interactive environments that bridge the gap between tradition and technology. By providing realistic simulations and engaging experiences, VR has proven to be effective in promoting cultural knowledge while enhancing user engagement and retention. However, the application of VR in preserving intangible food heritage, such as Wadai Banjar, remains largely unexplored, particularly in Indonesia. This research addresses this gap by leveraging VR technology to present Wadai Banjar in an interactive and educational format.

The novelty of this study lies in its innovative application of VR technology to merge cultural preservation with immersive educational experiences. While prior research has utilized VR to preserve traditional practices such as music and martial arts, this study uniquely focuses on food heritage—a vital but often underrepresented aspect of intangible culture. By incorporating cutting-edge VR technologies, such as hand gesture tracking, the application enables users to learn about the history and cultural significance of Wadai Banjar while engaging in a simulated preparation process. This interactive and engaging approach not only enhances user immersion but also offers a memorable and educational experience, representing a significant advancement in the use of VR for cultural preservation. Furthermore, by addressing the challenges of maintaining cultural heritage in the digital age, this study expands the scope of VR applications, providing critical insights into how interactive technologies can foster cultural appreciation and education, particularly for future generations.

2. Method

This study employed the Game Development Life Cycle (GDLC) methodology to develop a VR game designed to preserve and promote the cultural heritage of Wadai Banjar. The methodology was chosen for its structured, iterative approach, which ensures that development processes align with both technical and cultural objectives. Additionally, the study integrates hand gesture interaction technology to enhance user immersion and interactivity, leveraging state-of-the-art VR hardware and software.

2.1. Game Development Life Cycle (GDLC)

The development method used in this research is the GDLC method, adapted from research by [21]. The GDLC method involves six stages: Initiation, Pre-Production, Production, Testing, Beta, and Release. The flow of the GDLC method is presented in Fig. 2. Each stage was tailored to meet the objectives of cultural education and user engagement.

- Initiation Stage: During this stage, the conceptual framework of the game was established, focusing on the cultural and educational goals of introducing Wadai Banjar. Key requirements were identified through consultations with ten stakeholders, including cultural experts and educators from the Banjar tribe. The outcome was a clear vision for a VR game that incorporates traditional Banjar culinary heritage with modern interactive technology.
- Pre-Production Stage: The game design was formalized during this stage, including storyboarding and the creation of prototypes. A detailed storyboard outlined the gameplay,

narrative flow, and cultural elements to ensure authenticity. Hand gesture interactions were integrated into the design to provide an intuitive and immersive user experience, leveraging the hand-tracking capabilities of the Meta Quest 2 headset.

- Production Stage: This stage focused on creating and integrating game assets, developing source code, and implementing gameplay mechanics. Visual assets of Wadai Banjar were meticulously designed to reflect their cultural and aesthetic significance. Unity 2020.3.48f1 was used as the primary development platform due to its robust support for VR development and compatibility with the Meta Quest 2. Hand gesture interactions were implemented using the Meta Quest 2's inside-out camera system, which tracks the position and orientation of users' hands and fingers. This method was chosen over traditional controllers for its ability to provide natural, intuitive interactions, enhancing user immersion.
- Testing Stage: Internal testing was conducted using black-box testing to ensure the functionality of the game mechanics, including hand gesture interactions, cultural fidelity, and visual presentation. Any identified bugs or inconsistencies were resolved before proceeding to external testing.
- Beta Stage: In this stage, the game was tested by 10 external participants, including five young adults and five educators from the Banjar tribe. Participants were selected to represent the intended audience of the game. Feedback was collected through structured questionnaires and focus group discussions, evaluating the game's usability, engagement, and educational value.
- Release Stage: Following iterative refinements based on user feedback, the game was finalized and prepared for public release. This stage ensured that the game met all technical, educational, and cultural objectives

2.2. Hand Gesture Interaction Technology

The Meta Quest 2 headset was selected for its advanced hand-tracking capabilities, which eliminate the need for external controllers. This feature uses built-in cameras and computer vision algorithms to detect hand movements and gestures, offering a more intuitive and immersive user experience. Key gestures include pointing and pinching to select objects and hand movements for object manipulation, providing a natural interaction method aligned with the game's cultural context. Hand gesture interaction was chosen over traditional controllers for its ability to simulate real-world actions, enhancing the sense of presence and engagement

2.3. Evaluation Metrics and Data Collection

The game's effectiveness was evaluated using a combination of Playtesting, Gameflow, and immersion metrics. The evaluation framework focused on three key areas: user engagement, immersion, and educational impact. The following tools and methods were used:

- Playtesting and Gameflow Evaluation: Participants rated their experience using a structured questionnaire adapted from the Gameflow model. Metrics included enjoyment, challenge, control, clear goals, feedback, and immersion. Average scores were calculated for each element to identify strengths and areas for improvement.
- Immersion Assessment: Immersion levels were measured using the Temple Presence Inventory (TPI), a validated tool for assessing telepresence in virtual environments. Metrics included spatial presence, social presence, and mental immersion. High scores indicated intense user immersion and engagement.
- Educational Impact: Participants provided qualitative feedback on the game's educational value, specifically regarding their understanding of Wadai Banjar and its cultural significance. The impact was assessed through post-game interviews and thematic analysis of participant responses.

