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Augmented Reality Innovations for Showcasing East Kalimantan Sculptures: Evaluation and Development

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Abstrak

Dewasa ini terdapat kecenderungan generasi muda yang kurang mengenal budaya daerah di Indonesia. Khususnya budaya patung yang merupakan budaya warisan nenek moyang, seperti patung di daerah Kalimantan Timur. Adanya pengenalan patung bagi generasi muda dapat membantu mereka dalam mengenali fungsi patung serta tindakan saat bertemu dengan patung sakral. Tujuan dari penelitian ini adalah merancang aplikasi yang dilengkapi fitur augmented reality dan melakukan evaluasi aplikasi untuk membantu generasi muda mengetahui dan mengenal patung khas daerah Kalimantan Timur. Hasil analisis keadaan digunakan untuk memenuhi kebutuhan dalam pembuatan aplikasi yang menampilkan model 3D beserta informasi pada patung menggunakan augmented reality. Penelitian ini menggunakan metode kuantitatif yang dilakukan oleh 60 orang responden. Setiap responden akan mengisi pre-test dan post-test, kemudian akan dibandingkan hasil test nya dengan uji statistik paired sample t-test. Hasil uji tersebut menunjukkan adanya perbedaan jumlah jawaban benar dari nilai rata-rata pre-test yaitu 23 orang dan post-test yaitu 58 orang. Hasil tersebut signifikan dibuktikan dari nilai 0.000. Evaluasi pada uji coba melalui pengisian kuesioner untuk mengetahui tingkat kepuasan dari masyarakat dalam menggunakan aplikasi. Berdasarkan hasil uji coba dan evaluasi, terbukti bahwa aplikasi augmented reality yang telah dirancang dapat meningkatkan pengetahuan masyarakat dalam mengetahui dan mengenal patung daerah Kalimantan Timur.

***Kata kunci*:** *Patung*, Augmented Reality, *Marker*, *Kalimantan Timur*

Abstract

Nowadays, there is a tendency among the younger generation to be less familiar with regional cultures in Indonesia, particularly the culture of statues, which are a heritage from our ancestors, such as the statues in East Kalimantan. Introducing these statues to the younger generation can help them understand the function of the statues and the appropriate behavior when encountering sacred statues. The objective of this research is to design an application equipped with augmented reality features and to evaluate the application to help the younger generation learn about and recognize the traditional statues of East Kalimantan. The analysis of the current situation was used to meet the needs in developing an application that displays 3D models along with information on the statues using augmented reality. This research employed a quantitative method involving 60 respondents. Each respondent completed a pre-test and a post-test, and the test results were compared using the paired sample t-test. The test results indicated a difference in the number of correct answers, with an average of 23 respondents on the pre-test and 58 respondents on the post-test. The results were statistically significant, with a value of 0.000. The evaluation was carried out through a questionnaire to determine the level of user satisfaction with the application. Based on the test and evaluation results, it was proven that the augmented reality application designed can enhance public knowledge about and recognition of the traditional statues of East Kalimantan.

Keywords: Sculpture, Augmented Reality, Marker, East Kalimantan

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1. INTRODUCTION

Currently, many young generations in Indonesia need to be better acquainted with regional cultures. Some are familiar with their own regional cultures but need more interest in learning about the cultures of other regions in Indonesia. The lesser-known areas, such as East Kalimantan, are often sparsely populated (Magomedkhan & Sadovoy, 2021; Rezeki et al., 2021). The lack of introduction and information has made people outside Kalimantan less familiar with the history, culture, and other aspects of East Kalimantan. This is particularly significant as East Kalimantan is set to become the new capital region in 2024. Indonesian youth need to familiarize themselves with Indonesia's diverse cultures, including East Kalimantan (Harpiyani et al., 2022; Wijayanti, 2018).

East Kalimantan is a region rich in cultural heritage. One notable cultural element in this area is its tradition of sculptures. Each sculpture in East Kalimantan serves a different purpose. There are two primary functions of these sculptures: ornamental and sacred. However, distinguishing between the two can be challenging without understanding their unique characteristics (David, 2012; Gilmanshina et al., 2021). Inappropriate interactions with sacred sculptures, such as taking photos, making derogatory remarks, or touching, can have adverse effects on the local community. Learning about cultural subjects is still largely done through lectures or books, which can be very boring and difficult to understand (Lionar & Mulyana, 2019; Normah et al., 2022). Therefore, there is an urgent need for a medium that can assist Indonesians in recognizing and learning about these sculptures. With the presence of an interactive medium, it can increase a person's interest in learning and understanding a particular subject (Pramugita et al., 2023; Sumanto & Syahrina, 2018).

