Development of Virtual Reality Applications for Promoting Educational Tourism and Architectural History: Insights from Indonesia

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Abstract

Promoting heritage objects for educational tourism is always challenging. Indonesia, for example, has many unique local architectural heritage sites scattered among its 34 provinces. Unfortunately, ordinary tourists like visiting popular and easily accessible heritage sites leaving the rest behind. Fortunately, Virtual Reality (VR) technology can offer virtual visits to all those objects without the time and distance constraints.

This research used a literature study and a user-centered design (UCD) method to develop a VR-based open-source application called Abiyasa to help local governments promote educational tourism and architectural heritage. The research used Pulo Kenanga of the Yogyakarta Palace as its case study.

The research resulted in an application that enables the provincial government to provide valid information on its heritage objects in a user-friendly and educating way, online and offline. Thirty tester respondents found Abiyasa was enjoyable and informative.

Keywords: Application, Education, Heritage, Tourism, Virtual Reality

Introduction

Values on cultural heritage sites have an essential role in education, tourism, and national pride. The story behind the architecture of the cultural area, for example, is fascinating to know. Cultural heritage sites represent the identity or history of a place or region. Therefore, a city must harness and highlight local culture and traditions (Angelidou and Stylianidis 2020). Cultural heritage connects the past and the present and affects regional stability and development (Yang et al. 2021).

The way visitors enjoy cultural heritage sites has changed over the last century. Cultural heritage activities and exhibitions are centered around places and objects. Visitors are only allowed to see, read, and listen to stories but not touch and interact with the objects. It causes visitors to draw conclusions and interpret themselves. In developing tourism with the help of digital technologies, it is necessary to pay attention to the aspect of users with information and interaction problems, who cannot even visit the heritage sites (Pisoni et al. 2021). VR

technology is relevant when tourists cannot visit locations in person, such as during the COVID-19 pandemic (Akhtar et al. 2021). Therefore, the digitalization of tourism, especially culture and history, are essential. This paper takes the view that travel experiences with VR technology can be used as a marketing tool for tourism and heritage object development (Merkx and Nawijn, 2021; Ercan, 2020)

The special province of Yogyakarta is one of the 34 provinces of Indonesia and is renowned as the center of the Javanese culture. It is a global tourist destination known for its historical and cultural heritages. Among them, one of the destinations and references for cultural and historical tourism in Yogyakarta is Taman Sari or the Flower Garden. Pulo Kenanga (the Kenanga island) is an artificial island built on water surrounded by Kenanga (lt. *Cananga odorata*) flowers. It is a part of Taman Sari that has undergone several renovations since 1803 (Karaton Ngayogyakarta Hadiningrat 2018) .Unfortunately, only a few of the many parts of the building in the Taman Sari area, can be restored. In 2006, Taman Sari was damaged by a 5.9 Richter scale earthquake. VR is expected to provide benefits and help preserve the cultural heritage by introducing cultural potential and helping reduce the impact of damage on cultural heritage tourism buildings.

The digital application of education and tourism methods from traditional methods can lead to the improvement and higher quality of tourism services (Kallou and Kikilia 2021). Tourism digitalization has proven to be superior in terms of service because it can be customized according to the parameters desired by tourist consumers (Nikolskaya et al. 2019). Digital tourguide plays an important role in helping tourists gain knowledge and experience in visiting virtual tours (Chiao, Chen, and Huang 2018).

Maximizing digital technology is needed in the heritage conservation process so that can enjoy future generations (Aburamadan *et al.*, 2021; Chardymskiy *et al.*, 2022). Virtual tours can help promote tourist destinations in a positive direction. It can also reduce damage to heritage assets that must be protected due to the increasing flow of tourists (Voronkova 2018). With the latest technological advances, digital tourism can be made interactive such as adding games especially with an educational mission to make it easier for tourists to get an experience in these activities (Lopes *et al.*, 2019; Pahlevi, Sayono and Hermanto, 2021). The existence of a digital tourgude interface with users helps increase user motivation in trying and interacting in a virtual tour (de Almeida, Pilar; Yokoi 2003).

This research aims to develop a VR technology as a digital tour guide that could help the visitors understand the architectural history of a heritage site. The tour guide called Abiyasa, is an internet-based VR application to assist onsite and offsite visitors (remote viewing). This application is made in an open-source form to be easily used by the government or private institutions concerned with the cultural heritage and architectural education tours to be adapted for other objects.