2.4. Data Collection and Analysis

Quantitative data, such as Playtesting and TPI scores, were analyzed using descriptive statistics to identify trends and overall effectiveness. Qualitative data from interviews and open-ended questionnaire responses were thematically analyzed to extract insights about user experiences and

cultural understanding. All findings were used to refine the game and validate its effectiveness as a tool for cultural preservation and education.

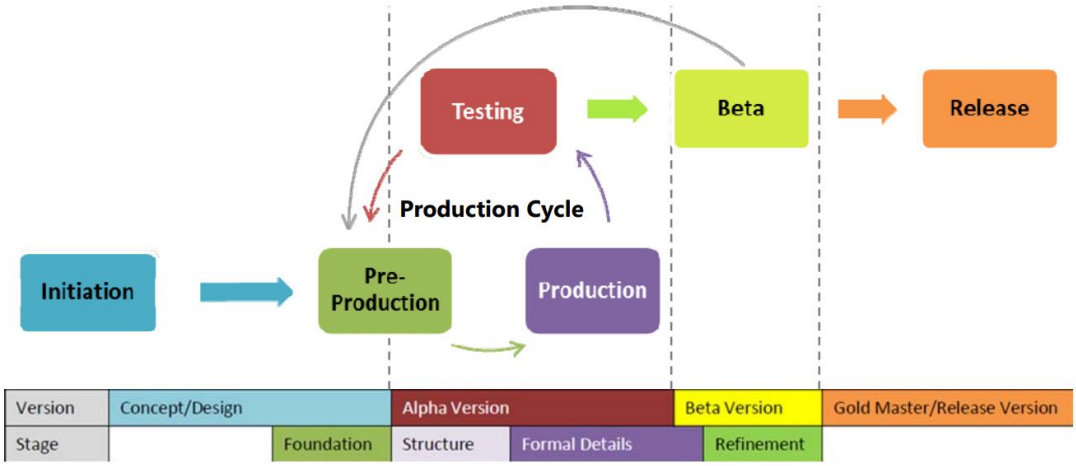

Fig. 2. Game Development Life Cycle (GDLC)

3. Results and Discussion

3.1. Initation

In the Initiation stage, a requirement analysis was conducted with ten resource persons from the Banjar tribe, including young members and teaching staff, to formulate the game concept. The resulting "Game Virtual Reality Wadai Banjar 41 Macam" is an educational simulation with five difficulty levels. Players learn about Wadai Banjar, including their shapes, ingredients, and preparation, before taking on the role of a seller fulfilling customer orders. Accurate orders increase the player's score, while mistakes result in no payment. A storyboard and a list of hand gesture interactions were developed to support the game design, as shown in Fig. 3 and Table 1.

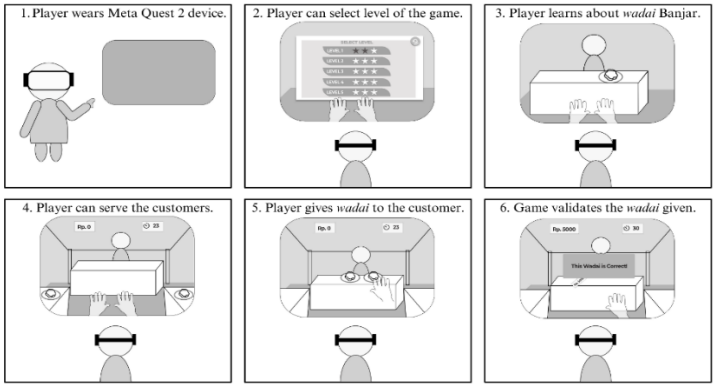

Fig. 3. Storyboard

Table.1 Hand Gesture Interactions

Gesture	Function	How to do it
Point and Pinch	To select something.	When the cursor appears, Players point their hand to the object they wish to select. Then, Players pinch their thumb and finger to select.
Pinch and Scroll	Scrolling up, down, left, or right.	Players pinch their thumb and finger inward. While still pinched inward, They can move their hand up, down, left, or right to scroll. When they are done scrolling, they can release.
Hand	To interact with objects.	When the virtual hand appears, Players can use their own hands to direct it and interact with objects. For example, if a player wants to take an object, they move their hand to take the object, and the virtual hand follows.

3.2. Pre-Production

At this stage, a reality sequence was created to map the mixed reality user flow, following the method developed by Lilian Warner et al. in 2017. Unlike traditional user flows, a reality sequence effectively illustrates the user journey and interactions in mixed-reality environments. It combines elements of a storyboard (depicting scenes and narratives) with user flow (describing specific interactions and goals) [22]. The game's reality sequence, shown in Fig. 4, includes (1) Scene names, (2) Input options for interaction, (3) Audio elements describing actions or feedback, and (4) User actions defining movement and choices.