One rapidly advancing technology is Augmented Reality (AR). AR integrates real and virtual objects within a real-world 3D environment (Macariu et al., 2020; Saleem et al., 2023). This integration is achieved through interactive and effective technology. AR enables users to view the real world augmented with virtual objects from the digital realm. This technology is widely used in education for learning purposes (Gargrish et al., 2020; Harun et al., 2020; Macariu et al., 2020). AR applications have been shown to aid individuals in learning and visualization processes significantly. Previous research has demonstrated that AR applications can enhance recognition and learning (Koparan et al., 2023).

AR applications are also widely used as learning media in museums to study history or historical object (Chen & Lai, 2021; Goff et al., 2018). An AR application implemented in a museum can enhance a person's motivation to learn and improve learning effectiveness in museums or with historical objects. Other study also states that AR applications can increase a person's interest in learning a subject (Pranotoa & Panggabeana, 2019). AR applications have proven capable of displaying 3D representations of objects and aiding individuals in learning or recognizing various elements (Gargrish et al., 2020; Harun et al., 2020; Macariu et al., 2020). AR technology is highly effective in facilitating learning and enhancing user experiences.

Research on the use of AR for cultural heritage needs is still very limited in Indonesia (Boboc et al., 2022). The study conducted an analysis of various journals and found that the countries most frequently using AR in cultural heritage are Italy, Greece, and Spain. There is very little research in Asia, especially in Indonesia. In fact, the use of AR for learning cultural heritage has significant benefits. Meanwhile, the presence of AR applications can enhance students' motivation to learn about cultural heritage (Baabdullah et al., 2022; Vargas et al., 2020). Another study also revealed that AR is easy to use and has a positive impact on learning about cultural heritage materials (Koutromanos et al., 2024).

Based on the explanation above, the research question is formulated as follows: Does the AR application assist individuals in recognizing and learning about the unique carving art of East Kalimantan in an engaging, effective, and efficient manner. To address this question, an evaluation will be carried out by administering pre-tests and post-tests to assess understanding of the sculpture culture in East Kalimantan. The data will then be analyzed using a paired sample t-test. The objective of this research is to design an application equipped with augmented reality features and to evaluate the application to help the younger generation learn about and recognize the traditional statues of East Kalimantan. The novelty of this research focuses on the development of AR-based applications to introduce typical statues in the East Kalimantan region. Although AR has been applied in various sectors, its application in the context of introducing local cultural heritage, especially traditional statues in East Kalimantan, is still rare. This provides a new contribution in exploring the potential of AR technology for cultural preservation.

2. METHODS

This research will go through several methodological stages. This research uses a quantitative approach because, after the application is developed, it will be tested quantitatively by distributing questionnaires that need to be filled out by users (Creswell, 2010). The first stage is conducting a System Requirement Analysis. The purpose of this stage is to identify the necessary components for designing the AR application and the pocketbook required to introduce and teach about statues in East Kalimantan. The next stage involves the process of creating the AR application and the pocketbook that will aid in recognizing and learning about the statues in East Kalimantan. The following stage is an evaluation through pre-tests and post-tests to assess users' understanding of the cultural material related to the statues in East Kalimantan. The final stage is the evaluation of the AR application and the pocketbook created. This involves assessing how users experience the AR application and the pocketbook for learning. Figure 1 shows the flowchart of the research methodology used.

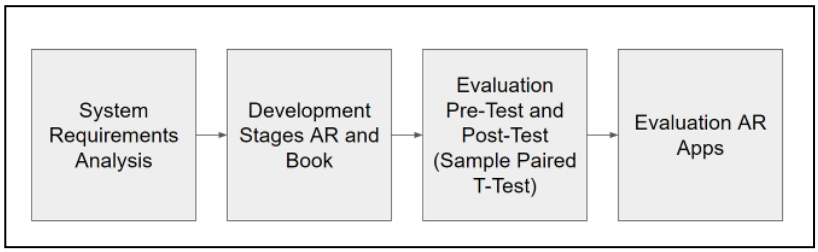

Figure 1. Research Methods

The research began with analyzing the current situation, existing applications, problem identification, and system analysis. The current situation analysis was conducted through interviews and questionnaires distributed to 60 respondents. This aimed to gauge the local community's awareness of East Kalimantan's distinctive sculptures. The analysis revealed that the community needed more information and exposure to these sculptures. Furthermore, more concise informational media was required to be available about the sculptures. Thus, an AR-based application was necessary to help the local community better understand and learn about their regional culture.