Research Methods

The development of Abiyasa began with a literature study to prepare the concept of using virtual reality technology in educational (and entertaining) tourism of architectural and cultural heritage. It was followed by a two-stage user-centered application design to develop Abiyasa's prototype. In the first stage, two architects worked closely with a software developer to make the initial prototype of Abiyasa. Then, when the prototype was considered satisfactory, in terms of the requirement as a virtual reality-based media for educational tourism and architecture history, thirty respondents tested it. It was the second stage. Both the first and second stages were iterative processes.

Abiyasa's development involved some software (

Table 1), a computer (Table 2), a VR headset (Table 3), and a 360 Ricoh Theta.

Table 1 Software for developing Abiyasa
Source: author's documentation

Software	Used for
Sony Vegas	video editing
Audacity	audio mixing
Blender 3D	model construction
Unity 3D	virtual reality construction
Visual Studio 2017	coding
Coreldraw and Photoshop	feature graphical editing

Table 2 Computer
Source: author's documentation

Processor	Intel ® Core ™ i7-6700K CPU @ 4.00Ghz (8 CPUs), ~4.0Ghz
Memory	8192MB RAM
VGA	Radeon RX 570 Series
VGA memory	8117MB

Table 3 Oculus Quest 2 VR Headset
Source: author's documentation

CPU	Qualcomm® Snapdragon XR2 Platform
Resolution	2,560 x 1,440
Memory	6GB
Panel type per eye	Single Fast-Switch LCD, 1832×1920px per eye
Supported Refresh Rate 60Hz in some cases	72Hz (default) can be configured to 60Hz in some cases
Default SDK Color Space	Rec.2020 gamut, 2.2 gammas, D65 white point

Theoretical Review

VR technology is a powerful tool to stimulate educational tourism in cultural heritage objects. In cultural heritage sites and museums, engaging activities such as games are considered practical tools to motivate visitors and provide an exciting and memorable user experience equipped with the game technology (Tzima, Styliaras, and Bassounas 2021). The development of the heritage field leads to the integration of exhibitions and intelligent installations through physical content and digital technologies (Luigina Ciolfi &Liam J. Bannon 2008). The utilization of digital technology contributes to the increased promotion of cultural heritage sites. thus, allowing the visitors to interact and gain a better knowledge (López Martínez, Carrera, and Iglesias 2020). Collaboration with conservation experts, tour guides, and teachers in management and development can support increased learning and education on cultural heritage sites (Hernàndez-Cardona, Sospedra Roca, and Íñiguez Gracia 2021).

In tourism, Virtual Reality (VR) technology has been used to simulate museums, archaeological sites, historical sites, and other places of interest (Ambrosio Arias et al. 2020). It creates innovative ways of sharing information, facilitating access, and increasing people's values and awareness of cultural and natural heritage (Bruno et al. 2020). The VR shapes digital data as an engaging, educational, and entertaining lesson so that visitors will be interested in cultural heritage. The digital technologies help freely increase knowledge, understanding, enhancement, awareness, and enjoyment of cultural heritage (Ibañez Etxeberria et al. 2020).

The meaning of free here is that the users can access without restrictions and propose tools or contexts to interact with the cultural heritage.

Digital reconstruction is a technique currently commonly used in historic buildings (Caciora *et al.*, 2021; Hu *et al.*, 2020; Shehade and Stylianou-Lambert, 2020). Efforts to préserve cultural heritage for the future generations are essential given that the historical artifacts are damaged by natural disasters or time. It is kept by accurately documenting it to improve user experience in virtual visits, science, and education (Ovidia Soto Martin, Alba Fuentes Porto 2020). Combining 360-degree video technology with VR can minimize the interactions with the real world. This method is also expected to be better than the images commonly used in VR (Mouratidis and Hassan 2020).

There are two applications with almost similar objectives with Abiyasa, i.e., (Samah et al. 2021) and (Ovidia Soto Martin, Alba Fuentes Porto 2020) .

Table 4 compares Abiyasa with those two applications.

