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Designing The METTAREKA Interface: Collaborative Interaction During 15th Century Voyage

Reka Bentuk Antara Muka METTAREKA: Interaksi Kolaboratif Pelayaran Abad ke-15

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ABSTRACT

This research delves into enhancing the user experience within a Metaverse environment through the development of a collaborative virtual reality interface called METTAREKA (Metaverse of Gallery REKA). Rooted in the GeSToUX model and adapted for virtual reality headset technology and collaborative interaction, METTAREKA aims to provide an immersive exploration of the 15th-century voyage in Southeast Asia. The study identifies key problems in existing virtual systems, emphasizing the need to stimulate visitors' knowledge and experience effectively. To address this, METTAREKA integrates non-touchable gesture movement techniques and collaborative aspects, allowing multiple users to interact using virtual reality headset technology. The immersive environment features avatars, digital storytelling, and collaborative navigation and editing, promoting a dynamic and interconnected digital realm where users collaboratively engage with the history and heritage presented. The study contributes to the evolving landscape of immersive technologies, fostering collaborative interactions that redefine how individuals work, socialize, and innovate within the digital sphere.

Keywords: Metaverse, virtual reality, collaborative interaction, immersive gallery, user interaction

ABSTRAK

Penyelidikan ini bertujuan mempertingkatkan pengalaman pengguna dalam persekitaran metasemesta melalui pembangunan antara muka interaksi kolaboratif secara realiti maya yang dikenali sebagai METTAREKA (Metasemesta Galeri Reka). METTAREKA menyediakan penerokaan mendalam sejarah pelayaran abad ke-15 di Asia Tenggara berdasarkan model GeSToUX dan disesuaikan dengan teknologi set kepala realiti maya dan interaksi kolaboratif. Kajian mengenal pasti masalah utama dalam sistem maya sedia ada, menekankan keperluan untuk merangsang pengetahuan dan pengalaman pelawat dengan lebih berkesan. Oleh itu, METTAREKA menyepadukan teknik pergerakan isyarat bukan sentuhan dan aspek kolaboratif bagi membolehkan multipengguna berinteraksi menggunakan teknologi set kepala realiti maya. Selain itu, persekitaran imersif yang direka bentuk turut meliputi pembangunan avatar, penceritaan digital serta navigasi bersama dan penyuntingan secara kolaboratif. Komponen ini membantu meningkatkan persekitaran galeri maya secara dinamik di mana pengguna dapat mendalami sejarah pelayaran di samping berinteraksi dengan pengguna yang lain. Kajian ini menyumbang kepada landskap teknologi imersif yang kian berkembang, memupuk interaksi kolaboratif yang mentakrifkan kaedah individu bersosial dan berinovasi dalam sfera digital.

Kata kunci: Metasemesta, realiti maya, interaksi kolaboratif, galeri imersif, interaksi pengguna

INTRODUCTION

Computer-based interactive technology to preserve the country's visual art heritage for open dissemination of information to the public by providing an educational experience has been actively carried out (Napoleon & Elochukwu 2021; Champion & Rahaman 2019). The most recent development in terms of preserving the national heritage is through a computerized system. There are several digitization efforts in the field of visual arts, which is now a national priority to create awareness, understanding, and appreciation of the arts. Recently, researchers have conducted a study on heritage site, which is part of the national heritage along with artefacts, culture and monuments. The site used as a case study is Bewah Cave in Kenyir Lake in Terengganu. In this study, a virtual system for a non-immersive environment was developed using the non-contact gesture technique. It allows visitors to browse and interact using Leap Motion technology tools to give users the experience of exploring the cave, in addition to providing information through video displays. The model created in this study is Gua Bewah Virtual Heritage (GBVH). With the rapid development of virtual reality technology and the needs of today's generation who demand services and offers that are more interesting to them. These factors encourage researchers to approach the National Gallery of Art to improve the virtual system, because there are problems that need to be taken seriously.