The evaluation will be conducted in two stages. The first stage is an evaluation using pre-tests and post-tests distributed to 60 respondents. The test consists of 10 questions regarding the respondents' understanding of the sculptures' culture in East Kalimantan. The average number of respondents who answered correctly will be calculated from the test results. The pre-test and post-test results will undergo a paired sample t-test to determine if there is a significant change in the correct answers between the pre-test and post-test. In the second evaluation stage, an assessment will be conducted on the AR application that has been developed. The questions are based on previous research that analyzed the creation of AR applications (Uiphanit et al., 2020). These questions will use a Likert scale of 1-5, with 1 indicating 'strongly disagree' and 5 indicating 'strongly agree'.

3. RESULTS AND DISCUSSION

Results

After carrying out the analysis, the stage is to design the application, including 3D model design, visuals in the form of color and typography, audio, application logo, user interface, and process design. The design of the pocketbook involves making designs on the cover, contents, and markers on the book. The markers are created using geometric patterns

and Dayak tribal ornaments arranged to form a frame. The initials of the sculpture 3D model will be displayed in the middle of the marker. The design concept for the entire application and pocketbook uses natural themes and materials from sculptures and ornaments from the Dayak tribe. The 3D model created must be adapted to the original sculpture to maintain its uniqueness and sacredness. The motifs or plots used are those in the original Dayak sculptures. Figure 2 shows one of the 3D models of sculptures in the Dayak Tribe, East Kalimantan.

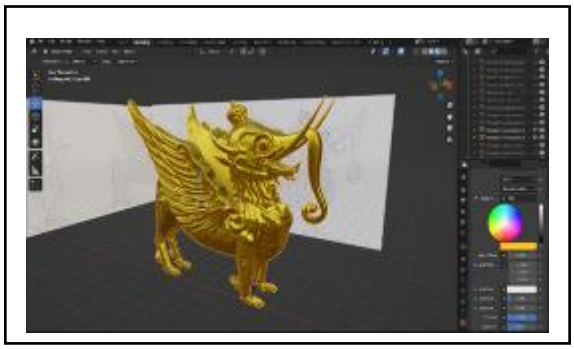

Figure 2. 3D Model of Sculptures

Next, the implementation stage is carried out on the previously designed design. From the design implementation results, we will continue with the verification stage of the AR statute application and pocketbook, which is a companion to the application. The pocketbook contains a marker page of the sculptures, as shown in Figure 3.

Figure 3. Pocketbook Marker Page

The marker pattern on the pocketbook can be scanned via the AR sculpture application. In the application, there are five buttons, namely the View AR button to scan the marker and view AR, the Sculptures Catalog button to read complete information about the sculptures, the Application Guide button to find out how to download markers, and the function of the icon in the application, the AR Marker button to download markers on Google Drive, as well as the exit button to close the application. Next, when the View AR button is pressed, the AR viewing page will display with the camera ready to scan marker patterns on various devices. Apart from that, there are four buttons on the AR viewing page: the Home button to return to the home menu, the infographic button to bring up the infographic panel, the sound button to play dubbed audio, and the music button to play East Kalimantan music. When the marker pattern is successfully scanned, a 3D model of the sculptures will appear

along with an infographic panel, audio/sound history, and background music, which can be activated and deactivated, as shown in Figure 4.

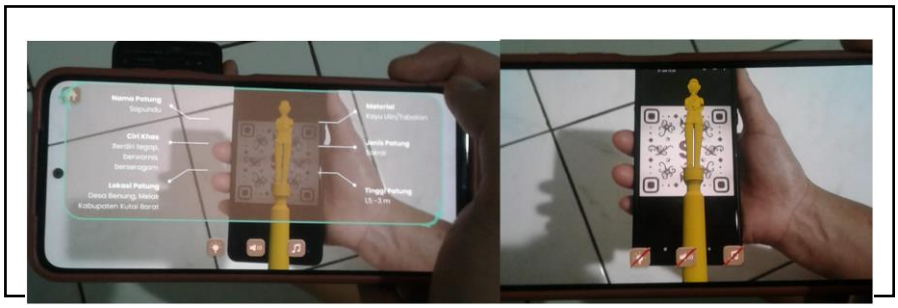

Figure 4. AR Viewing Page with All Three Buttons On and Off

On the sculptures catalog page, there is a photo, photo source, brief description, and paragraph of the sculptures, as in Figure 5 regarding the sculptures catalog page with vertical and horizontal orientation. The information conveyed in the application is relatively complete but has few words. So that users who read it are more comfortable with lots of visuals/images. Brief information provided in the application is the type of sculptures, year of manufacture, location, material, and height of the sculptures. Apart from that, the information needed is the meaning and significance of the sculptures, if any. Then an explanation of the sacred value of a sculpture.