Table 4: Comparison of the two similar applications
Source: author's documentation

Application	**Malay and Islamic World Museum VR** (Samah et al. 2021)	**Digital Reconstruction of a Historical Building and Virtual Reintegration St. Augustine church** (Ovidia Soto Martin, Alba Fuentes Porto 2020)	**Abiyasa**
Content	Explains and tells the Museum of Malay and Islamic history. There is a choice of music, narrative text in information, and a virtual environment in the application.	Reconstruction of the church of St. Augustine. This application lets users see visualizations and interact in directing hands (VR) and camera angles. For example, the application will bring up a text box containing information when highlighted with the VR hand.	Explain in terms of history and architectural education on the Pulo Kenanga building. With the help of VR, this application has a choice of music, text boxes in the form of information, a virtual 360 environment, and a digital tour guide that guides from the start of the application to the completion. The provincial government can easily change the heritage objects in its region. Each object provides integrated elements to create a unique atmosphere of a particular culture. Even the tour guide can speak in the local language, although Indonesian is the formal language in Indonesia. English is provided for international visitors.

The comparison table above focuses on the theoretical content and object visualization. The first and second applications have their explanatory narrative in a written form. Meanwhile, Abiyasa has the advantage of a digital tour guide that can be tailored to the needs of the users. It helps visitors convey information more effectively than merely listening to narration and viewing subtitles. Another advantage of Abiyasa is that the application's language, background, and tour guide can be adjusted according to the needs to be used for other tourist objects.

UCD (User-Centered Design) is a design philosophy that places the user at the center of a system development process (Fig. 1). It is a method to evaluate if the design result meets user satisfaction. A basic UCD has four steps, namely (1) understanding the context of use, (2) specifying the user requirements, (3) producing a design solution, and (4) evaluating the design (ISO 2010), which is iterative. Before entering the four steps, a UCD is preceded by a plan for

the human-centered design process. The iterative process is terminated when the designs solution meets the user requirements.

Results and Discussion

Abiyasa Development

The development of Abiyasa followed a design flowchart and an algorithm, as seen by Fig. 2 and Fig. **3**, respectively. Any provincial government can use the step in the red-dash square (Fig. 3) to set the heritage objects that exist in their region. They can then put Abiyasa in the Google Play and Playstore for the public to download.

A two-stage user-centered design method was applied to develop Abiyasa's prototype. In the first stage, two architects acted as expert users and worked closely with a software developer to design the initial prototype of Abiyasa. These architects provided design guidelines for the software developer based on their literature study and survey. They formulated Abiyasa's design to meet the requirement as media for educational tourism and architecture history. These two architects tested the initial prototype and gave feedback to the developer. The prototype was tested, evaluated, and modified through a cyclic process until it met the required primary performance. Thus, the prototype was not intended to be a final (elaborated) version. Before entering the coding stage, the Abiyasa algorithm was prepared as the Fig. 3. Finally, thirty respondents alternately used an Oculus Quest 2 VR headset to test the Abiyasa's prototype before filling in the questionnaires for the performance evaluation of the application. That was the second stage.

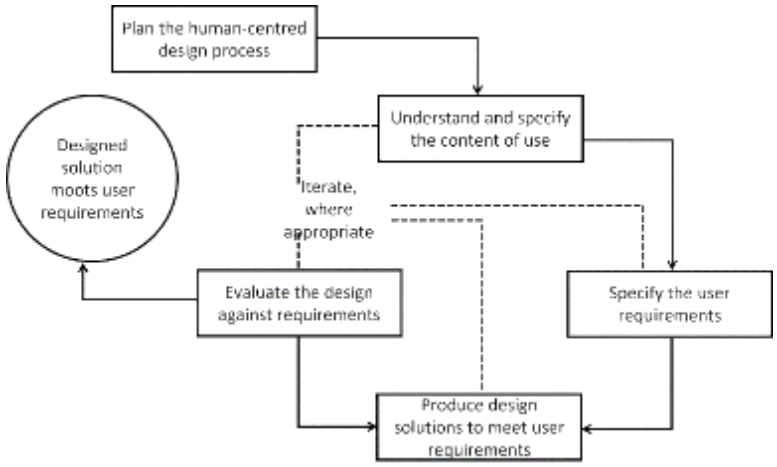


Fig. 1: User-centered design (UCD) process
source: ISO 9241-210, 2010

Step 1: understand and define the context of use.

This is to promote cultural heritage objects for educational tourism that can be accessed without the limitations of distance and time for tourists. Local governments can also use it for conservation and promotion.

Step 2: define the user requirements.

The users must have the ability to operate smartphones, Oculus and VR tools.

Step 3: generate design solutions to meet the user requirements.

Utilization of VR technology to assist the tourists in learning valid information about cultural heritage objects in a user-friendly and educational way, online and offline.