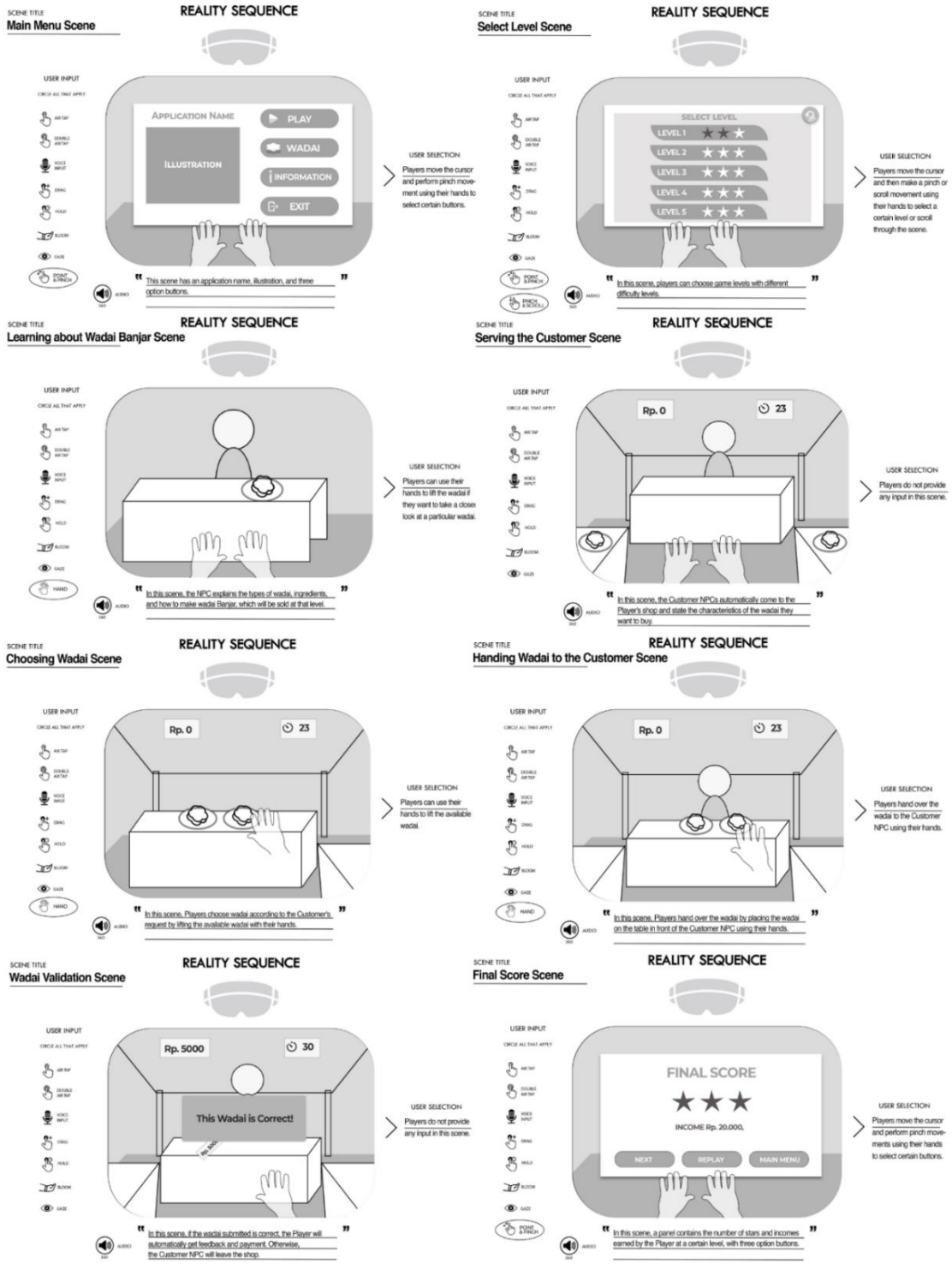

Fig. 4. Reality sequence diagram

3.3. Production

The implementation of the Game Virtual Reality Wadai Banjar 41 Macam was developed based on reality sequence designs that had been created previously. This implementation was created by integrating assets and source code in Unity 2020.3.48f1. The game scenes include the Main Menu scene, Select Level scene, Learning about Wadai Banjar scene, Serving the Customer scene, Choosing Wadai scene, Handing Wadai to the Customer scene, Wadai Validation scene, and Final Score scene. The scenes of the game are presented in Fig. 5.