The first problem is that the existing virtual system does not stimulate visitors' knowledge and experience in performing activities and viewing video information (Normala Rahim et al. 2017). According to research (Miraz et al. 2021), stimulation of knowledge and user experience is the key factor for effectiveness, efficiency, and satisfaction in human-computer interaction. Researchers (Flavián et al. 2019) provide an outlook on the importance of user experience, which is able to mediate the user's emotional response to the system behavior. Some previous studies also show that browsing in a non-immersive environment does not maximally stimulate the visitor's knowledge and experience (Mahmoud et al. 2020). The second problem is that the single interaction of the visitor with the system also affects the low level of user experience. A single interaction that does not provide activities or information according to the metaphor of

storytelling or narrative may also result in the user experience not being effectively achieved (Li et al. 2019). The effect of these two problems is to fail to educate the younger generation to remain interested in recognizing the country's visual art heritage.

Therefore, this study aims to develop a collaborative virtual reality interface design called METTAREKA (Metaverse of Gallery REKA) that has a collaborative aspect to enhance the user experience in immersing themselves in the history of 15th century voyage in Southeast Asia. The interface design of the virtual system is developed based on the GBVH model while maintaining the non-touchable gesture movement technique. The collaborative interaction aspect takes place in an immersive environment by applying the metaverse concept, which allows more than one visitor to interact with each other using virtual reality headset technology. According to Dwivedi et al. (2022), the design of the visitor's experience interface in the real environment that is immersive can have an entertaining emotional effect and increase the user's interest in interacting with the system to the end.

RELATED STUDY

The National Art Gallery is a gallery that exhibits paintings, sculptures, batik and various visual arts created by local and international artist. This gallery supports the development of the country's visual arts industry, which houses various forms of art, including in the form of photography, multimedia and interesting technology. There are many efforts to conserve, preserve, document and promote the quality of the country's visual arts, and the latest is the use of computer systems. This includes the use of mobile devices and Internet of Things (IoT) components that can be connected and act as components that allow users to interact with digital entities through touch or network gestures on the interface and also through conversational agents for the purpose of natural interaction (Rojc et al. 2018). Nowadays, research on immersive environments applying virtual reality is a leading technology in various scientific and educational fields (Tengku Siti Meriam Tengku Wook et al., 2016; Norul Maslissa Ahmad et al. 2019). The design of narrative interfaces plays an important role in improving the user experience. Virtual reality and virtual continuum related technologies such as immersive environments are new media for user interaction with systems.

VIRTUAL REALITY TECHNOLOGY

Interactive and immersive technologies such as virtual reality are a new phenomenon that naturally changes interaction patterns, and the way people think in real-world environments through a new approach (Mansor et al. 2022). Virtual reality can be a powerful medium to bring about changes in social reality. Therefore, this study addresses its potential impact and influence on new media and communication technologies that can effectively convey information (Barbot & Kaufman 2020). According to Rubio-Tamayo et al. (2017), the challenge of virtual reality-based technologies and applications is the concept of shaping information, new narratives, and storytelling as a possible medium that has not been fully explored. This challenge is not only related to technology, but also to the concept of information delivery and dynamic interaction. The study from Zhao et al. (2022) describes the concept of metaverse, which is able to overcome this challenge, as it is part of the development of new technologies that involve the senses and the cultural, symbolic and representational factors of the users, using a multidisciplinary approach to natural interactions.

METAVERSE CONCEPT AND COLLABORATIVE INTERACTION

The Metaverse, as conceptualized by Dwivedi et al. (2022), consists of four primary categories: environment, interface, interaction, and social value. These categories serve as the foundational pillars of the virtual space, resembling and often mirroring components of the real world. Developed within a virtual environment, this digital realm seamlessly merges physical and digital elements, harnessing the convergence of technology and the web. For example, the Metaverse's environment may simulate a bustling virtual city where users can navigate and explore, attend events, or even engage in commerce—all within a digital landscape that mirrors aspects of the physical world.

One pivotal component shaping the Metaverse is Extended Reality (XR), a technological framework highlighted by Dwivedi et al. (2022). XR plays a central role in enabling multimodal interaction with digital objects in a collaborative manner. This includes various degrees of integration between digital and physical elements, with distinct manifestations like Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR), as expounded by Krajčovič et al. (2021). In practical terms, users in the Metaverse may experience AR by overlaying digital information onto their real-world surroundings, engage in MR where virtual and physical elements coexist seamlessly, or immerse themselves entirely in a virtual environment through VR.

