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Designing an Interactive and Educational Virtual Reality Game for Museum Bahari

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ABSTRACT

This study explores the potential of Virtual Reality (VR) technology to enhance museum visitor engagement through the "Jelajah Bahari" VR game at Museum Bahari, DKI Jakarta. By integrating VR, the museum offers an immersive and interactive experience that brings Indonesia's maritime heritage to life. This VR game combines educational content with an engaging narrative, allowing users to embody a Pinisi ship captain on a journey to Kepulauan Seribu. It was tested by museum staff and evaluated qualitatively. It showed positive responses to the game's design and educational value, highlighting VR game's potential to increase visitor's curiosity and engage younger audience. However, challenges like VR unfamiliarity, equipment maintenance, and visitor safety considerations were noted as essential to successful implementation. These findings indicate that, with proper support, VR installations can significantly benefit Indonesian museums by making historical education more engaging and accessible. Overall, the "Jelajah Bahari" VR game serves as a model for other museums seeking to integrate immersive technology, showcasing VR's potential to elevate traditional exhibits and broaden cultural engagement in an evolving digital landscape.

Keywords: virtual reality, human-technology interaction, user experience, museum, audience development

INTRODUCTION

Museum Bahari or Maritime Museum houses an extensive collection of boats and ships, including full-size and scale models, providing a historical learning experience of Jakarta's maritime history over the past centuries. Its strategic location at the Kota Tua or Old Town offers direct access to other museums such as Museum Fatahillah, Museum Wayang, Museum Seni dan Keramik, Museum Bank Indonesia, and Museum Bank Mandiri by walking distance, illustrating the potential of the museum to attract large numbers of visitors while promoting Indonesian history and culture.

Figure 1. Museum Kebaharian Jakarta
source: author's documentation

This research aims to maximize the museum's potential using audience development strategies based on Hansen (2024) and Kawashima (2024) The strategies are narrowed down to attendees instead of non-attendees, namely taste cultivation for positive attendees and audience education for negative attendees. Both are combined to create a better experience at the museum, hopefully prompting the visitors to revisit, share the experience, and invite others.

With the demand of museums to integrate technology into how they display and present their collections (Erbay, 2019), the research utilizes Virtual Reality (VR) technology to create a new immersive experience based on the museum's theme

and collections. Apart from that, the product development is based on the data gathered from the museum workers both in the ideation and validation process.

Figure 2. Example of Vr experience at Petrosains, Malaysia
source: author's documentation

VR is an experience where the user is stimulated by artificial stimulation and unaware of being in the virtual environment (LaValle, 2023). That sensation is also called presence, which (Slater, 2009) defined as a plausible illusion (PI). Together with plausibility illusion, VR users will give responses similar to what they usually respond to.

Another important aspect of VR is embodiment. A VR user embodies an avatar where one can experience the virtual environment (VE) in a first-person view. This embodiment creates a more natural understanding of the presented narratives in the VR experience that cannot be found using traditional monitors (Rose & Green, 2021). Particularly in a VR game, a player, who is embodied in an avatar, can interact and receive haptic feedback, commonly using the hand controllers. Despite its immersion, the current VR headsets in the mass market are still heavy and have limited display resolution. As a result, players can feel fatigue and motion sickness (Jerald, 2015).

Considering the primary function of museums to collect and preserve artifacts for educational purposes and the rising importance of entertainment for museum visitors (Packer, J., & Bond, 2010), the research applies VR technology in the form of an educational and interactive game. Games in the cultural heritage domain

have been studied in various mediums, including board games, video games, and VR games. Specifically in the museum sector, improving visitors' engagement and providing a more interactive educational experience is useful (Carrozzino & Bergamasco, 2010). Several Indonesian museums have implemented more interactive technology in exhibiting their collections and providing education, such as in immersive large-screen projections in Museum Gedung Sate Bandung and the National Museum of Indonesia. It has successfully attracted more visitors and increased their engagement through its 360 videos (Demolingo & Remilenita, 2023). However, Indonesian museums that provide VR experiences are difficult to find. Looking at the research by Yudhawasthi (2017), there are only 3 percent of the total of 434 museums in Indonesia who used digital display in their exhibition. This shows the low use of digital technology in the Indonesian museum.

Figure 3. Immersive room with large projection where visitors can interact
Source: Museum Nasional official website (Mulyadi, 2022)

A VR game has opportunities to implement interactive technology at a lower cost than large-screen projections, and it has higher mobility to be exhibited outside the museum at external events. Moreover, a VR user can have greater empathy by embodying the avatar as part of the narrative (Barbot & Kaufman, 2020). In this case, the narrative is part of the learning experience of the museum, and VR technology can create a special experience that cannot be reproduced in traditional museum exhibitions (Carrozzino & Bergamasco, 2010). For example, the player can walk around old Rome inside the Assassin's Creed Nexus game and interact with its citizens.