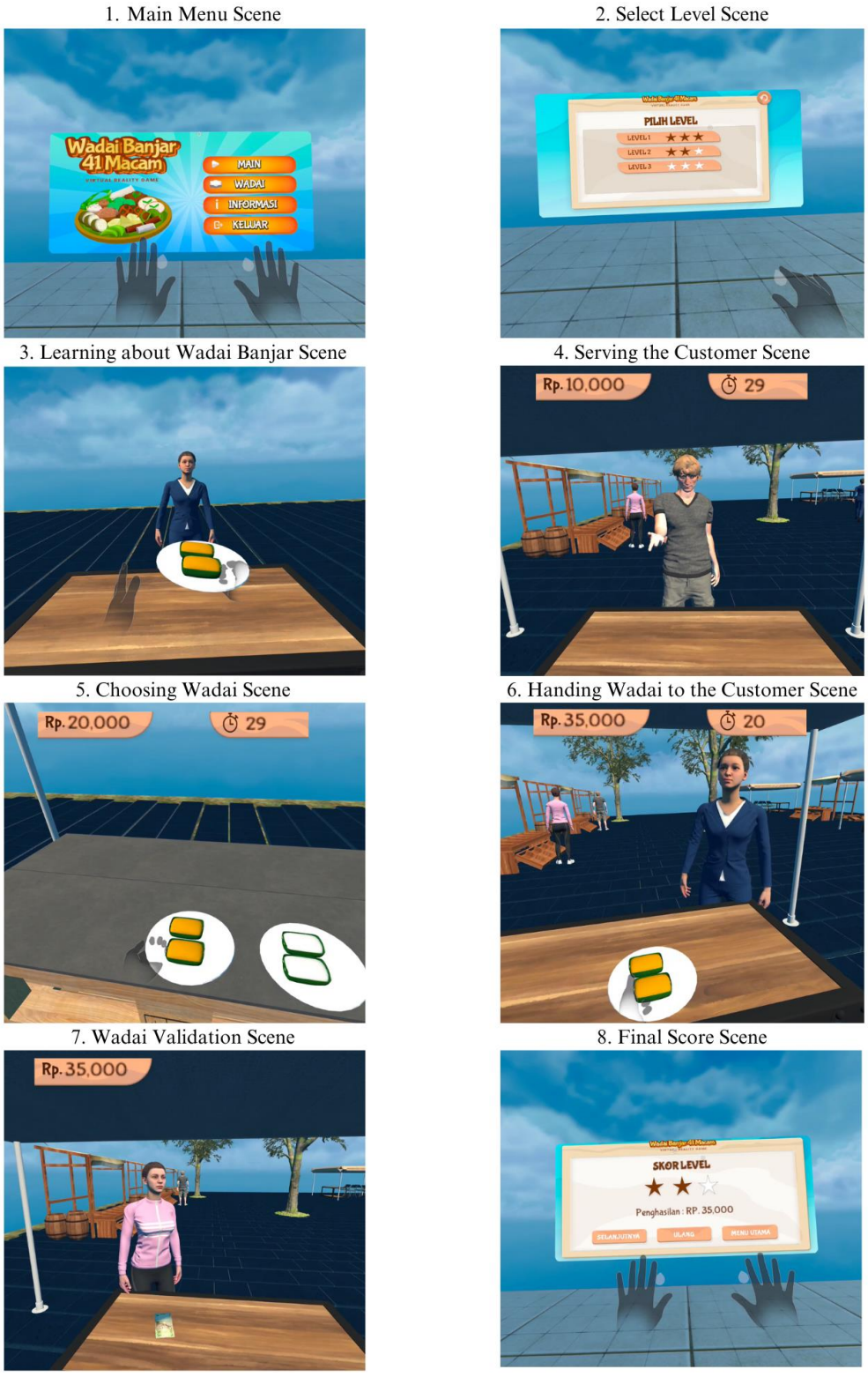

Fig. 5. Scenes implementation

3.4. Testing Stage

Internal testing was conducted at this stage to evaluate the validity of the functionality of the developed game. The Black Box Testing method was employed to verify that all features and interactions functioned as intended. The results confirmed that all functionalities were working correctly, ensuring the game met its design and development specifications.

3.5. Beta Stage

Following functionality testing with the BlackBox Testing method, the development proceeded to the Beta stage, where external testing focused on evaluating the game's playability and usability. Ten participants, including five young members and five teaching staff from the Banjar tribe, played the game and completed questionnaires assessing various aspects. Fig. 6 illustrates the testing process.

Fig. 6. Photos of respondents in the Beta testing process

The Playtesting and Gameflow method, adapted from [23], was employed to gather feedback on game elements such as graphics, gameplay, story, and controls. Additionally, the method assessed players' enjoyment and engagement with the game. The results of this evaluation, presented in Table 2, provided valuable insights for refining the game's design and user experience. The result of testing the game using the Playtesting and Gameflow method is presented in Table. 2.

Table.2 Playtesting and Gameflow Result

No.	Criteria	Scale					Total	Average
		1	*2*	*3*	*4*	*5*		
1	Players do not feel burdened by unimportant tasks.		1	2	4	3	39	3.9
2	The game can quickly attract the player's attention, and the player can maintain focus throughout the game.			1	1	8	47	4.7
	Average Score of the Concentration Element							4.3
3	Games provide different levels of challenge.				6	4	44	4.4
4	The level of challenge increases as the player's ability to play the game develops.				4	6	46	4.6
5	The game provides new challenges in the next scene/level.			1	5	4	43	4.3
	Average Score of the Challenge Element							4.433
6	Players are taught to play the game through tutorials or initial levels that make them feel like they are playing it.			2	2	6	44	4.4
7	The game can improve the player's abilities at an appropriate pace as the game progresses.			2	4	4	42	4.2
8	Players feel that they are appropriately rewarded for the player's efforts and skills in playing the game.			1	6	3	42	4.2
9	The game interface and mechanics are easy to learn and use.			2	3	5	43	4.3
	Average Score of the Player Skills Element							4.275
10	Players can feel control over the player's character or unit, movement, and player interaction in the game world.			2	5	3	41	4.1
11	Players can experience control over the game interface and input devices.				5	5	45	4.5

No.	Criteria	Scale					Total	Average
		1	*2*	*3*	*4*	*5*		
12	Players can feel the control and impact of player actions within the game world.			1	5	4	43	4.3
	Average Score of the Control Element							4.3
13	The main goal of the game is clear and easy to understand.				3	7	47	4.7
14	Other objectives are clear, easy to understand, and presented promptly.			3	1	6	43	4.3
	Average Score of the Clear Goals Element							4.5
15	Players receive immediate feedback on their actions.			1	3	6	45	4.5
16	Players always know their status and scores.				4	6	46	4.6
	Average Score of the Feedback Element							4.55
17	Players become less aware of their surroundings when playing games.		2		4	4	40	4
18	Players feel unaware of changes in time while playing the game (time feels like it is running faster).		1	2	3	4	40	4
19	Players feel deeply involved while playing the game.			3	3	4	41	4.1
	Average Score of the Immersion Element							4.033
20	Players feel like talking about this game with other people.		1	1	3	5	42	4.2
	Average Score of the Social Interaction Element							4.2
	Average Score of Playtesting and Gameflow							4.324