The Metaverse idea depicts a new digital frontier where users may communicate beyond geographical borders inside a shared virtual area. This immersive environment, which frequently combines augmented, mixed, and virtual reality, encourages collaborative activities beyond standard Internet communication. Collaborative engagement takes on new dimensions in the Metaverse, allowing users to share experiences, control digital things together, and converse in real-time via avatars (Dwivedi et al. 2022). This collaborative component pervades many activities, from corporate meetings and educational initiatives to social gatherings and artistic collaborations. Therefore, Metaverse redefines the paradigm of collaborative interaction, offering a dynamic and interconnected digital realm where individuals can work, socialize, and innovate collectively, marking a significant shift in the way we engage and collaborate in the digital.

IMMERSIVE ENVIRONMENT OF THE NATIONAL ART GALLERY

The development of the immersive environment of the National Gallery of Art is based on the existing virtual system model. However, the system model can only be explored non-immersively and has a single interaction function. This may result in an ineffective user experience, which impacts the effectiveness of creating understanding and appreciation for the community to remain interested in recognizing the nation's visual art heritage (Li et al. 2019). METTAREKA will extend the virtual system with the Metaverse concept through a virtual reality headset, namely Meta Quest 2 Advanced. This system will allow gallery visitors to have an immersive experience and fully engage in collaborative interaction in the gallery (Krajčovič et al. 2021). Using this device, visitors enter METTAREKA and navigate the 3D artifacts and environment through eye movements, feedback control, or voice commands. The use of this device can create "presence" that is achieved by simulating a realistic physical experience. METTAREKA allows users to activate their full body movements through position and rotation tracking. The movements can be tracked through the headset's sensors and cameras that monitor changes in the position of the physical environment. The supported degrees of

freedom (DoF) of the headset is an important specification that reflects the user's ability to track motion (Atsikpasi & Fokides 2021).

METHODOLOGY

This research method involves three phases, namely collaborative user interaction analysis, conceptual model development and prototype interface design.

COLLABORATIVE USER INTERACTION ANALYSIS

Designing the environment starts with conducting a literature review on the metaverse and collaborative interaction concept. A field study was also conducted at the REKA Gallery to gather information on the exhibition and the physical gallery environment. By analyzing the literature review and the field study results, the elements and mechanisms of collaborative interaction were identified to create a list of specifications for the METTAREKA interface design. These design requirements serve as the foundation for developing the conceptual model. Table 1 presents the various elements of collaborative user interaction.

TABLE 1.Collaborative user interaction in a metaverse environment (Zhao et al. 2022)

Category	**Interaction**	**Technique**
Communication	Gesture Verbal	Touch (Surface): Swipe, Drag, Drop, Grasp Body Language: Body motion, facial expression, hand, finger
Joint Navigation	Multi-user operation	1. Forming navigational groups by multi-user 2. Distributing navigational responsibilities 3. Performing navigation task together 4. Ending joint navigation by splitting up
Collaborative Editing	Co-manipulate object	Change properties, position or orientation any object by multi-user

The table outlines various interaction categories in a virtual environment, each linked to particular techniques. In the communication domain, the first category encompasses non-verbal interactions, including gestures that involve both surface touch and the use of body language for expressive communication. Regarding verbal communication, the table emphasizes the importance of avatar intonation, speech speed, and sound volume as techniques shaping message delivery. Another category, joint navigation, involves multi-user operations that include activities such as forming navigational groups, distributing responsibilities, collectively performing navigation tasks, and concluding joint navigation by splitting up. Lastly, collaborative editing enables multiple users to co-manipulate objects, allowing them to collaboratively adjust properties, positions, or orientations within the virtual space. Each interaction category is associated with specific techniques facilitating engagement and collaboration in the virtual environment. These elements contribute to the overall structure, function and characteristics of METTAREKA system.

Meanwhile, Table 2 shows the mechanism of the collaborative interaction that provide the means by which elements interact and work together. The collaborative interaction mechanism

comprises two primary components: interaction and collaborative mechanism. The interaction component demands synchronization across all users in the metaverse environment. The interactions involved in each mechanism are listed in Table 2 for reference.