As an education and entertainment (edutainment) medium (Lee et al., 2020), VR games are perfect for attracting more young visitors and increasing their interest

in learning more about history. Using VR as a social space in the museum raised some issues (Gugenheimer et al., 2019). For instance, visitors were divided into VR users and spectators. Therefore, it is recommended to have shared experience by sharing screens and ensuring safety for both parties to mitigate negative experiences by using VR headsets in the presence of other people (Eghbali & Jokela, 2019). However, it is known that developing a VR game, particularly for museum and heritage education, is costly because it requires a substantial amount of resources and expertise. It will need collaboration with different stakeholders to grow and sustain (Champion, 2016).

Designing a VR game requires the implementation of playability rather than usability alone. The two differ greatly in terms of goals, with productivity and task completion as the core experience of usability and entertainment in playability (Lazzaro, 2008). In essence, a game increases the user's workload instead of eliminating it, and the designers have to offer intrinsic rewards and joy in overcoming the challenges provided. To help craft playfulness, the research examines several angles based on the 100 game lenses theory (Schell, 2008), particularly the lenses of surprise, fun, curiosity, problem-solving, and unification. Another consideration to ensure the functionality of the VR game is the mechanics, aesthetics, and dynamics (MDA) framework (Hunicke et al., 2024), resulting in its implementation in the design process.

To conclude, VR game has potential in providing entertainment and education in the Indonesian museum. By leveraging its immersion and interactivity, a museum can uniquely deliver its educational materials by bringing their collections into the virtual environment to be enjoyed as a VR game.

RESEARCH METHOD

The research methodology is adapted from the double diamond design process (Design Council, 2024) consisting of four phases: (1) discover, (2) define, (3) develop, and (4) deliver as illustrated in Figure 4. The research was done through a collaboration with the stakeholders at the Museum Bahari, a professional survey

service provider, and an external party to help manufacture the VR content for the game.

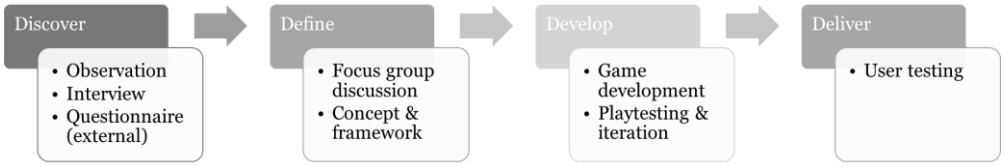

Figure 4. Research Methodology
source: author's documentation

The "discover" phase gathered information through several methods: on-site observation, interviews with the museum staff and visitors, and questionnaires for the general public whose findings are highlighted in another paper (Widarsyah et al., 2024), but still directly related to this research. In this stage, Populix, the professional survey service provider, was contracted to gather the survey data. It employed content analysis and thematic analysis where we focused on asking about how they perceived technology at the museum, their past experience of other museums, and their expectation with how VR can be implemented in Museum Bahari.

The "define" phase condensed the findings into concept finalization and design framework, resulting in the Game Design Document (GDD). Since this research was done collaboratively, a focus group discussion with museum stakeholders and domain experts was held to ensure the product would be approved and beneficial for the Museum Bahari before going further into the development process.
There are three iterations in the "develop" phase before reaching the final product. In this stage, an external VR developer was contracted to build the game. To validate the result, the museum staff tried the VR game as a part of user testing in the "deliver" phase. Ideally, there will be a second user test involving museum visitors. However, this research specifies the testing subject to the staff, hence depicting the current phase's research limitations.

RESULT AND DISCUSSION

Discover Phase

A preliminary in-depth discussion was held with the museum staff at the Museum Bahari to gain permission to execute the research, followed by interviews. In general, Museum Bahari embraced the opportunity to integrate technology into its display. Still, the lack of funding and resources prompted the museum to collaborate with universities and provide innovative experiences to the public. As there was an apparent gap between the staff's expectations and abilities, the idea of developing a VR game was welcomed with enthusiasm.