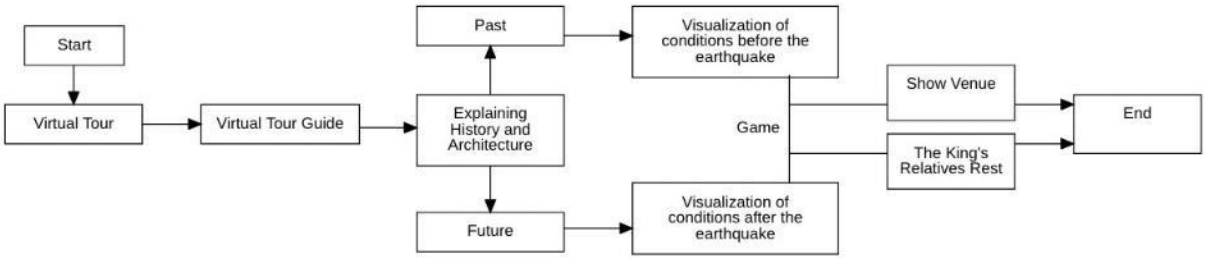


Fig. 2: The Abiyasa's design flowchart.
Source: author's documentation

Step 4: evaluate the design against the requirements.

Test and evaluate the prototype to meet the design requirements.

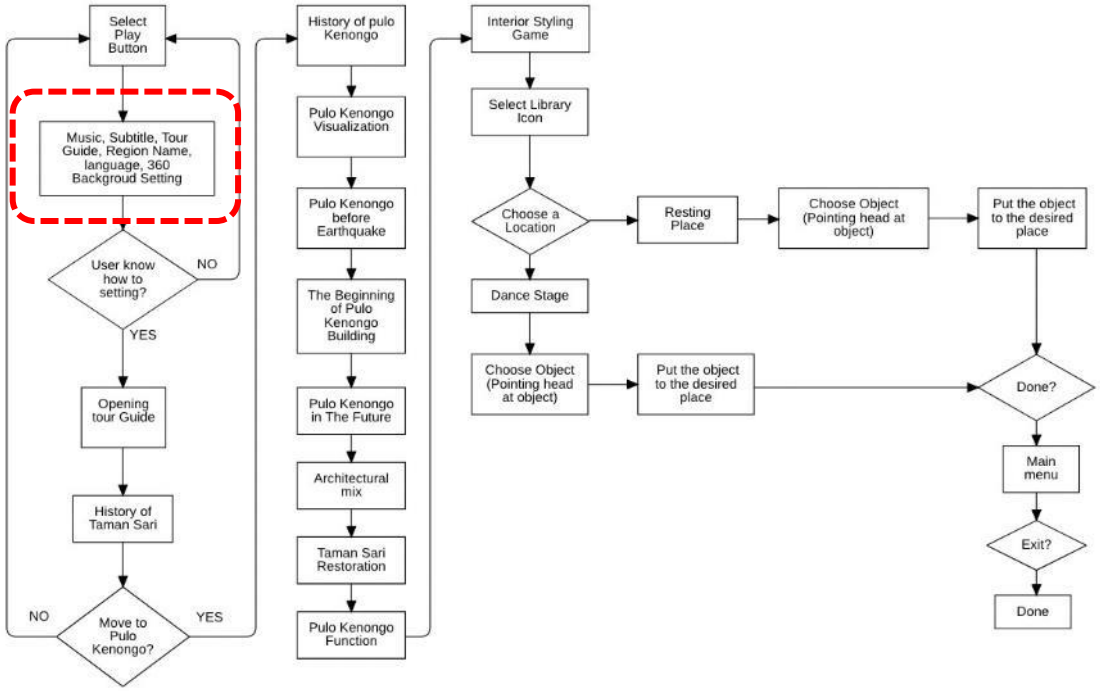


Fig. 3: The Abiyasa's basic algorithm.
Source: author's documentation

With Abiyasa, visitors can see the shape of Pulo Kenanga before the earthquake damaged it. It helps educate visitors or tourists about the history of the Pulo Kenanga building. Educational games were added to make it easier for Abiyasa's users to understand the visualization of Pulo Kenanga. Technological engagement with the virtual dimension of virtual reality and game context can provide a memorable travel experience, foster emotional connection and curiosity for users, and have a high level of fun in the game version. VR delivers ease of use, freedom, creativity, more aesthetics in audio and narration (Han et al. 2019). This application is wrapped with games to feel more interested and encourage curiosity as an educational medium.