TABLE 2. Collaborative interaction mechanism in a metaverse interaction (Pereira et al. 2012)

Category	**Interaction**	**Technique**
Interaction	Manipulate Object	Grab, drag, throw, scale, rotate
	Search Object	Rotate and move the camera in virtual environment
Joint Navigation	Visualize User	Avatar
	Highlight User	Highlight user & receive user highlight
	Visualize Object	Highlight object & receive object highlight
	Preview	Create preview, manipulate & accept preview

CONCEPTUAL MODEL DEVELOPMENT

After conducting an analysis, a model is developed to provide an initial concept for the prototype design. This model includes collaborative interaction design, which encompasses communication, co-navigation, and collaborative editing. Additionally, Natural User Interface (NUI) displays, such as virtual objects, virtual environments, and information displays, are incorporated into the model. The focus of the model is to enhance collaborative user engagement within the metaverse environment by utilizing collaborative interaction elements.

The METTAREKA conceptual model, shown in Figure 1, was derived from the GeSToUX model (Normala Rahim 2020) and modified to accommodate virtual reality headset technology and collaborative interaction. Integrating NUI design and VR headset technology in the Metaverse creates a symbiotic relationship between professionals, students, and stakeholders as users. It improves usability by making interactions more natural and intuitive, enhances aesthetic visuals through immersive experiences, and addresses the emotional aspect by creating engaging and emotionally resonant virtual environments (Cilizoglu et al. 2023). This synergy contributes to a more collaborative, efficient, and compelling experience for all users involved in the Metaverse environment.