These first interviews introduced the history, collections of artifacts, programs, and exhibitions—past, present, and future—at the Museum Bahari. It also explored the staff attitudes towards technology, such as how the museum started implementing digital technology to mitigate the visitation shortage due to the pandemic. The public responded well to this approach, as mentioned by one of the staff in the interview that their online events during the pandemic were well received and had a large attendance. Since then, there has been a high demand to implement new technology, particularly to attract young visitors. However, apart from a currently refurnished audiovisual room, there was no short-term plan to integrate more advanced technology such as VR or interactive touchscreen panels. Since any additional technology requires installation and maintenance, it is essential to train the staff accordingly.

This process was continued with a site observation guided by the staff, providing a general overview of the space that could be utilized for the VR game installation and the range of collections as the source of inspiration. At the time of the research, the exhibition display at the Museum Bahari relied heavily on passive physical objects such as replicas, statues, dioramas, and printed descriptions to explain the context of the displayed objects. As a result, the museum frequently held events as a part of museum activation, noting the relevance of the taste cultivation strategy (Hansen, 2015) that elevates the current offers from the museum by providing more sensory experiences. On the other hand, the visitor education strategy must

be implemented as a response to the visitors who perceive traditional museums as boring.

To widen the perspective of the general visitors not limited to Museum Bahari, the research distributed an online questionnaire to 282 respondents to understand their preferred VR experience by combining the classification from (Pekarik et al., 1999), Packer and Ballantyne (2016). Since the questionnaire is extensive and detailed, the findings are presented in another paper (Widharsyah, 2024), as a part of this long-term research.

In short, 78.37% of the respondents are highly interested in trying a VR game at the museum. The ideal VR experience must combine a cognitive experience that supports learning and an introspective experience that instantly transports them into another location and time frame, prompting them to forget reality, which is trying the VR device at a museum. In addition, there is a need for a social experience where they hope to share what they experience with other museum-goers, especially friends and family. Even though VR usage is limited to one person only, the respondents look forward to watching other people trying it. The thematic analysis also discovers three big themes based on open-ended questions related to ideas for an ideal VR experience at the Museum Bahari consisting of sailing, going back to pastimes, and diving to explore the beauty of the ocean—things that are difficult or impossible to try in person.

Define Phase

The results from the previous phase are narrowed down into a design concept and a design framework in the defined phase. This phase started with a focus group discussion between the research team, museum staff, and an archeologist with expertise in Jakarta's cultural heritage. It was essential to ensure that the game was relevant to the museum's objectives and collections as well as its historical accuracy.

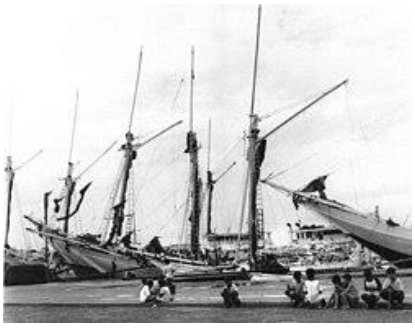

Figure 5. Pinisi ships in Makassar
Source: Taopere by Marc Obrowski, 1994. Public domain.

After considering several themes related to sailing, it was decided that the central theme would revolve around the Pinisi ship since it is imbued with rich history and is still operating today, although primarily for tourism purposes. The player could act as a captain who navigates the ship, and they will face obstacles during the game. The game is expected to elevate a quiz game since integrating learning materials into a VR experience has been proven to enhance learning outcomes compared to traditional media (Haryana et al., 2022). Once the FGD participants approved the initial idea, the research team further developed the concept and created the MDA framework (Hunicke et al., 2004). The visual direction leans towards the middle spectrum of stylization and realism to keep the feeling of real experience yet lighten the processing, referencing the aesthetics of the "I Expect You to Die" and "Tin Hearts" games as depicted in Figure 6. This visual decision also makes the game more optimized for a standalone VR game.

Inspired by the escape room genre, like "I Expect You to Die", this game allows player to be immersed as the captain of the ship by embodying the captain character trying to navigate the ship and conquer the challenges along the way. The captain character is only represented by a pair of hands covered in gloves, which is typical for a first person-view VR game. To provide instruction, a narrator will act like a guide from the harbor who gives audio messages along the journey. This will add more context for the player while keeping them still immersed in the story.