Based on the evaluation results using the Playtesting and Gameflow method, the average score was 4.324 out of 5. This data shows that end-users agree that the Game Virtual Reality Wadai Banjar 41 Macam has good game aspects and is fun to play. The elements that get the highest assessment compared to other elements are the Clear Goals and Feedback elements. This result shows that the end-user feels the game has provided clear goals at the right time and has provided the proper feedback at the right time.

In this stage, apart from testing the game aspects using the Playtesting and Gameflow method, tests are conducted to measure the level of immersivity of the game that has been developed. The factors used to measure immersive are telepresence, controller naturalness, and cybersickness felt by the user. The telepresence factor was measured using The Temple Presence Inventory (TPI), adapted from research by [24]. The controller naturalness factor was measured using Skalski's Perceived Controller Naturalness Scale, adapted from research by [20]. The cybersickness factor was measured using the Cybersickness in Virtual Reality Questionnaire (CSQ-VR), adapted from research by [25]. Table. 3 presents the results of testing the telepresence factor of the game using the TPI method.

Table.3 The Temple Presence Inventory (TPI) Result

No.	Criteria	Scale							Total
		1	*2*	*3*	*4*	*5*	*6*	*7*	
1	How much did it seem that the objects and people you saw/heard had come to where you were?		1			2	3	4	58
2	How much did it seem as if you could reach out and touch the objects or people you saw/heard?				1	2	2	5	61
3	How often, when an object seemed to be headed toward you, did you want to move to get out of its way?	1	2	1	1		1	4	46
4	To what extent did you experience a sense of being there inside the environment you saw/heard?			1		2	4	3	58
5	To what extent did it seem that sounds came from specific different locations?			1	1	2	1	5	58
6	How often did you want to or try to touch something you saw/heard?				1	1	3	5	62
7	Did the experience seem more like looking at the events/people on a movie screen or more like looking at the events/people through a window?	1		1	1	2	1	4	52

No.	Criteria	Scale							Total
		1	*2*	*3*	*4*	*5*	*6*	*7*	
	Average Total Score of the Spatial Presence Dimension								56.43
8	How often did you feel that people you saw/heard could also see/hear you?			1	2	1		6	58
9	To what extent did you feel you could interact with the person or people you saw/heard?			1	3		2	4	55
10	How much did it seem as if you and the people you saw/heard both left the places where you were and went to a new place?			2	2			6	56
11	How much did it seem as if you and the people you saw/heard were together in the same place?			1		1	3	5	61
12	How often did it feel that someone you saw/heard in the environment was talking directly to you?			1	1	2	3	3	56
13	How often did you want to or did you make eye contact with someone you saw/heard?				2		5	3	59
14	Seeing and hearing a person through a medium constitutes an interaction with him or her. How much control over the interaction with the person or people you saw/heard did you feel you had?			1	1	1	1	6	60
	Average Total Score of Social Presence – Actor within Medium								57.86
15	During the media experience, how well were you able to observe the facial expressions of the people you saw/heard?			2		1	1	6	59
16	During the media experience, how well were you able to observe the changes in the tone of voice of the people you saw/heard?			1	2		4	3	56
17	During the media experience, how well could you observe the dress style of the people you saw/heard?		1		1	1	1	6	59
18	During the media experience, how well could you observe the body language of the people you saw/heard?			2		2	3	3	55
	Average Total Score of Social Presence – Passive Interpersonal								57.25
19	How often did you make a sound out loud (e.g., laugh or speak) in response to someone you saw/heard in the media environment?		1		1	1	4	3	56
20	How often did you smile in response to someone you saw/heard in the media environment?			2	1	1		6	57
21	How often did you want to or did you speak to a person you saw/heard in the media environment?		1	1		1	2	5	57
	Average Total Score of Social Presence – Active Interpersonal								56.67
22	To what extent did you feel mentally immersed in the experience?			1	2		3	4	57
23	How involved was the experience?			1	1	1	1	6	60
24	How completely were your senses engaged?		1	2		1		6	55
25	To what extent did you experience a sensation of reality?			1	1	1		7	61
26	How relaxing or exciting was the experience?				2	1	1	6	61
27	How engaging was the story?			2	1		1	6	58
	Average Total Score of Engagement (Mental Immersion)								58.67
28	Remote - Immediate		1		1	1	4	3	56
29	Unemotional - Emotional		1	1	1	1	1	5	55
30	Unresponsive - Responsive				3	1	3	3	56
31	Dead - Lively			2	1		3	4	56
32	Impersonal - Personal		1		2	1	3	3	54
33	Insensitive - Sensitive			1	1	2	1	5	58
34	Unsociable - Sociable			2			1	7	61
	Average Total Score of the Social Richness Dimension								56.57
35	The events I saw/heard would occur in the real world.				1	1	4	4	61
36	The events I saw/heard could occur in the real world.				2		2	6	62