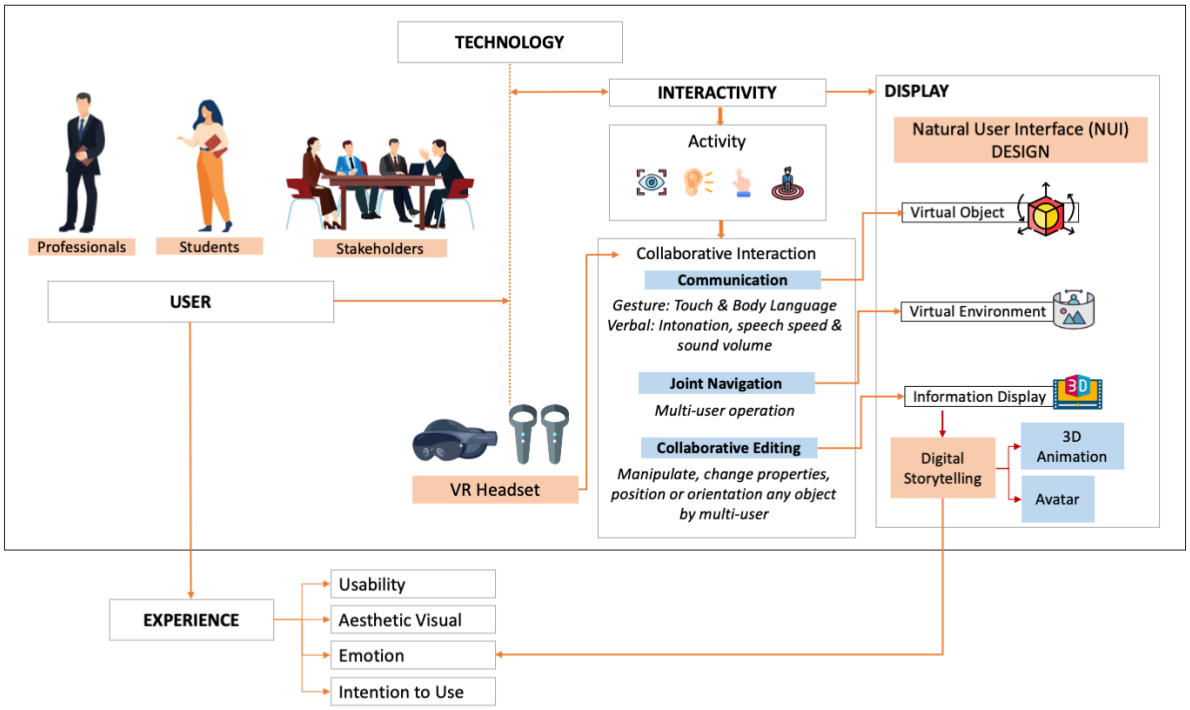
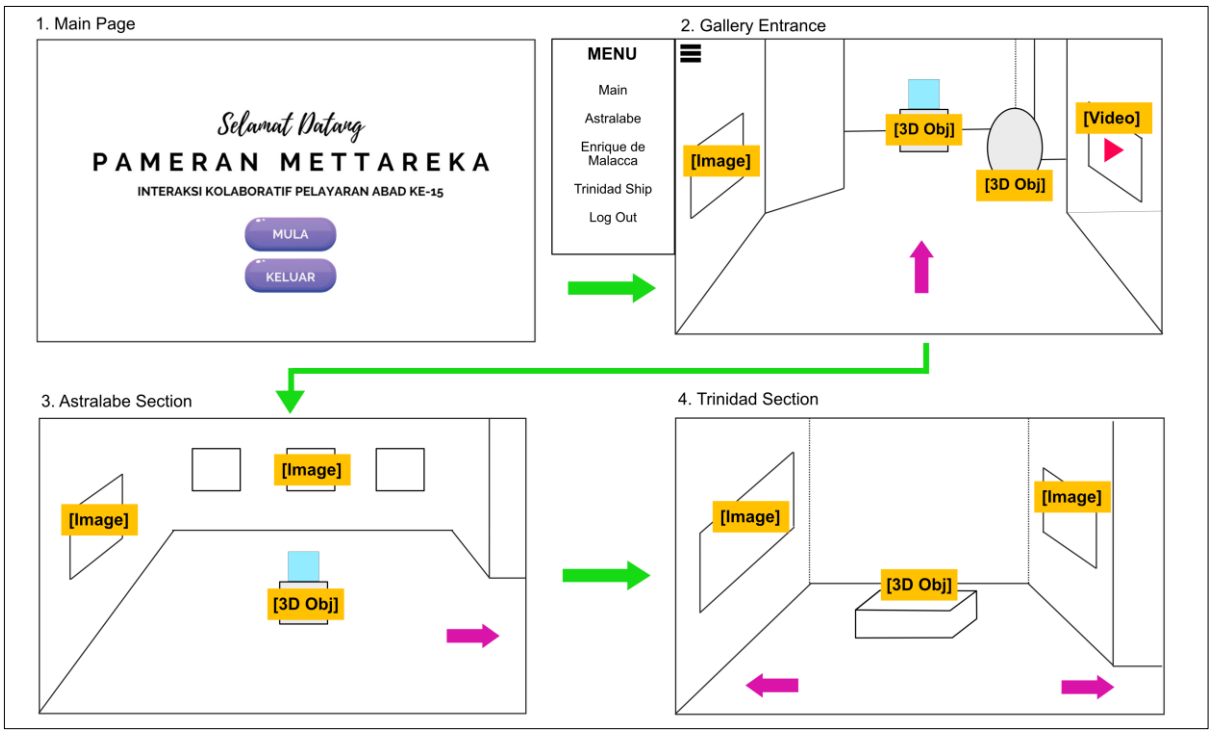