Reconstruction of existing buildings in roofs, floor arrangements, and walls can be done based on the initial building condition (before restoration). Visitors can interact by playing games in the future mode choices, namely compiling and adding interiors and characters in Pulo Kenanga. The setting of the place can be chosen by the visitors, namely the performing arts area and the living room for relatives or guests of the king. Interactions that appear in the

games in VR can be in the form of vibrations, tactile sensations, sounds, and real visuals (Dani 2019).

The design of the Abiyasa application begins by creating and collecting three-dimensional objects to bring an original atmosphere and picture of the environment into the application (Fig. 4). Every culture creates a unique environment comprehensively formed by all its cultural elements. The Javanese atmosphere of a place, for example, is altogether formed by its unique style of architecture, furniture, music, language, culinary, scents, and even fashion. Thus, by carefully selecting and integrally combining cultural elements, we can create a more substantial impact for the public to feel the uniqueness of the corresponding culture. The tour guide in the prototype of Abiyasa, for example, speaks and dresses like a Javanese. The existence of a tour guide is an added value for the tourist attractions; this will increase the quality of the essential elements of tourism such as transportation, attractions, and tourist satisfaction (Kruczek 2013). With the help of a tour guide, tourists will also be helped in understanding the materials so that they do not interpret personally about cultural heritage, but the information obtained is more accurate.