No.	Criteria	Scale							Total
		1	*2*	*3*	*4*	*5*	*6*	*7*	
37	How the events I saw/heard occurred is a lot like the way they occur in the real world				1	1	2	6	63
	Average Total Score of the Social Realism Dimension								62
38	How much did touching the things and people in the environment you saw/heard feel like it would if you had experienced them directly?			1		2	2	5	60
39	How much did the heat or coolness (temperature) of the environment you saw/heard feel like it would if you had experienced it directly?		1	2	2		2	3	49
40	Overall, how much did the things and people in the environment you saw/heard smell like they would have you experienced them directly?	2		1	3		3	1	42
41	Overall, how much did the things and people in the environment you saw/heard look like they would if you had experienced them directly?			1		2	3	4	59
42	Overall, how much did the things and people in the environment you saw/heard sound like they would if you had experienced them directly?			1	2	2	2	5	61
	Average Total Score of the Perceptual Realism Dimension								54.2
	Average Total Score of The Temple Presence Inventory (TPI)								64.46

Table. 4 presents the results of testing the controller naturalness factor of the game using Skalski's Perceived Controller Naturalness Scale.

Table.4 Skalski's Controller Naturalness Scale Result

No.	Criteria	Scale							Total
		1	*2*	*3*	*4*	*5*	*6*	*7*	
1	The game controls seemed natural.			1		2	2	5	60
2	The actions used to interact with the game environment were similar to those used to do the same things in the real world.					2	1	7	65
3	The game interface was not realistic.					2		8	66
4	The game environment was manipulated in a lifelike manner.			1		1	2	6	62
5	The actions I performed with the controller were closely connected to the actions happening in the game environment.				1	2	3	4	60
6	The actions used to control the game seemed natural.		1		1		1	7	61
	Average Total Score of Skalski's Controller Naturalness Scale								62.3

Table. 5 presents the results of testing the cybersickness factor of the game using the CSQ-VR. Based on the telepresence factor testing results using The TPI method, the average total score for the Game Virtual Reality Wadai Banjar 41 Macam was 64.46 out of 70. This data shows that end-users agree that the game has shown a high level of telepresence, so the user experience when using the virtual reality game has been quite good, almost like a real live experience. The dimension that received the highest assessment compared to other dimensions was the Social Realism dimension. Meanwhile, the dimension that received the lowest assessment compared to the other dimensions was the Perceptual Realism dimension. A high score on the Social Realism dimension indicates that the depiction of objects, events and people in the game is reasonable or "real"; it accurately reflects events that occur or could occur in the real world (the unmediated world). Meanwhile, the Perceptual Realism score level, which is not too high, indicates that the objects, events, and people in the game are not yet fully photorealistic (a state where the quality in art such as animation and painting depicts or seems to depict people and objects very real like a photo).

Table.5 Cybersickness in Virtual Reality Questionnaire (CSQ-VR) Result

No.	Symptom	Scale							Total
		1	*2*	*3*	*4*	*5*	*6*	*7*	
1	Do you experience nausea (e.g., stomach pain, acid reflux, or tension to vomit)?	6	3			1			17
2	Do you experience dizziness (e.g., light-headedness or spinning feeling)?	5	4	1					16
3	Do you experience disorientation (e.g., spatial confusion or vertigo)?	7	2	1					14
4	Do you experience postural instability (i.e., imbalance)?	7	3						13
5	Do you experience visually induced fatigue (e.g., feeling of tiredness or sleepiness)?	7		3					16
6	Do you experience a visually induced discomfort (e.g., eyestrain, blurred vision, or headache)?	5	2	1	2				20
	Average Total Score of Cybersickness Questionnaire (CSQ-VR)								16

The controller naturalness of the Game Virtual Reality Wadai Banjar 41 Macam was evaluated using Skalski's Perceived Controller Naturalness Scale, achieving an average score of 62.3 out of 70. This result indicates that users found the hand gesture controls intuitive and realistic, enhancing their overall gaming experience. The highest-rated criteria were items 3 and 2, with scores of 66 and 65, respectively. These scores reflect that users perceived the game interface as highly realistic and felt that the actions performed within the virtual environment closely mirrored real-world interactions.

Cybersickness was assessed using the CSQ-VR, where the game received a low average score of 16 out of 70. This suggests that the game induces minimal discomfort, allowing users to play comfortably without significant adverse effects. The highest-rated symptom, with a score of 20, was visually induced discomfort, where a few participants reported minor issues such as eye strain, blurred vision, or headaches. Conversely, the lowest-rated symptom, disorientation (score of 14), showed that nearly all users did not experience spatial confusion or vertigo while playing. These results demonstrate the game's strong usability and comfort levels, ensuring a positive and immersive user experience.

3.6. Discussion

This study developed and evaluated an immersive VR game, "Game Virtual Reality Wadai Banjar 41 Macam," to introduce users to the traditional cakes of the Banjar tribe in Indonesia through hand gesture interaction. The findings demonstrate the game's ability to engage users in a rich cultural and culinary experience effectively. Immersion was supported by two key factors: telepresence, which scored 64.46 out of 70 using the TPI, and controller naturalness, which scored 62.3 out of 70 on Skalski's Perceived Controller Naturalness Scale. Additionally, the game achieved a low cybersickness score of 16 out of 70, indicating a comfortable and enjoyable user experience.