FIGURE 1. METTAREKA conceptual model

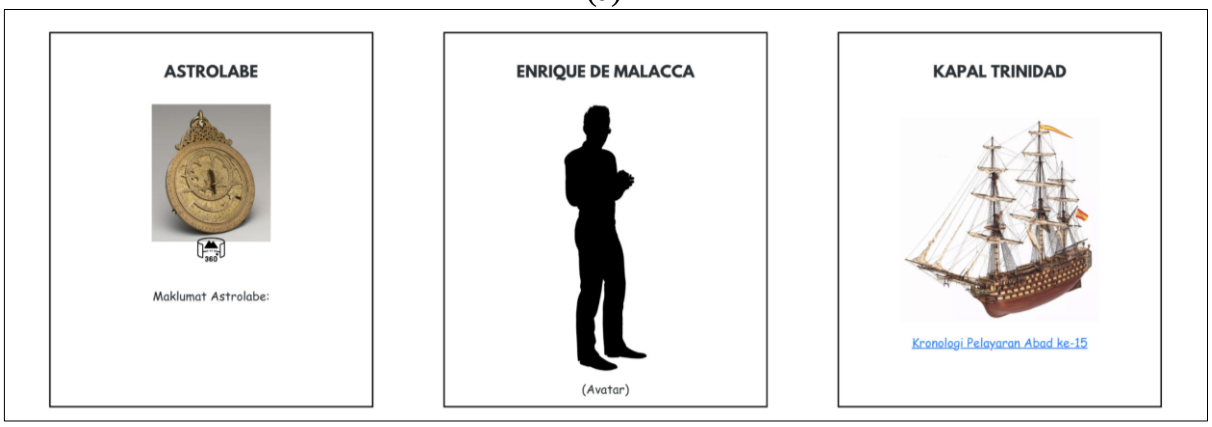
Besides that, the NUI design was also enhanced to facilitate collaborative interactions where users can manipulate virtual objects using gestures or verbal commands. In the realm of joint navigation, the system permits multiple users to collaboratively explore a shared virtual environment. This entails the formation of navigational groups, where users collectively contribute to navigation, distribute responsibilities, and execute navigation tasks as a team. For instance, in scenarios like virtual tours or explorations, users collaboratively make decisions on direction, destination, or waypoints, resulting in a shared navigation experience. The system facilitates real-time communication and coordination, ensuring a synchronized exploration of the virtual space. Joint navigation enriches social interactions in the digital environment, offering users a collective and immersive navigation experience. Conversely, collaborative editing empowers multiple users to jointly manipulate digital objects in the virtual space. Users can collaboratively alter the properties, positions, or orientations of shared objects, fostering a creative collaborative process. Effective communication and real-time synchronization are integral in both joint navigation and collaborative editing. The system provides the infrastructure for users to communicate, share inputs, and observe each other's actions, establishing a cohesive and interactive digital setting. These functionalities not only elevate user engagement but also unlock new possibilities for collaborative endeavors, learning, and social interactions in the digital sphere.

STORYBOARD DESIGN FOR USER INTERFACE

Next, a prototype interface storyboard is created and developed, utilizing the identified specifications and conceptual model. The storyboard design for the development of digital storytelling places emphasis on three key components: the astronomical instrument artifact (Astrolabe), the Trinidad ship sculpture, and the Enrique de Malacca sculpture. Figure 2(a) displays the prototype interface storyboard design for the REKA gallery virtual environment. Meanwhile, Figure 2(b) show the interaction design board for virtual objects and digital storytelling in the form of 3D animation and avatars.



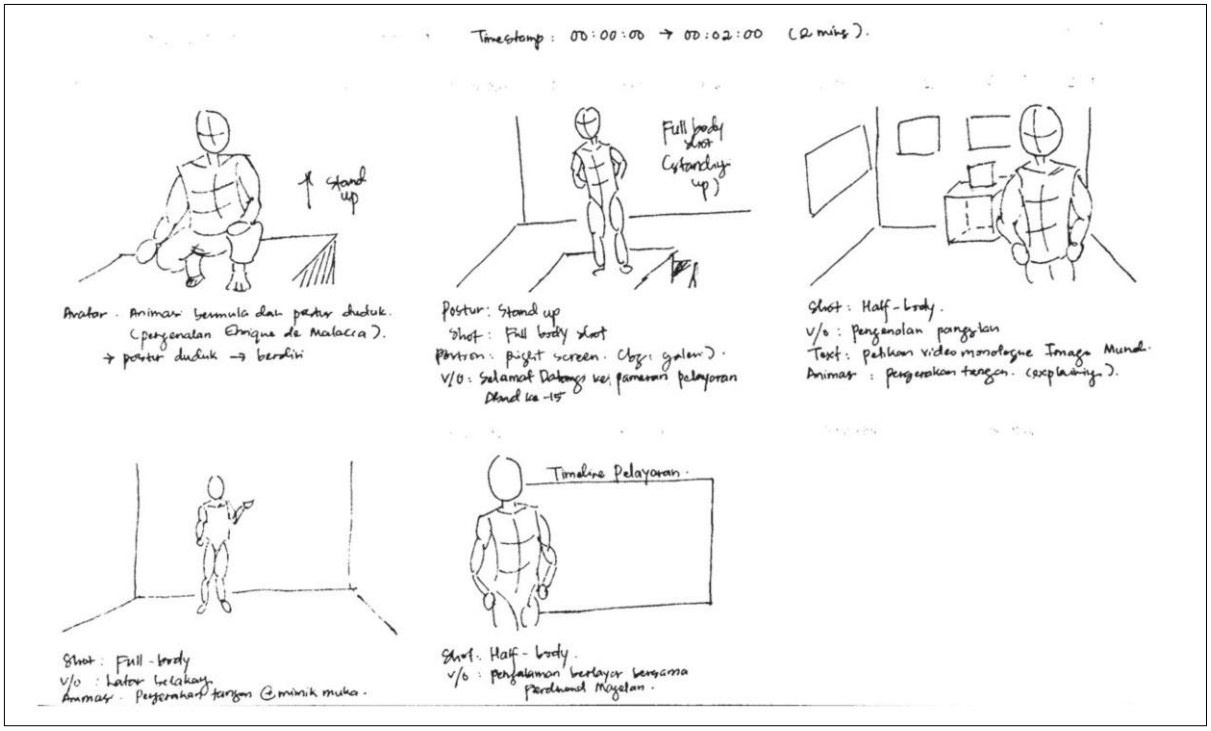
(a)