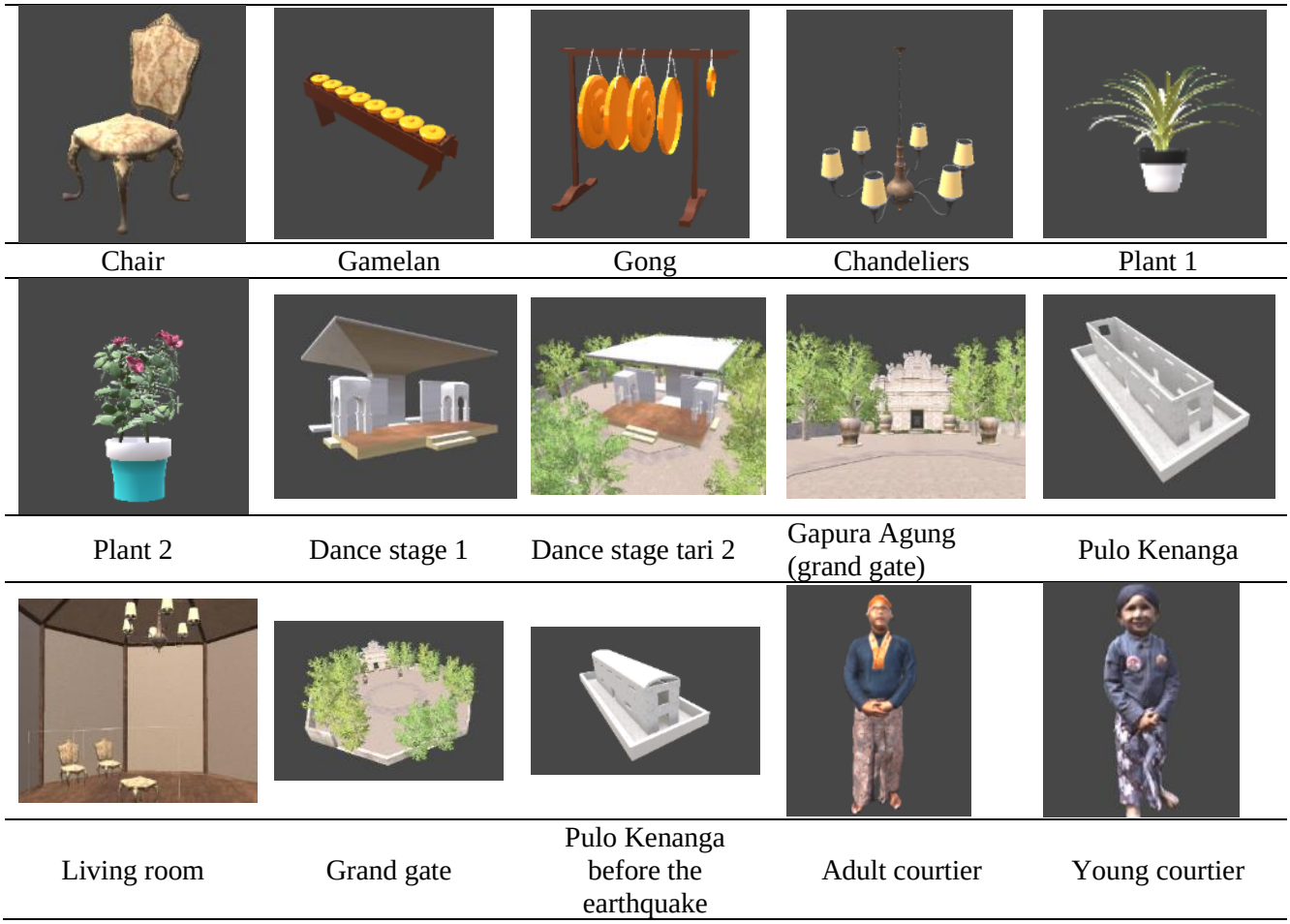


Fig. 4: Elements to form a unique atmosphere based on the related culture.
Source: author's documentation

3.1.1. Homepage design

On the home screen of the Abiyasa virtual reality application, there are menu options (
Fig. 5) as follows:

a) Setting menu
It contains a guide in the form of a selection of traditional and modern gamelan music, activating subtitles, and a choice of tour guide 'On the Tourguide' option.

b) Menu CC

To turn subtitles on and off on the main screen

c) Volume
It is an option to adjust the music volume to not interfere with the tour guide's voice.

d) Menu Home
Used when the user/visitor does not understand and wants to repeat the explanation from the beginning.

e) Menu Power off
To complete the application when the virtual tour is complete.

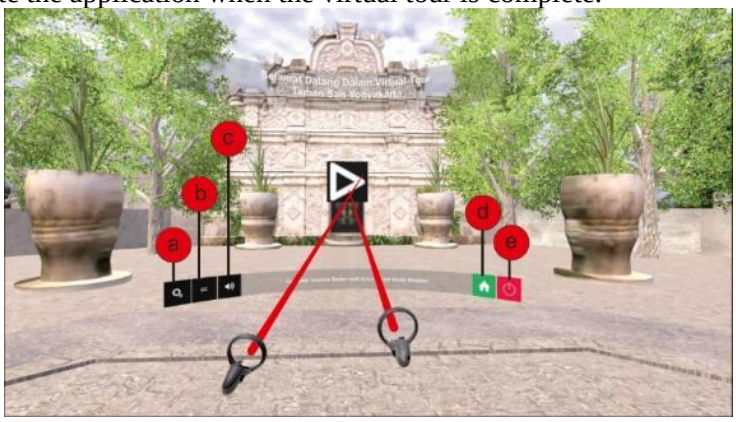


Fig. 5: The main Menu homepage of Abiyasa.
Source: author's documentation

The homepage explains the virtual tour that will be carried out. This section describes the features of the application such as setting music, language, volume, subtitles, and selecting a tour guide. When the virtual tour guide has been chosen, the user can start the tour. The tour guide will explain the parts of the Taman Sari area that are a favorite for tourists to visit, such as the Gumuling Well, Pasiraman Umbul Binangun, and Pulo Kenanga (Fig. 6). After the visitor selects Pulo Kenanga, the display will switch to the Pulo Kenanga building.

Fig. 6: 360º tour and navigation inside Pulo Kenanga.
Source: author's documentation

3.1.2. Main room display design.

At the stage of displaying the Pulo Kenanga section, the tour guide will explain the history and architectural aspects of Pulo Kenanga (

Fig.7). Indeed, he will explain several parts of the architectural side, such as defining the materials, forms of building styles, and the philosophy of the building. In addition, the Pulo Kenanga section will explain the differences in visualization in the era before and after the earthquake. For example, Pulo Kenanga before the earthquake depicted that the roof was still the same with a curved shape.

