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Development of Historical Learning Media Based on Virtual Reality of The National Awakening Museum

Mira Suryani[1], Rispansah Sakti Rusidiawan[2], Rudi Rosadi[3]

[1,2,3]*Computer Science Department, Faculty of Mathematics and Natural Science, Universitas Padjadjaran, Indonesia*
[1]mira.suryani@unpad.ac.id (*)
[2]rispansah.saktir4797@gmail.com, [3]r.rosadi@unpad.ac.id

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Abstract— In history learning, visits to locations such as museums or other historical places in the pandemic Covid-19 situation are minimal. However, learning activities must be continued, and the existing conventional learning media in the pandemic scenario are deemed less to provide the experience. Based on previous learning experiences, an obligation to transfer knowledge from museum managers, and technological developments related to virtual reality, supports an idea to develop a museum national awakening virtual reality. This VR application is expected to become an alternative historical learning medium. This study aims to create a museum national awakening VR based on 360-degree images of the museum location. The multimedia development life cycle (MDLC) is chosen as the method used in developing the proposed VR application. The procedure consists of six steps: defining the concept based on on-site observation and interviews with the manager, creating the design, collecting the material, assembling materials and interactions with code, testing the proposed application, and distributing the system. The proposed virtual tour application has been successfully developed following the methodological principles chosen. It is also supported by a series of observations in the field using a cognitive walkthrough approach. The application was then reviewed by five experts: historians, multimedia, and learning experts. The location detailing is perfectly captured, including all the objects shown in each museum room. The quiz feature also strengthens the VR application as the learning medium, but it needs to be developed further in the evaluation section.

Keywords— 360-Degrees Images, History Learning Media, Virtual Museum, Virtual Reality, Virtual Tour.

I. INTRODUCTION

Few people make the national museum the first list of places to visit. Generally, the national museums are visited in the context of learning activities, especially history learning. However, unfortunately, with the current Covid-19 pandemic conditions, domestic and international direct visits are greatly minimized [1]. Learning is diverted to presentations, lecturing, reviewing books, or online learning activities [2] that use other conventional media. These media seemed static and less interactive.

The National Awakening Museum is one of the national museums in Indonesia. This museum is located in the center of Jakarta, Indonesia. This museum displays the history of School Tot Opleiding van Inlandsche Artsen (STOVIA), the first medical school built in Indonesia in 1889. The STOVIA also became a place where young leaders gathered to think about Indonesia's independence [3]. Currently, the government manages the museum under the Ministry of Education, Culture, Research, and Higher Education. Usually, this museum is visited by various students from all over Indonesia. However, this is still very limited, so there needs to be another alternative to deliver educational content about this museum. The history lessons displayed at the National Awakening Museum follow the learning curriculum for the high school level, specifically for 11th grade. Following the Minister of Education and Culture No. 59 of 2019 concerning the 2013 Curriculum, especially in high school history subjects, there are learning contents regarding the awakening of heroism and Indonesian nationality.

Conversely, the rapidly advancing nature of technology in our day and age makes it possible to accomplish previously unattainable things. The existence of 360^o virtual tour technology as part of virtual reality (VR) allows users to see and feel the atmosphere of a location as close to the original through a sequence of images or videos that support narration, music, sound effects, and text [4]. The implementation of virtual reality tours is often used to introduce famous geological landmarks [5], tourist attractions [6], heritage artifacts [7], and so on.

The use of virtual reality technology with the concept of a tour in the museum area is also widely carried out by researchers. One of the review studies conducted by [8] states that there are at least 51 studies related to the implementation of VR for museums in the United States (11 studies), Taiwan (7 studies), United Kingdom (7 studies), and other European countries (15 studies). Viewed from the visitor category, 40% of the 51 studies had subjects K-12 students, followed by general visitors (including the family category) as much as 34%, then higher education students as much as 17%, and adults as much as 7%. The use of VR technology itself is widely used in art museums (13 studies, 25.5%), history museums (14 studies, 27.4%), archaeology museums (4 studies, 7.8%). Based on design elements and technology affordances, the VR aspect is used to add or amplify information to physical exhibits to explain exhibition content

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[9]. This was done by 23 of the 51 existing studies, both in the form of images, audio, video, and 3D models. It has also been discovered, via the compilation of data, that there is a connection between the utilization of VR and academic accomplishment and perceptions. In terms of academic achievement, VR significantly increases academic achievement in the context of learning at the museum compared to those who do not use VR. Meanwhile, in terms of perception, VR provides a medium effect. However, VR provides a better flow experience and makes visitors more proactive in appreciating artwork or information.