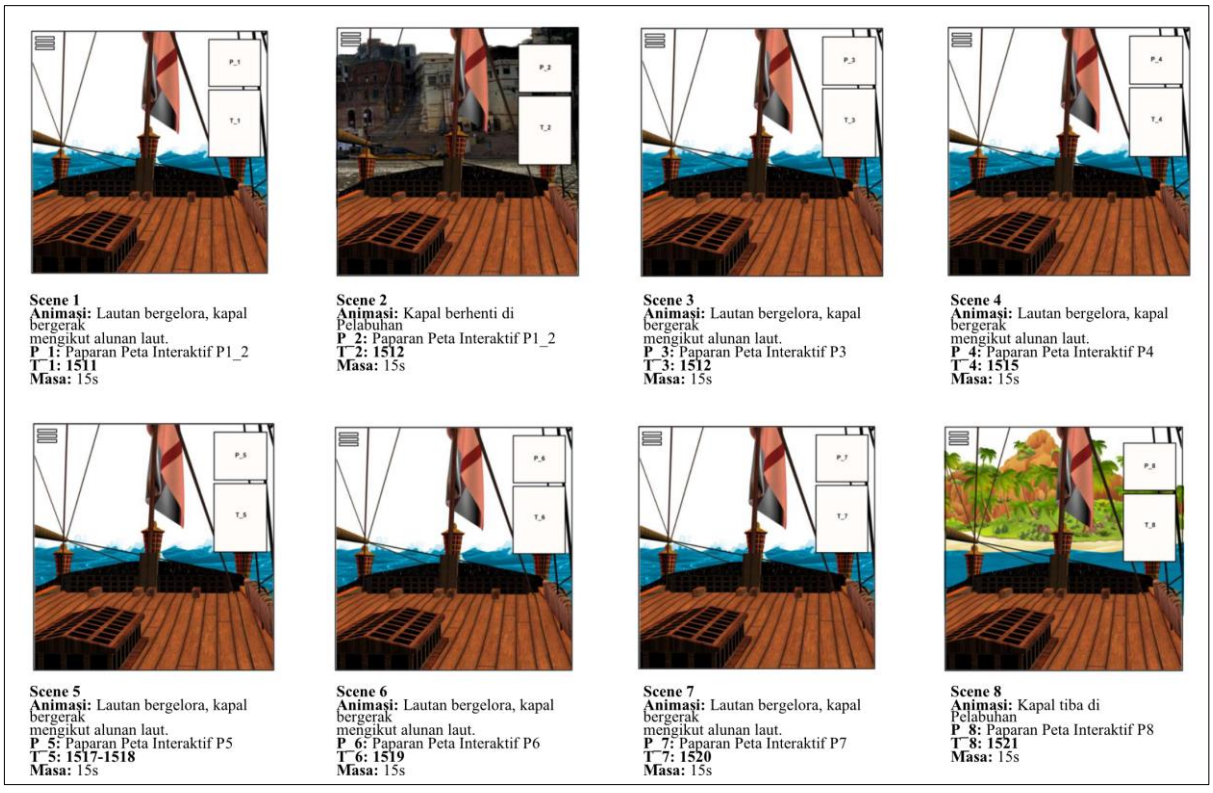
(b)