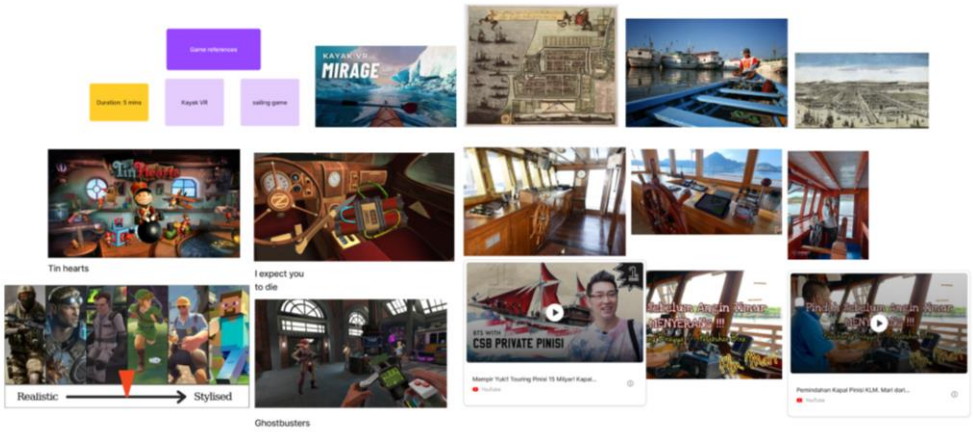

Figure 6. Visual Direction
source: author's documentation

In terms of dynamics, the story takes place in a port where the player, as a captain, will be transferred from a small boat to the Pinisi ship. This activity is inspired by the actual scene at the port near the museum where visitors could also ride the Pinisi ship, providing contiguity. The ship model in the game is based on a modern Pinisi ship for tourism which has been motorised for safety and practical reasons (Pelly & Baiduri, 2020). The goal is to reach Sebira island, one of the furthest islands in the Kepulauan Seribu, by answering several questions related to the museum exhibits correctly instead of navigating the ship like a typical racing game. Therefore, the game also aims to promote Sebira Island as a tourist destination. The narrative is almost linear, inspired by the "I Expect You to Die" game, in which the player is expected to finish the quest in an orderly manner. The overall user workflow for the game is illustrated in Figure 7 and Figure 8.

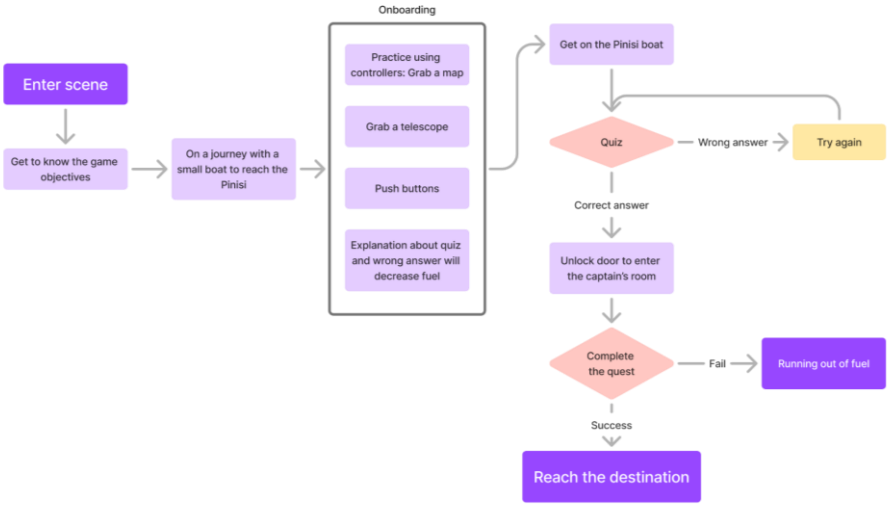

Figure 7. Game Workflow 1
source: author's documentation

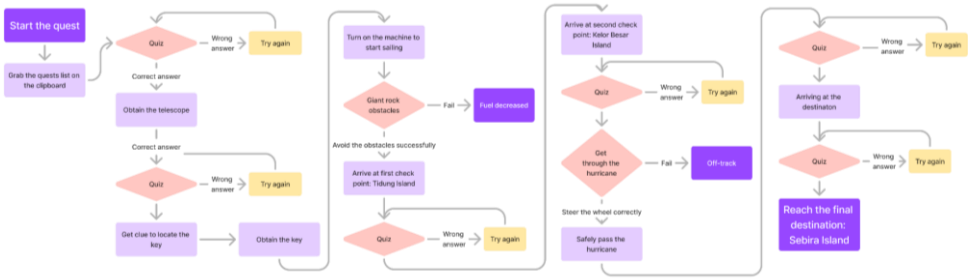

Figure 8. Game Workflow 2
source: author's documentation

To ensure the playfulness of the game, it incorporates several game lenses in the game dynamics (Schell, 2008) as comprised in Table 1. For instance, to provide surprise, there is a hurricane in the middle of the journey. While the user can steer the wheel to overcome it, the obstacle can be overcome by correctly answering the question. Besides, not all users can reach the final destination depending on the number of wrong answers, with the alternative ending being out of fuel or stranded on another island. Moreover, to increase curiosity, the game adds the preparation before the sailing phase where the user will be introduced to

artifacts such as a telescope and a compass in case the current generation is not familiar with those objects.