Figure 5. Sculptures Catalog Page with Vertical and Horizontal Orientation

This is different from the display on the guide page which displays two other pages, namely the marker download page and the icon function page. This menu aims to guide applications to users. The appearance of the marker download page and the icon function page is shown in Figure 6. Apart from that, on the application guide page, there is also a button with the "i" symbol, which contains information or credits from the application.

Figure 6. Application Guide Page

Similar media analysis was also carried out in the previous chapter on AR applications, namely Civilizations AR and AR Solar System. Based on the results of the study of similar applications, several system requirements are listed, such as an infographic panel related to the characteristics of the sculptures, a menu explaining the history of the sculptures, and audio dubbing of the history of the sculptures with a user interface display using menu icons that are commonly used by the public. Also, the smartphone's orientation should be adapted to a horizontal and vertical position for applications similar to the application that will be created. These system requirements have been implemented into the application.

After the verification stage was completed, a validation stage was carried out, which began with an interview regarding the appropriateness of the function of the application and pocketbook to the traditional head of the Dayak tribe village, East Kalimantan—followed by working on pre-test questions, using the application, and ending with working on post-test questions. Based on the validation stage through interviews with the traditional head of the Dayak tribe village, he revealed that the application, which displays 3D models with AR features, has helped recognize the typical sculptures of East Kalimantan. He added that this application was exciting and creative because no one had previously applied to acknowledge the East Kalimantan sculptures. The information conveyed on the infographic panel display and the sculptures catalog page when the 3D model appears is considered adequate because it displays an accurate visualization of the sculptures to the public without visiting the East Kalimantan area.

In the evaluation stage, pre-test and post-test questions were tested on 60 general public respondents, 30 men and 30 women, from various areas of origin, from East Java to East Kalimantan. The respondents' ages ranged from 17 to 35. The pre-test and post-test questions were distributed via different Google Forms with the same number of queries and questions. The pre-test questions are intended to determine the level of public understanding before using AR application media.

Next, the stages of using the application were carried out by forming groups and trying the application in turns, which the author observed. The marker scanning experiment in the application was carried out using a pocketbook and computer. The activity of trying out the AR sculpture application is shown in Figure 7.

Figure 7. Experimental Activities Using the AR Sculpture Application

Then, after finishing trying the application, respondents were given a Google Form link containing ten post-test questions to complete after the application trial process. The post-test questions were aimed at discovering the level of people's understanding after trying the AR application and comparing the average correct answer between the pre-test and post-test questions. Data were compared from the correct answers to each pre-test and post-test question, as shown in Table 1.

Table 1. Comparison Results of the Number of Correct Answers Between Pre & Post Test

Category	Question									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pre-Test	22	21	23	27	28	35	7	28	12	30
Post-Test	59	57	60	60	55	59	58	59	56	58

Base on Table 1, regarding the recapitulation results of comparing the number of correct answers between the pre-test and post-test questions. espondents for questions 1-10. Meanwhile, during the post-test, 58 respondents answered correctly. Next, a statistical paired sample t-test was carried out with 10 question data on 60 respondents with the number of correct answers on the pre-test and post-test questions. Statistical testing uses the Shapiro-Wilk technique. The Shapiro-Wilk test is used because the results of the normality test were not appropriate, so this method is applied. The results of statistical testing shown in Table 2.

Table 2. Paired Sample T-Test

Category	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval		t	df	Sig. (2-tailed)
				Lower	Upper			
Rigth Answer Pre Test-Right-Answer Post Test	-34.800	8.162	2.581	-40.639	-28.961	-13.482	9	0.000

Base on Table 2, the difference in the average correct answers between the pre-test and post-test is -34.800 with a significance value (2-tailed) of 0.000 or less than 0.05. So, it was concluded that there was a difference in the average number of correct answers between the pre-test and post-test, which means there was an influence of using the AR application in helping to recognize the East Kalimantan sculptures. The final validation stage was giving a questionnaire to each respondent, totaling 60 people. At this stage, respondents were asked to evaluate the AR application. The evaluation process is done by distributing a questionnaire using the Google Form link. Application evaluation questions can be filled in after respondents have filled in the post-test questions. Respondents are guided by descriptive sentences on the evaluation page display. The evaluation was completed to determine respondents' satisfaction with the AR application regarding introducing typical East Kalimantan statutes. The following review uses 5 Likert scales to assess a person's level of satisfaction with the application for introducing East Kalimantan's sculptures. Table 3 shows the results of the questionnaire.