FIGURE 2. (a) Storyboard for immersive gallery environment; (b) Storyboard design for virtual object, avatar, and digital storytelling

One of the gallery's artifacts, an astronomical instrument called the astrolabe, was chosen as the virtual object for the development of this immersive gallery to help visitors understand the importance of its use in navigation in the 15th century voyages. Users can interact tactilely through a virtual reality headset and manipulate objects by rotating 360 degrees and zooming in for a closer look at the artifacts. In addition, the character of Enrique de Malacca was developed as an avatar to digitally represent his background and role during the 15th century voyage. Users can interact directly with this avatar. The final component in the design of the exhibition is the development of a three-dimensional (3D) model of the Trinidad ship and the chronological animation of the voyage from 1511 to 1521. The chronological animation video of the voyage is developed from the perspective of the first point of view, which can provide a real experience to the users of the system. The interface design for the avatar and animated video are shown in Figure 3.



(a)



(b)

FIGURE 3. (a) Storyboard for avatar animated video; (b) Storyboard for voyage digital storytelling

RESULT AND DISCUSSION

The main objective of this study is to analyze the specification requirements for developing an immersive gallery design in a metaverse environment that promotes collaborative interaction between users. Based on the literature review, three interaction categories were identified that play a role in developing the collaborative interaction of this immersive gallery, namely communication, collaborative navigation, and collaborative editing. Communication can be achieved through touch gestures such as swiping, dragging, dropping, and grasping when user is using tablet. Meanwhile non-touch gestures can be achieved through body movements, hands, eyes, or fingers when using Head Mounted Display (HMD) VR Headset. By coordinating two different type of input devices, users can view, interact and collaborate with each other freely and flexible in the virtual world (Zhao et al. 2022). Verbal communication also includes voice intonation, speech rate, and volume of the avatar's voice to influence the effectiveness of the social interaction process (Roth et al. 2017). The interaction design of virtual objects and avatars representing the character of Enrique de Malacca considers these specifications to allow users to manipulate the Astrolabe 360 degrees in a virtual environment while obtaining background information about the character through digital narration by the avatar. A character's image is significant in the context of storytelling. Avatars or virtual characters can be used in a digital context to maintain user expectations and experiences while using the system (Ortiz et al. 2003). One of the advantages of using avatars in digital storytelling is that when users interact with the system, they are given the illusion that they are communicating with a real person. This can be achieved by mimicking real human dialogs and behaviors.

The next category of interaction is co-navigation, where multiple users collaborate. The process of co-navigation consists of forming a navigation group of different users, assigning navigation responsibilities, performing joint tasks, and finally ending the co-navigation by separating from the developed group. This interaction is implemented in the development of a digital storytelling design of the 15th century voyage chronology, which allows different users to navigate in the ship environment of Trinidad to live the real experience of the voyage chronology through animated videos. Users can also explore the ship's virtual environment collaboratively with other users. The final interaction is collaborative editing, which allows system users to change the properties, position, or orientation of virtual objects together. Each user of the system is able to jointly manipulate objects that are stored, modified, or moved by other users through a collaborative mechanism (Greenwald, Wiley & Pattie 2017). The collaborative mechanism is a component involved in the interaction of different users and includes four main processes, namely: a) visualization of users through the use of avatars; b) highlighting of users; c) highlighting of objects; and d) previewing, manipulating, and receiving previews (Pereira et al. 2012).

CONCLUSION

In summary, this study successfully achieved the goal of analyzing user requirement specifications to design an immersive gallery environment interface that promotes collaborative interaction between users. Three important components identified in the development of a collaborative interaction in a Metaverse environment are communication, co-navigation, and collaborative editing. The collaborative interaction aspect developed was then used as the basis for developing a conceptual model and storyboard design to enhance the user experience of exploring and learning the history of voyages in Southeast Asia.

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