The broader social and cultural implications of this study are significant. VR technology provides an innovative platform for cultural preservation, particularly in engaging younger audiences who are increasingly distanced from traditional practices [26]. By creating an interactive and immersive experience, the game bridges generational gaps, making cultural education more accessible and appealing to tech-savvy users. This approach is crucial in ensuring the continuity of intangible cultural heritage like Wadai Banjar in a rapidly modernizing world.

Compared to similar studies, this research extends the application of VR in cultural education by focusing on food heritage, an often-overlooked aspect of intangible culture. Previous works have utilized VR to teach traditional music or martial arts, such as Gamelan and Pencak Silat, achieving high usability and immersion scores. This study builds on those findings by demonstrating that food heritage can also be effectively preserved and promoted through VR, expanding the scope of VR's role in cultural education.

Despite its successes, the study has limitations that offer opportunities for future research. The current VR experience focuses exclusively on Wadai Banjar. It could be expanded to include other

cultural elements, such as traditional stories, dances, or broader culinary practices, to provide a more holistic representation of Banjar heritage. Additionally, while the hand gesture controls were found to be natural and intuitive, further refinement is needed to enhance precision and responsiveness, especially for complex interactions. Future studies could also explore the use of advanced haptic feedback to improve the realism of the experience.

Finally, a longitudinal approach is recommended to assess the long-term impact of VR cultural education on users' cultural knowledge, retention, and engagement. By addressing these areas, future research could further establish VR as a transformative tool for cultural preservation and education, ensuring that traditional heritage remains vibrant and relevant in the digital age

4. Conclusion

This study demonstrates the potential of Virtual Reality (VR) as an innovative tool for cultural preservation and education, particularly in introducing and engaging users with Wadai Banjar, a traditional cake from South Kalimantan. By integrating hand gesture interaction within the Meta Quest 2 VR environment, the developed game effectively immerses users in the cultural and historical significance of Wadai Banjar while providing an engaging and interactive learning experience. The evaluation results indicate a high level of telepresence (64.46/70), strong controller naturalness (62.3/70), and minimal cybersickness (16/70), affirming the effectiveness of the game's design in fostering an intuitive and immersive user experience. These findings highlight the potential of VR not only as an educational platform but also as a means to bridge generational gaps and enhance cultural appreciation among younger audiences. Despite these achievements, several areas remain in need of improvement. Expanding the game to incorporate additional cultural elements, such as traditional storytelling or dance, could further enrich the learning experience. Moreover, refining the hand gesture controls to improve precision and incorporating haptic feedback may enhance the realism of interactions. A longitudinal study could also be conducted to assess the long-term impact of VR cultural education on knowledge retention and user engagement. Ultimately, this research underscores the growing significance of immersive technology in preserving intangible cultural heritage. By leveraging VR, this study provides a compelling model for integrating tradition with modern digital experiences, ensuring that cultural knowledge remains relevant and accessible in the digital era.

References

[1] Z. Gibbons, "UNESCO calls Indonesia a cultural superpower," *KWRI UNESCO*, 2017. [Online]. Available at: https://kwriu.kemdikbud.go.id/berita/unesco-sebut-indonesia-negara-super-power-bidang-budaya/.

[2] A. D. Hapip, *Banjar-Indonesian Dictionary*. Pusat Pembinaan dan Pengembangan Bahasa, 2017. [Online]. Available at: https://repositori.kemdikbud.go.id/2888/.

[3] M. S. Seman, *Banjar Cake 41 Kinds of Banjarmasin*, 1st ed. Banjar: Lembaga Pendidikan Banua, 2009. [Online]. Available at: https://repositori.kemdikbud.go.id/2888/.

[4] A. K. Bhowmik, "Virtual and augmented reality: Human sensory-perceptual requirements and trends for immersive spatial computing experiences," *J. Soc. Inf. Disp.*, vol. 32, no. 8, pp. 605–646, Aug. 2024, doi: 10.1002/jsid.2001.

[5] C. R. Guerra-Tamez, "The Impact of Immersion through Virtual Reality in the Learning Experiences of Art and Design Students: The Mediating Effect of the Flow Experience," *Educ. Sci.*, vol. 13, no. 2, p. 185, Feb. 2023, doi: 10.3390/educsci13020185.

[6] A. M. Al-Ansi, M. Jaboob, A. Garad, and A. Al-Ansi, "Analyzing augmented reality (AR) and virtual reality (VR) recent development in education," *Soc. Sci. Humanit. Open*, vol. 8, no. 1, p. 100532, Jan. 2023, doi: 10.1016/j.ssaho.2023.100532.

[7] J. Radianti, T. A. Majchrzak, J. Fromm, and I. Wohlgenannt, "A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda," *Comput. Educ.*, vol. 147, p. 103778, Apr. 2020, doi: 10.1016/j.compedu.2019.103778.

[8] B. Xie *et al.*, "A Review on Virtual Reality Skill Training Applications," *Front. Virtual Real.*, vol. 2, p. 645153, Apr. 2021, doi: 10.3389/frvir.2021.645153.

[9] P. Kourtesis and S. E. MacPherson, "How immersive virtual reality methods may meet the criteria of the National Academy of Neuropsychology and American Academy of Clinical Neuropsychology: A software review of the Virtual Reality Everyday Assessment Lab (VR-EAL)," *Comput. Hum. Behav. Reports*, vol. 4, p. 100151, Aug. 2021, doi: 10.1016/j.chbr.2021.100151.