No	Game Lens	Game Dynamics
1	Surprise	A hurricane in the middle of the journey Not every user can reach the final destination, the ship can run out of gas or be stranded on another Island, prompting the user to try again or pay more attention to the museum exhibits
2	Fun	Pretending to be the captain of the ship Steering the wheel even though it does not directly affect the game result
3	Curiosity	Introducing objects related to sailing such as telescope and compass, context-based knowledge Asking medium-level questions that can be solved by paying attention to the exhibits and/or asking for help from friends
4	Problem-solving	Answering the questions Getting through the hurricane
5	Unification	Inspired by the real Pinisi ship and activities that take place in the port near the museum

Table 1. Game lenses and dynamics
source: author's documentation

There are several game mechanics such as climbing the wooden stairs, steering wheel to navigate the Pinisi ship, and answering quizzes to reveal the next actions. Between actions, the player has a short time to explore the ship, although the area is restricted to the captain's room and the front part of the ship to keep the player more focused on the game.

The quiz is the quintessential mechanism to provide the player with educational value. A correct answer leads to the next action, while wrong answers cost some fuel, thus halting the game's progression. The quiz materials cover some fun facts about Museum Bahari and its historical background, the Pinisi ship, and other learning materials from the museum collection and exhibition. Thirteen multiple-choice questions appear randomly in the game, and the question will remain on the screen until the player selects the correct answer. Two additional questions are included in the diegetic interface as a password to unlock the door to the captain's

room and options for the drawers' labels. Furthermore, this mechanism allows other visitors to act as spectators by watching the game on an external monitor or participating by providing the player with correct answers.

Develop Phase

The develop phase consists of three iterative processes including prototype and playtesting before reaching the final prototype that is ready to be tested by the museum staff. The overall VR game development was assigned to an external consultant, though the researchers actively participated throughout the development. The developer used Unity as the game engine and targeted Meta Quest 2 as the main device for this game.

The first process was started by preproduction to prepare the required assets, such as 3D files of the objects and environments, audio files for narrations and sound effects, and text files for the quizzes and User Interface (UI). Due to time and capital limitations, several 3D and 2D assets were sourced from free and paid assets licensed free for non-commercial use in online platforms, such as sketchfab.com and Unity Asset Store. However, the purchased Pinisi ship 3d was not fully compatible with Unity. As a result, many parts of the boat were remodelled and retextured in Blender.

The audio files were self-recorded following a script that had been created. These were prepared based on the game's flow so that the player could listen to the instructions for each step. Meanwhile, the sound effects were designed to provide a realistic experience of being on the ocean, with some effects matching specific actions in the game. This included background music featuring ocean waves, hurricane sounds, ship engine running noises, and audio feedback for player interactions.

The text file covers the UI and quiz content. The copywriting for the UI was more focused on the onboarding part where the player is presented with the game objectives and how to play the game. Since this game is intended to provide a relaxing and explorative experience without becoming too competitive, it does not

implement a scoring system. However, the fuel availability is visible in a bar view so the player can see whether it is full or not to reach the destination or compensate for their wrong answers in the quiz. This fuel bar is the replacement of the score bar, so the player still has the urgency to reach the target without getting too fixated to the score. This is also to support the main objective of the game where the player is encouraged to finish the story as their knowledge will also be tested along the journey.

In the first iteration, placeholder objects were used to test game mechanics, such as steering the wheel that will influence the ship's direction, turning on the ship's machine, answering quizzes, grabbing objects, and locomotion as shown in Figure 9. The objective is to make sure the main actions are doable, confirming the project's viability.

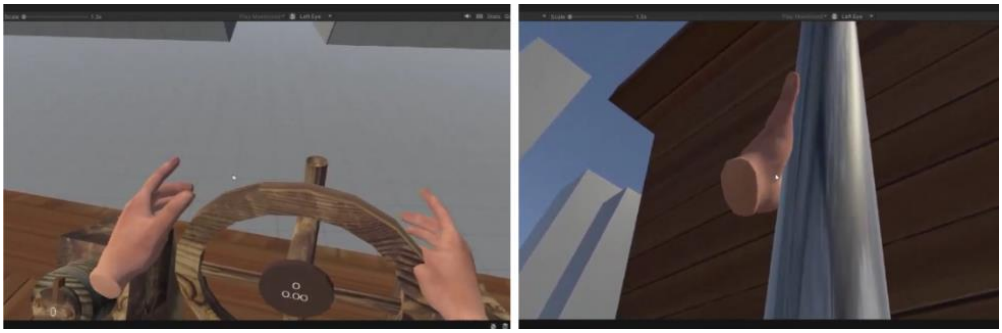

Figure 9. Game Mechanics
source: author's documentation

The second iteration includes more refined mechanics. The playtesting is conducted by the research team, and the APK file was installed into the device using the Meta Quest Developer Hub application. There are three main evaluations during this phase:

1. The climbing rope interaction has been replaced with walking on a ladder. This change was made because it was difficult for play testers unfamiliar with VR to use the hand controller to climb a rope with two hands.
2. The steering wheel needs hand-grabbing interaction to make the gesture more natural with the ship steering wheel.

3. Several bugs such as the missing map texture and the persisting cross mark in the clipboard need to be fixed (Figure 6).

Figure 10. Bugs in Second Iteration
source: author's documentation

The third iteration was then built as an APK file after integrating the previous feedback into the game. Throughout this phase, the researcher encountered several issues that were effectively addressed by the developers, as outlined in Table 2. One of the most urgent issues is the difficulty of pressing the numerical button to answer the question about the year Museum Bahari was built. The solution is to automatically generate a correct hand pose in the game interface—one index finger pressing the button—that the player can easily imitate.

No	Problem	Solution
1	Use of shaders on seawater assets efficiently so that they can be applied in stand-alone VR	To maintain the VR performance, shaders are optimized with efficient rendering techniques like normal maps.
2	Players have difficulty pressing the buttons on the smart lock because they have to press the controller button to get a certain hand pose	As the player approaches the door, the hand pose is automatically generated for immediate button pressing.
3	Lagging/scattering occurs due to dropped frame rates	Optimize lighting by reducing the number of light sources and using baked lighting. Apply Level of Detail (LoD) to assets to reduce rendering overhead and increase frame rates.
4	When the ship starts moving, the player is not carried along on it because of the application of gravity	Physics System settings changed so that the player's gravity will not hinder friction between the player and the ship floor. Rigidbody and Collider parameters are adjusted to take the player along.

Table 2. Evaluation from the third iteration
source: author's documentation

The final version of this game was built as an APK file for Meta Quest 2 titled "Jelajah Bahari." The gameplay lasts around 10-15 minutes, and the teleport function is changed to moving locomotion with the thumb sticks. The final storyline follows the initial idea where the player acts as a captain who will navigate a Pinisi ship named Ewako from a port in North Jakarta to Sebira Island in Kepulauan Seribu. At the beginning of the game, the player is placed in a small boat where a UI screen shows some information about the game and how to use the controller (Figure 11). If the player needs more guidance, audio narration is also provided. Then, several objects appear in turns to let the player practice using the touch controller. The boat will arrive shortly at a point where the player can walk to the Pinisi ship through a ladder.

Figure 11. Game Information
source: author's documentation

Inside the Pinisi ship, an arrow directs the player to a door with a password. The password can be unlocked by pressing the numeric buttons to convey the year the Museum Bahari building was built. After getting the correct answer, the player can walk to the captain's room upstairs. Inside, the player must follow the quest by finding sailing-related objects needed to start the engine. The quest instructions are displayed on a clipboard, outlining a series of actions to be completed in a specific order (Figure 12). The player can easily identify the next interactable object as it will be highlighted by outlining the object's shape (Figure 13) as an update from the previous playtest. Additionally, players can track their route using the responsive map available in the table (Figure 13). The ship icon will move according to the game's progress.