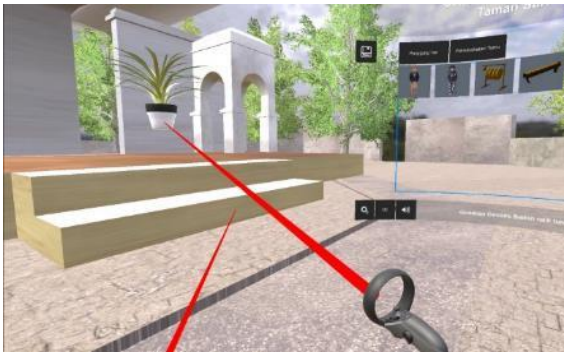
Image visualization of Pulo Kenanga after the earthquake

Picture visualization of the past Pulo Kenanga

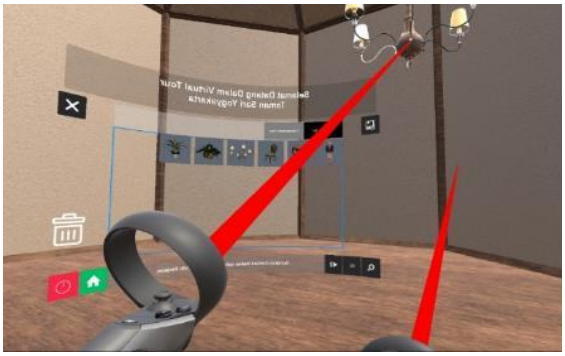
Fig.7: Visualization of Pulo Kenanga after and before the 2005 earthquake in Yogyakarta. Source: author's documentation

3.1.3. Abiyasa Game Section

Conventional learning will lag, while advances in virtual learning based on VR technology will help improve learning experiences and knowledge in the various fields, especially cultural heritage (Ghaliya Al Farsi et al. 2021). Therefore, it is essential to use the digital technology in VR as a learning medium in cultural heritage. In the display of the game section, the moderator will be guided verbally by giving instructions for choosing three-dimensional objects and setting the location in the form of an art stage and living room to welcome the king's relatives (Fig. 8) . In addition, there is a library menu option to choose place settings, characters, and interior objects. Visitors will be invited to develop characters and build a unique atmosphere. With choices, visitors can easily represent events and situations that occurred in the past.



Picture of the display when on the art stage



Picture of the display when in the meeting room or welcoming dignitaries or close relatives of the king

Fig. 8: Game section to 'create' a unique atmosphere based on related cultures. Source: author's documentation

3.2. Abiyasa Application Test Results Analysis

Thirty respondents tested Abiyasa to evaluate its performance. They filled in a questionnaire after trying Abiyasa. Before attempting the application, the procedures and the conditions were explained, i.e., the menus and the features in the application. The questionnaire was structured and divided into two question groups: open and closed questions (Table 5).

Fig. 9: An ordinary respondent tested the prototype of Abiyasa. He then filled out a questionnaire to improve the prototype's performance.
Source: author's documentation

Table 5: Abiyasa Questionnaire
Source: author's documentation, 2021

		No	Closed Question	Answer	
				Yes	No
General introductory questions	Q	1	Have you ever traveled and know about Pulo Kenanga Taman Sari Yogyakarta tourism?		
	Q	2	Have you ever heard and understood the history and architecture of Taman Sari Yogyakarta?		
Application introduction	Q	3	Did you know about virtual travel apps before?		
	Q	4	Have you ever used a virtual travel app before?		
Application technical questions	Q	5	Can Tour Guides help provide information and understanding in educational and historical tours of Pulo Kenanga?		
	Q	6	In the Abiyasa application, is Taman Sari well described as its original condition?		
	Q	7	Can you be helped by traveling with the Abiyasa Application on Pulo Kenanga?		
Conclusion question	Q	8	Do you feel enthusiastic about trying the Abiyasa Application and playing games in it?		
	Q	9	Can the Abiyasa game help you understand and understand the situation in Pulo Kenanga in the past?		
	Q	10	After trying the Abiyasa application, do you agree and are interested in the application being applied to other cultural heritages?		
	Q	11	Have you started to be interested in educational tours and architectural history with the Abiyasa application?		
	Q	12	Have you understood architectural history education at Taman Sari Yogyakarta with the Abiyasa application?		

		No	Open question	Answer
Conclusion question	Q	1	Please write down your impression after trying the Abiyasa application on Pulo Kenanga.	
	Q	2	Regarding the Abiyasa application, are there any suggestions for feature development? If yes, please mention it.	