Table 3. AR Application Evaluation Results

No	Question	Answer				
		5	**4**	**3**	**2**	**1**
1	The 3D model of the sculpture helps you recognize the shape of the East Kalimantan area	50	6	3	1	0
2	Pocketbook helps you scan markers in the application.	48	9	3	0	0
3	The application features are easy to understand and use.	49	9	1	0	1
4	The explanation voice helps you to clarify the sculpture's description text.	49	7	3	1	0

Base on Table 3, the majority of respondents answered that they were very satisfied with the AR application and the book that were created. They really liked/were satisfied with the 3D models that were made. The guidebook was also very helpful for learning. The application features were very easy to understand, and the voice explanations were very helpful for better comprehension.

Discussion

The results of the AR application evaluation show that most respondents who have tried the AR application were greatly helped by this application to recognize the sculpture culture in East Kalimantan. The 3D models created can help better identify these sculptures because the sculptures in East Kalimantan have their characteristics (de Souza Cardoso et al., 2020; Kamlşll & Öznacar, 2020). A detailed 3D model is needed so respondents can better recognize the differences between the sculptures. Then, the created pocketbook helped respondents scan the marker to display the sculptures 's 3D model. This sculpture recognition application feature is straightforward for respondents to learn, understand, and use. The results of this study are in line with previous research findings that AR applications can be effectively used and are very helpful for learning (Uiphanit et al., 2020). However, one person found it difficult the first time they used it. The voice explaining the sculptures has been recorded very clearly so that it helps respondents understand and recognize the cultural sculptures of East Kalimantan. The addition of audio in this AR application greatly enhances the user's experience with AR (Kaghat et al., 2020).

This research shows that the AR application can increase people's understanding of cultural sculptures in East Kalimantan. This is in line with several previous studies that using AR applications can improve a person's learning experience and motivation (Gao et al., 2023; Ou Yang et al., 2023; Radu et al., 2023). A student who learns how to use AR applications can understand the material better. It was proven in this research that using the AR application was able to increase people's understanding of East Kalimantan's sculpture culture. The unique learning experience can also be enhanced so that users can get to know the cultural sculptures of East Kalimantan uniquely. Interested users can learn more about Indonesian culture by using the AR application.

Previous research also revealed that AR applications that have been developed can help individuals to learn more deeply about a particular topic (Chang et al., 2022). An AR application with well-designed 3D models will assist in learning and gaining a deeper understanding of the material being taught. Another study also revealed that AR applications used in learning are easy to understand and use by users (Jang et al., 2021). With AR technology, a person's experience and satisfaction with the application and learning process will increase (Jiang et al., 2022). This is also proven in this study, where using the AR application makes users more satisfied with their learning.

The implication of this research is that the AR application used for recognizing and learning about sculptures in East Kalimantan has proven effective in enhancing understanding and knowledge of that culture. By utilizing AR media for cultural content, it is possible to improve the user experience. This aligns with various studies on AR in education, which help individuals learn about new topics. (Arvanitis et al., 2011; Goff et al., 2018; Koparan et al., 2023; O'Connor & Mahony, 2023). AR media can assist in learning about cultural heritage and can be developed further in future research.

The AR application for the introduction and learning of statues in East Kalimantan can be further used in future research to create AR-based learning media to help people recognize historical statues. In this study, there were still some limitations in evaluating and developing the AR application. This study only involved 60 respondents; ideally, future research should involve a larger and more diverse group of respondents. This study was also

limited to the features of the AR application. It would be better to add various features and then evaluate each one to see if it helps in the introduction and learning of the statues.

This research also has several limitations that can be improved in further study. The results of suggestions obtained from traditional heads during the validation process, namely adding a video explaining sacred sculptures. There are suggestions from the general public in the validation process that can help further development, including adding game features in the form of quizzes to the application and creating animations of rural or forest scenes when the 3D model appears. This trial can also be carried out using other cultures to find out whether the application provides a good function for getting to know the culture of Indonesian society.

4. CONCLUSION

Based on the results of statistical trials using a paired sample t-test, it can be concluded that the augmented reality-based Borneo AR Sculptures application provides significant benefits to the community, both from East Kalimantan and from outside the region, in getting to know the typical regional sculptures more closely. East Kalimantan. With the 3D model display presented, this application helps ordinary people clearly differentiate between sacred sculptures and ordinary decorative sculptures. Apart from that, the contents of the sculpture catalog and photos of sculptures provide additional valuable insight for the public regarding the wealth of sculpture art that East Kalimantan has. Thus, this application opens up opportunities for people to better understand and appreciate the culture and sculpture in the area.

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