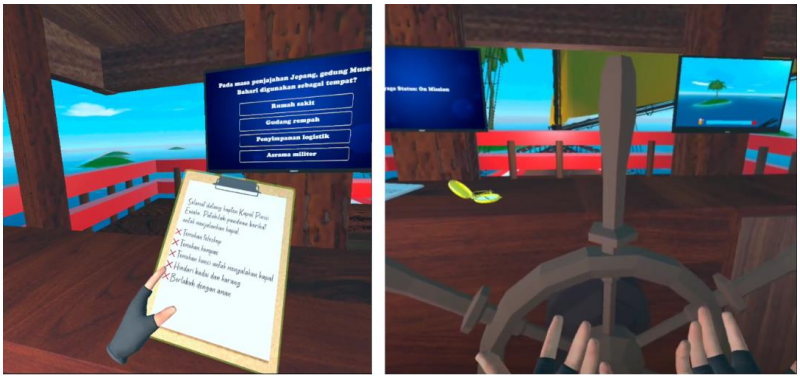

Figure 12. Quest Guideline
source: author's documentation

Figure 13. Object Outline and Map
source: author's documentation

During the journey, the captain's knowledge will be tested with quizzes, and the navigation skill will be challenged by steering the wheel and overcoming obstacles like hurricanes and large rocks. While the scenery of the ocean takes up the main vision, the questions and answers are presented on the left side of the monitor. By completing quests and participating in activities, players will navigate through these challenges, with opportunities to explore the ship in between. When the Pinisi ship arrives at Sebira Island, there will be a final quiz on the monitor, and after that, visual and sound effects will appear as the player completes the game. If the player does not follow the instructions to survive the hurricane or the navigation direction, the ship will deviate, and the player will not reach the destination. The winning condition is when the player reaches the destination.

Deliver Phase

User testing was conducted at the Museum Bahari to evaluate the content and interface of the VR experiences concerning the museum itself. Considering this, the users involved in this testing were not visitors, but exclusive to the museum staff as seen in Figure 10, while not excluding the importance of following user testing to gather the visitors' perception towards the VR experience. There are 10 participants (4 female and 6 male) in this session including the head of education, the head of facilities and infrastructure, the curator, and 7 exhibition guide interns. These interns were selected from tourism vocational high schools and frequently interacted with the museum visitors; hence they provided relevant insights in the testing. All participants must use the Meta Quest 2 headset and finish the "Jelajah Bahari" game to be able to evaluate it thoroughly.

Figure 14. Testing session with museum staff at the museum
source: author's documentation

The testing was separated into quantitative and qualitative questions which were asked during the pre-test and post-test. Using a Likert scale, the quantitative questions aimed to measure the probability of integrating the VR experience into Museum Bahari, while the qualitative questions provided an in-depth look into the reasoning behind the numbers. Combined with user observation, it helped to put the user's behaviour into context.

Quantitative: User & Museum Readiness

The first part of the survey utilised a Likert scale from 1 (less) to 5 (most). There were three questions for the pre-test and another three for the post-test including one repeated question to evaluate differing perceptions before and after trying the VR experience.

The survey reveals a low familiarity with VR technology, with only a 2.5 score on average and the highest standard deviation of 1.27. The importance of VR implementation in the museum (Q2) is perceived with a higher average score of 4.0. The museum's readiness to provide VR experience slightly increased after testing the game, as reflected in Q3A and Q3B from 3.7 to 4.0. Based on the Jelajah Bahari game, the staff perceived high feasibility of providing the VR installation (Q4), averaging 4.3. Similarly, the staff considered the VR game has represent the museum identity well (Q5) based on the average score of 4.2.

On the other hand, the survey shows that VR technology remains unfamiliar to most people, including to the museum staff. For example, four participants never tried VR before, and those who have tried it primarily did it outside the museum

setting. This is understandable since in 2017, only 3% of Indonesia's 434 museums had digital displays, and just 1% featured interactive media (Yudhawasthi, 2017). As of this writing, there is no data on VR usage in Indonesian museums and low national VR penetration—only 1.5 million users in 2024—likely contributing to this unfamiliarity. However, despite limited exposure, they positively view VR and show interest in offering it to visitors.

Qualitative: VR Experience

The qualitative part of user testing provides more information regarding the museum staff's subjective experiences with VR, both before the test (Q8-19) and during the usage of the "Jelajah Bahari" VR game (Q10-12). It also explores their perceptions towards integrating VR technology into Museum Bahari (Q6-Q7) and how it might impact visitors (Q-13-Q16).

No	Question
Q6	What are the considerations for providing VR technology to visitors? Are there any specific concerns?
Q7	Have you ever visited a museum or tourist attraction that uses VR technology? Please describe.
Q8	Have you tried VR technology? If so, describe it.
Q9	How did you feel while using the VR technology?
Q10	Which part was the most interesting?
Q11	Which part was the least interesting?
Q12	Were there any parts that were difficult to understand? If so, which ones?
Q13	Can VR technology enhance the positive visitor experience? If so, in what ways? If not, why?
Q14	Based on visitor profiles and behaviors, would visitors be interested in using this VR game? Which visitor segment would be the most suitable?
Q15	What additional resources need to be designed to make the game easier to use or for the museum to explain?
Q16	How likely is the VR game to be a permanent or temporary installation in the museum?