[10] P. M. G. Emmelkamp and K. Meyerbröker, "Virtual Reality Therapy in Mental Health," *Annu. Rev. Clin. Psychol.*, vol. 17, no. 1, pp. 495–519, May 2021, doi: 10.1146/annurev-clinpsy-081219-115923.

[11] C. Cruz-Neira, M. Fernández, and C. Portalés, "Virtual Reality and Games," *Multimodal Technol. Interact.*, vol. 2, no. 1, p. 8, Feb. 2018, doi: 10.3390/mti2010008.

[12] F. Permana, H. Tolle, F. Utaminingrum, and R. Dermawi, "Development of Augmented Reality (AR) Based Gamelan Simulation with Leap Motion Control," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 12, p. 120, Dec. 2019, doi: 10.3991/ijim.v13i12.9270.

[13] J. Sampoerna, W. Istiono, and A. Suryadibrata, "Virtual Reality Game for Introducing Pencak Silat," *Int. J. Interact. Mob. Technol.*, vol. 15, no. 01, p. 199, Jan. 2021, doi: 10.3991/ijim.v15i01.17679.

[14] O. J. Nwobodo, K. Wereszczyński, and K. Cyran, "A review on tracking head movement in augmented reality systems," *Procedia Comput. Sci.*, vol. 225, pp. 4344–4353, 2023, doi: 10.1016/j.procs.2023.10.431.

[15] A. Mitre-Ortiz, J. Muñoz-Arteaga, and H. Cardona-Reyes, "Developing a model to evaluate and improve user experience with hand motions in virtual reality environments," *Univers. Access Inf. Soc.*, vol. 22, no. 3, pp. 825–839, Aug. 2023, doi: 10.1007/s10209-022-00882-y.

[16] T. H. Laine and H. J. Suk, "Investigating User Experience of an Immersive Virtual Reality Simulation Based on a Gesture-Based User Interface," *Appl. Sci.*, vol. 14, no. 11, p. 4935, Jun. 2024, doi: 10.3390/app14114935.

[17] P. Monteiro, G. Goncalves, H. Coelho, M. Melo, and M. Bessa, "Hands-free interaction in immersive virtual reality: A systematic review," *IEEE Trans. Vis. Comput. Graph.*, vol. 27, no. 5, pp. 2702–2713, May 2021, doi: 10.1109/TVCG.2021.3067687.

[18] M. N. Iman Sa'adon, M. S. Sunar, and K. N. Ali, "Multi-Platform Virtual Reality Interaction with Hand Gestures for Precise Object Manipulation and Multi-User Collaboration," in *2023 3rd International Conference on Intelligent Cybernetics Technology & Applications (ICICyTA)*, Dec. 2023, pp. 312–317, doi: 10.1109/ICICyTA60173.2023.10428981.

[19] H. S. Moon, G. Orr, and M. Jeon, "Hand Tracking with Vibrotactile Feedback Enhanced Presence, Engagement, Usability, and Performance in a Virtual Reality Rhythm Game," *Int. J. Human–Computer Interact.*, vol. 39, no. 14, pp. 2840–2851, Aug. 2023, doi: 10.1080/10447318.2022.2087000.

[20] P. Skalski, R. Tamborini, A. Shelton, M. Buncher, and P. Lindmark, "Mapping the road to fun: Natural video game controllers, presence, and game enjoyment," *New Media Soc.*, vol. 13, no. 2, pp. 224–242, Mar. 2011, doi: 10.1177/1461444810370949.

[21] R. Ramadan and Y. Widyani, "Game development life cycle guidelines," in *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, Sep. 2013, pp. 95–100, doi: 10.1109/ICACSIS.2013.6761558.

[22] L. Warner, "Mixed Reality User Flows: A New Kind of Template," *Medium*, 2017. [Online]. Available at: https://blog.prototypr.io/mixed-reality-user-flows-a-new-kind-of-template-27d59991de4a.

[23] P. Sweetser and P. Wyeth, "GameFlow," *Comput. Entertain.*, vol. 3, no. 3, pp. 3–3, Jul. 2005, doi: 10.1145/1077246.1077253.

[24] M. Lombard, T. B. Ditton, and L. Weinstein, "Measuring Presence: The Temple Presence Inventory," *Proceeding Presence 2009 12th Int. Work. Presence*, no. January, pp. 1–14, 2009, [Online]. Available at: https://www.researchgate.net/profile/Theresa-Bolmarcich/publication/228450541.

[25] P. Kourtesis, J. Linnell, R. Amir, F. Argelaguet, and S. E. MacPherson, "Cybersickness in Virtual Reality Questionnaire (CSQ-VR): A Validation and Comparison against SSQ and VRSQ," *Virtual Worlds*, vol. 2, no. 1, pp. 16–35, Jan. 2023, doi: 10.3390/virtualworlds2010002.

[26] W. Wu and X. Yang, "Analysis of the Dissemination Effects of VR Audiovisual Arts on Local Culture in Cross-Cultural Contexts: A Case Study of the Broadcasting and Television Industry," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 14702 LNCS, Springer, Cham, 2024, pp. 60–73, doi: 10.1007/978-3-031-60913-8_5 .