Analysis of the application testing was needed to determine the advantages and disadvantages of the Abiyasa application design. The data obtained from the answers to the questionnaire were processed to obtain the conclusions or results from the respondents. The Guttman scale with an assessment score of "Yes" = 1 and "No" = 0 was used. Table 6 shows the summary of the questionnaire.

$$Percentage\ formula = \frac{total\ answered\ score}{Number\ of\ respondents}\ x\ 100\%$$

Table 6. The percentage result of Abiyasa's questionnaire
Source: author's documentation

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Number of answers	21	21	2	0	30	26	30	30	30	30	30	30
Presentage	70%	70%	7%	0	100%	87%	100%	100%	100%	100%	100%	100%

Note:
P1, P2, P3… : Questions Q1, … Qn
R1, R2, R3… : Respondent R1, … Respondent Rn
Score 0 : No
Score 1 : Yes

Based on the respondents' answers, 70% of the respondents have traveled and known about historical tourism and architectural education at Pulo Kenanga, Taman Sari, Yogyakarta. Taman Sari is one of the reference points for cultural and historical tourist destinations in Yogyakarta.

Table 6 shows that only 7% of respondents have heard of and learned about virtual travel applications. Moreover, no one has ever used the application, especially in cultural heritage, due to the lack of socialization to the public about the existence of technology that facilitates virtual tourism, especially cultural heritage sites.

From the respondents' technical feedback, 100% of the users felt assisted by the virtual tour guide of the Abiyasa application, which helped to understand and provide information about Pulo Kenanga. Furthermore, the technical description questionnaire obtained a percentage value of 87% of the respondents answered that this application described the condition of Pulo Kenanga well. It is because the depiction of the visualization was adjusted based on the field observations. The shape of the building, the environment, and the vegetation were constructed according to the original object.

The answer to the closed questions revealed that 100% of the respondents felt enthusiastic when they were explained and tried the Abiyasa application. With this application, respondents became more interested in the educational tours and the architectural history of Pulo Kenanga. Respondents were helped to understand better the condition of Pulo Kenanga with story narratives depicted by the games. It is due to innovation in games that one can

visualize the conditions and circumstances that occurred dyring the corresponding times. The game feature function also gives a sense of enthusiasm and can eliminate boredom after being explained with the story narration by the tour guide. With this application, respondents agree and are enthusiastic if this application is applied to other cultural heritages. It was decided by the respondents who answered with a presentation value of 100%. It happens because, until now, in Indonesia, no cultural heritage has utilized VR technology to facilitate onsite and offsite tours yet.

In general, respondents were enthusiastic, interested, and felt helped by the information and visualization of Pulo Kenanga. The tour guide's description with the information provided was made as close as possible to the conditions when the original tour guide was at the location. Respondents suggested enhancing the details and proportions of the building to make it more realistic. The addition of space exploration menu features and interactions such as walking around an object or a tour guide was also suggested by the respondents. Suggestions for adding online features to connect visitors who travel to these places are recommended from respondents because they feel lonely at Pulo Kenanga tourist attractions. Interaction between visitors and the tour guide in the form of questions and answers can also help eliminate boredom in this travel application. The development of more varied game content and application development to be accessed with personal cellphones was also recommended by respondents so that various groups could enjoy them.

3.3. Advantages and Disadvantages of Abiyasa Application

After testing the Abiyasa application, several advantages and disadvantages were discovered. The benefits of this application are:

1. It provides information to users who have never been to the Pulo Kenanga tourist attractions,
2. It displays three-dimensional objects that are pretty detailed and varied,
3. It can be developed for application to other cultural heritages.

The disadvantages of this application are:

1. There is no feature to walk to another room when the users feel bored and if the experience is monotonous if they stand somewhere,
2. There is a need to add a more varied selection of game features to attract more users from various circles to understand and be educated about the history of Pulo Kenanga architecture.

Those disadvantages are understandable as Abiyasa is still a prototype.

Conclusions

Based on the research results of the Abiyasa with its technology as a medium to support and facilitate onsite and offsite tours on Pulo Kenanga. The Abiyasa application can help travel virtually and learn the architecture history of Pulo Kenanga. Integration of culturally unique elements provides a better representation of traditional architecture. The Abiyasa application has a three-dimensional object display and game features. It has the advantage of providing detailed and varied information to users who have never been to Pulo Kenanga. However, the Abiyasa does not yet have a feature to walk to another room, limited game features, and the image quality is not good enough. These are the drawbacks of this application. However, suggestions are made to add online features to connect visitors who travel to tourist attractions.

Recommendation for Further Research

VR applications such as Abiyasa can be further developed as Mixed Reality applications and applied to other cultural heritages to preserve the historical heritage and facilitate offsite tours and onsite tours (visitors who come to these places).

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