Table 3. Qualitative Questions
source: author's documentation

Overall, the most highlighted experience was the game's interactivity, e.g. "interactive and fun" and "being a captain," and its visualization. Some parts of the game left more impressions on the participants, such as experiencing a storm, grabbing objects, and getting on the boat. Experiencing those in VR indeed improved the players' sense of presence (Slater, 2009) so that they are more immersed in the narrative (Rose & Green, 2021), as the participants also mentioned getting carried away by the game.

Another finding is related to fun learning experiences (Carrozzino & Bergamasco, 2010; Lee et al., 2020). Participants were not burdened by the educational content as it was presented as a quiz. Instead, they regarded the whole experience as a positive learning opportunity. Moreover, three participants said the quiz was the most exciting element of the game because it could increase their knowledge. Other participants also valued being a captain and navigating the Pinisi as a unique learning experience. This shows that the game expands beyond playfulness.

Regarding tourism, the participants believed that the addition of a VR game installation at the Museum Bahari would attract more people, especially the younger generation. They also regarded the technology as appealing to international tourists who are more familiar with VR technology, highlighting the importance of including more languages in the game.

Several aspects regarding usability can also be improved. First, more comprehensive tutorials can reduce technical challenges in operating the game, such as basic control movements and object interactions. (Carrozzino & Bergamasco, 2010) warned that the typical users would be people who have never tried VR, so it would be better to provide a smooth experience for them. Second, this current version needs to improve its audio content by enhancing the narrator's voiceover and adding more background music. Third, the game content has the potential to be expanded so the player can explore more areas or try other things. The game duration also needs to be shortened so more players in the museum can play it. Lastly, participants conveyed safety concerns. Visitors should be warned

about motion sickness, which can occur before playing because it is a common side effect (Jerald, 2015).

Based on user testing, museum staff are enthusiastic about providing VR game experience for visitors, with several empty spaces available for installation. However, human resources, infrastructure, and safety concerns must be addressed. As mentioned before, most of the museum staff were not knowledgeable in VR installation and operation. The museum must train dedicated staff to handle the equipment and assist the visitors. They will also need to be trained to solve some minor troubleshooting. For example, during the user testing, we restarted the game a couple of times due to bugs, running out of batteries, or when the key object in the game was unreachable due to misplacements.

On the other hand, museum staff's opinions on permanent VR installation are divided. Some oppose the idea due to concerns about equipment durability and theft risk, while others support it for its unique contribution to the museum's educational narrative. A potential solution is to implement the VR installation temporarily and evaluate visitor responses and equipment performance.

Thus, despite the enthusiasm, there were apparent concerns because adding a VR installation requires careful planning for new equipment and procedures. Museums must think about managing, maintaining, and storing VR headsets and other gear. They also need to keep visitors safe while using VR. For example, VR headsets need to be recharged regularly. The museum must protect all VR equipment, including screens and cables, from damage or theft. The area where people use VR should be kept clean and tidy. Museum staff who look after the VR installation will need special training, covering how to set up and take care of the equipment as well as how to help visitors use it. By planning these details carefully, the participants believed museums could ensure an enjoyable VR experience.

CONCLUSION

This research highlights the potential of VR technology to enhance visitor engagement and educational experiences in museums, exemplified by the "Jelajah Bahari" VR game at Museum Bahari. Museums in Indonesia can use VR experience to attract a wider audience, especially younger generations by combining immersive, interactive gameplay with historical education.

User testing with Museum Bahari staff emphasised the game's capacity to make learning enjoyable and its alignment with the museum's identity. Through VR, traditional museum experiences become more dynamic, adding value to the museum's cultural and educational objectives. However, museums will need to train museum staff in VR technology, to maintain equipment, and ensuring visitor safety, which are essential for successful integration. Many staff members had limited familiarity with VR, indicating a need for ongoing support to operate the installation confidently. Additionally, safety measures, like warnings about motion sickness, would enhance the visitor experience and ensure that the VR setup is accessible and maintained well.

Despite these logistical challenges, the enthusiasm from museum staff and their positive perceptions of VR technology suggests a promising future for such installations, particularly for museums in Indonesia that have low technological adoption. Temporary installations may serve as practical starting points, allowing the museum to evaluate visitor interest and address any technical issues before committing to a permanent setup.

In conclusion, VR technology, as demonstrated by the "Jelajah Bahari" game, holds immense potential to transform museum visits by blending traditional exhibits with digital interaction. This research underscores the capacity of VR to foster educational, enjoyable, and memorable experiences, suggesting that VR can help museums remain relevant in an increasingly digital age. Through thoughtful planning and attention to visitor needs, Museum Bahari's VR initiative serves as a

model for cultural institutions aiming to revitalize visitor engagement and education through immersive technology.

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