The Geevor Tin Mine VR software, which can be seen at the Museum of Science and Industry in Manchester, was used to transmit the results of an intriguing study on the application of virtual reality technology in museums [10]. The implication of his study states that the overall success of the VR museum experience is influenced by the absorption aspect, which consists of two sub-aspects: education and entertainment. These two sub-aspects are connected to the two sub-aspects of immersion: escapism and esthetics. Escapism is the main reason tourists travel to other destinations and visit various attractions [11]. The overall positive VR experience also leads to an intention to visit the museum [12]. This is in line with the changing paradigm of the museum, which initially had a mission of focusing on collecting, now focusing on visitors[13].

In detail, the exploration of VR implementation in real museums is stated by [14]. There are three schemes for using VR directly in the museum: full set VR to get full immersion, panoramic settings while still using a VR headset, and screen settings using 3D glasses. Unlike the research conducted by [15]–[18], developed does not seek to strengthen the museum's existing estate, but he developed an imaginative VR museum. With the speculative and extrapolative setting of the current museum, he developed three scenarios for the VR museum: 1)Future threat, which prioritizes the possibility of future technology and social relations. 2)UN Greenkeepers are related to urban, technology, social, and personal affective. 3) No More Borders, related to social focus, familiar effect, and daily life routine.

The wide use of virtual reality in the form of the virtual tour [19], especially for the museum, has inspired us to develop a virtual reality tour for the National Awakening Museum. The main development goal of this VR application is to provide an alternative media tour for visitors and become an interactive learning media for students. Not only to see the information listed, but the developed VR application also added a quiz feature that allows users to get challenges and hone knowledge. Furthermore, this application is expected to awaken museums as creative industries that can bring out the potential of museums in an interesting, attractive, and contemporary way.

This paper is organized as follows: Section II describes the methodology conducted in this study. Section III details the 360º VR system of the National Awakening Museum. Section IV contains the evaluation and discussion of issues in developing the VR application. Finally, the last section concludes this paper.

II. RESEARCH METHODOLOGY

The Multimedia Development Life Cycle (MDLC) methodology was chosen as the development methodology for the VR system in this study. The MDLC consists of 6 stages: concept, design, material collecting, assembly, testing, and distribution. Luther introduced the Multimedia Development Life Cycle (MDLC) method in 1994. Although MDLC theory is quite old, it is still relevant to guide development. In practice, the six stages can change positions and do not have to be sequential. However, the concept should be the first step taken [20]. The illustration of MDLC can be seen in Figure 1.

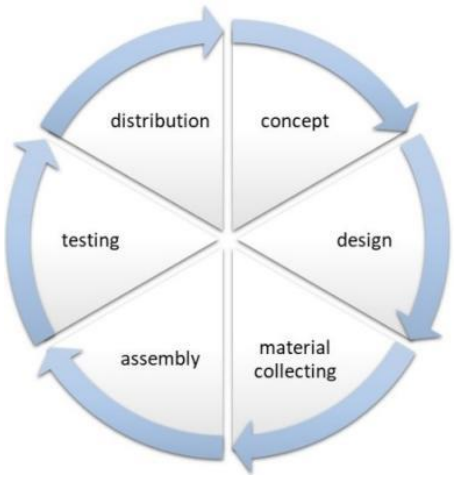

Figure 1. Multimedia Development Life Cycle Methodology [20]

The detailed activity was carried out using the MDLC methodology in this study.

1) Concept. The developer conducts a needs analysis and formulates the basis of the application to be created and developed. Needs analysis activities are carried out through a benchmarking process for similar applications, discussions with museum managers, and expert VR developers. Aspects of needs analysis discussed include application scenarios, target users, the technology used, to hardware and software requirements.

2) Design. The detail of the design application specifications was developed. Several diagrams, such as a use case diagram, activity diagram, and storyboard, were developed to better understand the proposed VR system.

3) Material Collecting. The 360 images of the museum are the primary material in this project. Moreover, some 3D objects, including menu pages and other environmental aspects, should be collected or developed.

4) Assembly. At this stage, the VR application development process involves several coding programs for interaction. Additionally, stitching images, 3D objects, and other materials according to the developed scenario is also part of this stage.

5) Testing. VR application testing involves several stakeholders who contribute at the concept stage. This is done

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to find out that the application is not only functioning properly but also fulfilled the needs at the concept stage.

6) Distribution. The developed VR applications are widely distributed but are still under the supervision of the museum's management.

A. Requirement Gathering

The VR application was built to make learning more attractive and up-to-date. Based on the need analysis activity, a virtual tour was chosen as the main approach and technology in developing the proposed VR application. In the virtual tour, documentation of all the information in the museum is presented so that users can learn. The presentation of information in a virtual tour in the form of multimedia includes images, text, sound, and their combination.

The VR application developed is planned to be run on the Android platform. This is considered because of the high user access to Android smartphones and following the target users, namely high school students. A high-specification computer, a 360-degree camera to capture the environment of the museum, a high-resolution camera to capture the objects, and an Android smartphone to test the proposed VR application are some of the pieces of hardware that the developer of the VR application will need to meet the goal of the application. In addition, a few pieces of software are essential, such as Unity and Affinity Photo. On the other side, some hardware is needed by the user, such as a smartphone with a minimum Android version of 5.0 accompanied by a proximity sensor and accelerometer. Additionally, VR glasses, VR Bluetooth controllers, and earphones are expected to support a better experience.

B. Collecting the Data

At the stage of collecting materials, the main content of the application is artifacts and information boards in the museum. Based on the museum map (see Figure 2), there are 32 rooms in the museum, but not all rooms function to display historical artifacts. Only the yellow room displaying historical artifacts became this application's focus. The details of the rooms and assets whose data was captured to be used as assets in the VR application can be seen in Table I.

TABLE I
ASSET LIST FOR PROPOSED VIRTUAL REALITY

Room No	Room	Number of Assets (image)
2	STOVIA dorm room	3
3	Boedi Utomo memorial room	6
4	Medical history room	10
10	Nusantara room	12
11	Kolonialism	6
12	Local resistance in the archipelago	14
13	Ethical politics the birth of a new elite	6
15	STOVIA class	1
16	Boedi Utomo	20
17	Kartini	3
18	Muhammadiyah	8
19	Tri Korodarmo	6
20	Meaning of national awakening	4
	Total	**99**

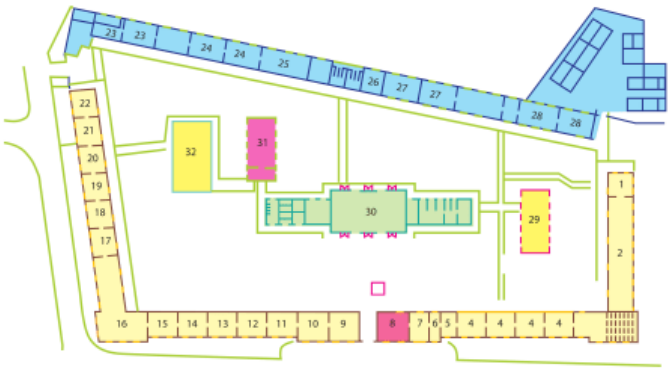

Figure 2. The Map of The National Awakening Museum [3]

The data collection process in this study adopted the tangible and intangible collection technique by [21]. All information boards and artifacts treated as tangible heritage were photographed one by one with a high-resolution camera. These objects will be used in the pop-up feature when the user wants to observe the artifacts or read the information boards. Then, a 360o camera is used to photograph locations with a maximum radius every 3 to 5 meters to create a simulated environment. We use a camera, Samsung gear 360 (2017), with two lenses, 4096 x 2048 (24fps), with a photo resolution of 15 MP (2x 8.4MP sensor). Due to the shooting results, there are several overlapping areas, and we sort each one to determine the quality of the best photo part, then tidy it up by stitching the image to form a 360º environment. Detailed illustrations of how to shoot with a 360º camera can be seen in Figure 3.

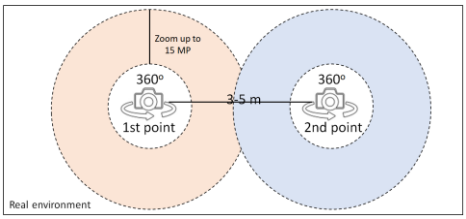

Figure 3. Illustration Of the Technique of Taking Pictures of The Museum Environment with A 360º Camera

Finally, several additional objects were developed to support interaction, such as arrows, a green pointer, and floating boxes for menus and questions. Additional information was obtained from interviews with managers and then used as audio narration, which was re-recorded. This kind of information belongs to an intangible collection.

C. The Description of the Proposed VR System

This application is a VR introduction to history at the National Awakening Museum in the form of 360º images. This application displays the environment as if the user is in the museum using VR devices such as low-cost Google Cardboard [22] or Glasses. The application scenario is an exploration of the National Awakening Museum using 360º images and stitched using the Affinity Photo application to

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combine each photo into one part. After that, the photos are then inserted into Unity to form a virtual environment.

The beginning of the scenario, the user will be on the application's main page in the form of a 360º image with the frontpage background of the STOVIA. On this home screen, there is a main menu consisting of two menu buttons, namely the "*Jelajah*" (Explore) and the "*Keluar*" (Exit) menu. The interface of the home screen, main lobby, and the intersection of the museum are shown in Figure 4.

The process of exploring the museum in this application is how users can explore every room in the museum by following pre-determined directions. When the user clicks "*Jelajah*" button, they will be directed to the museum lobby and start exploring. The exploration is divided into two parts: the left and right sides of the museum. Users are free to choose which side to start first.

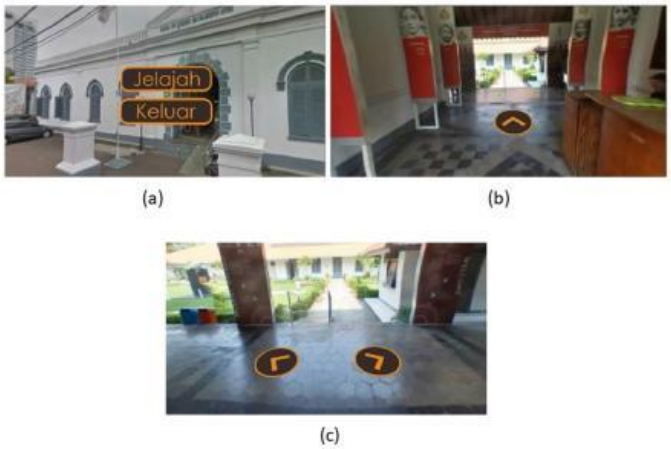

Figure 4. (a) The Interface of The Home Screen in Proposed VR Application; (B) Main Lobby of The Museum; (C) Intersection of The Museum, People Can Go Through Left Side or Right Side.

When the user enters the room, a green pointer points to the image, allowing the user to see the image more clearly. After that, the image will appear clearer, and there will be sound explanations in some images as well. Users only need to point the pointer to one of these images and press the interaction button on the controller. A pop-up will appear when the user points the pointer to the image they want to read more clearly and presses the interaction button on the controller. The interface of exploration in the room using a green pointer can be seen in Figure 5.

Figure 5. (A) A Green Pointer That Use to Access Information Board in A Room; (B) A Zoom in Feature in VR Application to Pop Up Information Board.

During the exploration process, some rooms have questions as keys to proceed to the next room. The questions are taken from the information in the previous room. There will be 2 up to 3 questions in each room. These questions aim to provide a challenge and an explanation of the information. Four answer options are given for each first question in the new room. If the answer is correct, a follow-up question will appear with the same number of choice options. However, if the question is answered incorrectly, fewer answer options are made for the next question. It aims to provide a lightening of the cognitive load to the user and continue to explore. An example of questions is shown in Figure 6.

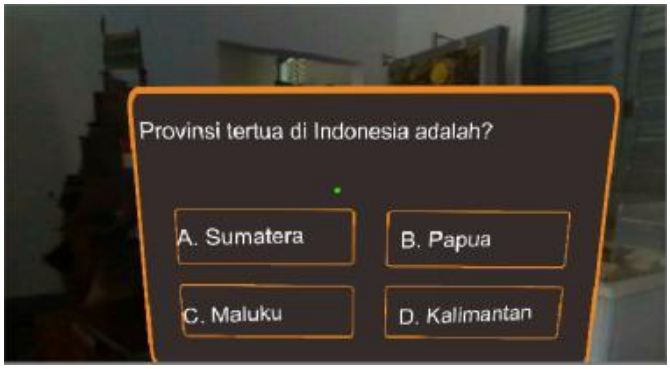

Figure 6. An Example of Pop-Up Question in The Proposed VR Application

The user must correctly answer the question. Each user who answers the question correctly will get a puzzle piece. If the user answers incorrectly, it will continue to the next question. If the user still answers incorrectly on the last question, there will be assistance in the form of a blue arrow on the information being asked to make it easier for users to answer questions. The concept of exploration is arranged in such a way that the learning process becomes more attractive, interactive, and challenging because the user must know each room's information to answer questions as the key to proceed to the next room. Thus, the user must correctly get the information in each room. The examples of puzzle pieces can be seen in Figure 7.

Figure 7. An Example of Getting a Puzzle After the User Has Successfully Answered the Question Correctly to Form a Complete Piece of Information.

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III. Result and Discussion

The proposed VR application was evaluated using a qualitative approach, namely Cognitive Walkthrough (CW). This is a usability evaluation method by asking one or more evaluators to work through a series of task scenarios and asking several questions from the user's perspective [23]. Five experts participated in the evaluation: two multimedia and VR experts, a historian expert, and two education experts. The cognitive walkthrough procedure consists of three steps: preparation, implementation, and results [24]. In the preparation steps, there are 11 scenarios or tasks provided. The scenario used during the trial can be seen in Table II. Then, the experts run the scenario on the VR application in the implementation step. In the last step, the experts conduct briefings and provide comments and questions (see Table 3) for the development team to study further.

Table II
User Scenario to Test The Proposed VR Application

No	Detail Scenario	Expected Feedback
1	The user starts the application	The application shows the start page in front of the museum building.
2	The user clicks the "*Jelajah*" button	The application directs the user to enter the museum lobby and stop at the main intersection of the museum.
3	The user selects an arrow (left or right) to go to the exhibition area	• The arrows work well and direct the user to the appropriate area of the exhibition room. • The users feel the effect of moving (virtual walks) smoothly.
4	The user sees the exhibition area	Users can see the exhibition area through head and body movements up to 360º.
5	The user uses the green pointer to observe the artifact	• The artifact image pop-up appears bigger and clearer. • Audio narration is playing.
6	User access information board with a green pointer	A larger and clearer information board pop-up appears.
7	When going to change rooms, the user gets a pop-up question	The first question pop-up with four answer options appears.
8	The user answers the question correctly	• The user gets a puzzle in the form of image pieces. • Puzzles are saved to the gallery. If it is complete, then information about the puzzle will appear. Another question with four answer options appears.
9	The user answers the question incorrectly	• The user does not get the puzzle. • Another question appears with fewer answer options or is directed to move to another room.
10	The users move randomly to another room or to the other side of the museum	The system directs the user according to the command.
11	The user exits the application by clicking the "Exit" button	The user is directed to the museum exit gate and exits the application.

In the cognitive walkthrough stage, the five experts run the application based on scenarios created by the team. In addition, experts also provide comments and questions based on the point of view of their expertise. Based on the scenario tested, there are several comments and questions from experts representing themselves and the user's views. Detailed comments and questions are divided by category of expertise and can be seen in Table III.

Table III
Evaluation Results by Experts on Proposed VR Application

Expertise Category	Detailed Comments and/or Questions
Multimedia and VR	*Comment* • All the features presented run well. However, in the section displaying a large information board, it is necessary to scale and scroll down if the viewing zone of VR does not allow it to be made more flexible. • The use of language needs to be consistent. The "Exit" button at the end of the application should be replaced with "Exit." *Question* -
History	*Comment* • Application usage is easy to follow. • The audio narration is helpful and well placed to explain the artifact. • Visitors may be domestic and international, and it would be better in the future if the content and menus could be found in English. • This application can be a solution for tourism in the era of the covid pandemic. It is good to provide an exploring mode without questions for general users. *Question* • Is there a map in the application? • Will this application reduce the number of visitors visiting the museum?
Education	*Comment* • The application is captivating to use. It is good to give information about the museum. • This application provides the flexibility to explore the museum based on users' desired direction. • It is good that there is a quantitative evaluation. The scoring mechanism is not yet complete. • It would be good if the application could be evaluated widely by students and general users. Students and general users can use this application independently. *Question* Are the questions presented in the system randomly generated?

Based on the comments and questions asked, several points have been corrected and answered. To overcome the information board that is too big, we try to implement the theory about the comfort zone in VR. The comfort zone technique to see surrounding objects refers to Mike Alger theory [25]. The most comfortable viewing distance is between 0-20 meters straight at eye level. Meanwhile, from the point of view of moving the head from left to right is most comfortable up to 55º. Then, move the head from the top to the eye level a maximum of 60º and then down to 40º. The solution of using scrolled-down frames has been implemented for information boards that are too large so that users do not need to move backward. On the front page, the button to leave

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the page and the brief information about the museum have both been updated.

Unfortunately, neither the English version of the material nor the menus can be fixed at this time. This is research for potential future enhancement. Similarly, the program needs to be updated to include a mini-map. Additionally, exploring features without questions that need to be provided for the general user was a good idea. Moreover, as a learning medium, the questions have not been done randomly, so the scoring techniques and discussion of questions need further study and investigation. To realize the additional features suggested by the expert requires additional time, cost, and human resources, especially with multidisciplinary knowledge. Not only to be provided but must meet the standards [14].

In the context of the suitability of the evaluation with the curriculum, the questions presented are prioritized to represent each section of information from the museum with different variations. Still, they have not been adjusted to the indicators of the depth of learning achievement. For example, the information section related to R. A. Kartini represents a puzzle arrangement. In contrast, the information section related to Indonesia's natural wealth is presented in the form of questions. In the context of deeper learning, it is hoped that questions for evaluation can be formulated in collaboration with history teachers at the high school level. Then later tested on target students.

The experts revealed that the proposed VR applications could be a solution for museums to stay alive and become virtual tourist destinations in this pandemic era. This is in line with e-services such as virtual walks for exploring museums like in Poland [6]. This VR application is captivating to use, and this is in line with the statement that VR technology can provide enjoyment, attractions, and immersive information for users who want to enjoy museum collections. The use of VR in museums supports a new paradigm, namely new museology, where museums display rare collections and increase visitor engagement. Visitors expect an enhanced educational experience and commensurate entertainment [10]. Even based on research conducted by [26], the telepresence effect that arises when using VR can reduce stress levels caused by travel restrictions due to Covid-19. The same benefits regarding the use of VR were also found in [27] VR implementation in three cathedrals: Notre-Dame de Paris, France; the Cathedral Church of Saint Peter in Exeter, England; and the Cathedral de Santa María de la Sede in Seville, Spain shows efforts to defend the Catedral. The existence of VR also provides virtual access for physically inaccessible visitors and provides an immersive spiritual experience.

Moreover, the modular design of the developed VR application provides good flexibility. A good modular design can provide a good focus for managers to exhibit collections like the museum of archaeological artifacts from Afrasiyab [28]. As well as learning media for students, the more modular the learning material presented, the more adaptable it will be to personal needs in achieving learning objectives [29]. For further implementation of the proposed application, it is also necessary to evaluate the user on a larger scale using the User Acceptance Testing method or Usability Testing specifically for VR applications adopted from [30]. In this case, the main target users of the application are high school students. Unfortunately, even though schools are starting to be held offline this year, the team has not yet permission to go out into the field to conduct trials. In addition, there was a mismatch in the time of the trial where all schools in Indonesia were on holiday when this research was published.

However, one expert question is intriguing regarding the concern of reducing someone's interest in visiting the location in person because of the use of this VR application. Based on research in [31], VR does allow for a decrease in visits to the original location. However, after being tested on several scenarios, psychologically, there are groups of people whose interest increases and makes VR a tool to check first before recommending the real location to others.

During the research, there were some limitations. First, the prototype has not received feedback from museum officials due to limitations in the pandemic conditions. Second, the developed VR applications require large resource storage to accommodate all the data, which is ineffective. Another alternative to overcome this deficiency is to use cloud technology. This is also in line with the vision of [32] to develop a cloud-based VR gaming application called Gaming anywhere. Third, in practical terms, virtual reality as a learning medium does not stand alone but is often combined with other media such as a learning management system. This aims to achieve pre-determined learning targets and increase the engagement value of online learning itself. Such as research conducted by [33] regarding the development of cloud-based solar energy VR applications and implemented on the desktop integrated with LMS.

IV. Conclusion

The development of the national awakening museum VR application with a 360-degree virtual tour technique provides innovation for national museums. Based on the test results, its use as a learning medium is possible. Apart from its modular nature in presenting information, the application is also equipped with an attractive quiz. The virtual walks feature allows users to move quickly from one area to another. Although there are several inputs, especially in the management of quizzes and scores, this application hopefully can be continued to be tested on a large scale in specific user targets so that it can be accepted widely and implemented during this pandemic situation.

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