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Augmented Reality Application as Interactive Learning Media Traditional Weapons using Unity AR

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Abstract−Technological advancements have widely permeated Indonesian society, particularly in education. The challenges of globalization and modernization are expected to pose new challenges for the education sector in creating interactive learning media to support the interest and willingness to learn among the younger generation, who are already dominated by current technology. Therefore, innovative and engaging learning approaches are necessary for students to actively participate in the teaching and learning process. The use of Augmented Reality (AR) is said to foster creativity, partial imagination, and help control learning according to their preferred learning styles, allowing teachers to create learning environments tailored to students' cognitive styles. This research directly integrates augmented reality applications as a cultural arts learning media, where students are assisted in learning innovatively and can actively interact with traditional weapons in Indonesia virtually. This aids teachers in providing instruction on weapons without the need to fear the physical dangers of weapon use. The agile method is utilized to ensure that changes are embraced, and evolving requirements can be readily accommodated, providing clients with a guarantee of adaptability. The implementation of the augmented reality application has received a very positive response with a score of 85.75%, indicating that it is well-received by MTsN Gema students.

Keywords: Agile; Augmeneted Reality; Interactive; Learning Media; Unity

1. INTRODUCTION

The development of technology has widely spread in Indonesian society, especially in education. The challenges of globalization and modernization are expected to become new challenges for the education world in creating interactive learning media to support the interest and willingness of the younger generation who are dominated by current technology. Therefore, innovative and engaging learning approaches are needed for students to actively participate in the teaching and learning process [1].

The use of learning media is considered to be one of the keys that is very effective in delivering information to students. This is faced with the tendency of students who are increasingly interested in gadgets, so they are more interested in learning and understanding something from within the gadget. By introducing new effective learning tools such as the use of virtual or augmented reality, it is said to simplify the process, costs, and management of school investments such as learning tablets and others [2], [3].

The use of Augmented Reality (AR) is said to develop creativity, partial imagination and can help control learning according to their preferred learning styles, so that teachers can create learning environments that are suitable for students' cognitive styles [4], [5]. Augmented Reality itself is a combination of the real world and the virtual world in creating an integrated environment. Institutions that have adopted cloud environments and installed AR learning modules believe that AR itself can be a means of exchanging information between teachers, developers, and students. This proves that the use of AR as a learning media has a positive impression and can help the teaching and learning process between teachers and students [5], [6], [7].

The use of AR by displaying images and additional information in real-time and projected as physical objects in the real world. This can be a more cost-effective study tour equivalent to visiting museums or historical objects with physical presence [8], [9], [10]. Therefore, research and development of augmented reality applications become a topic that must be rapidly developed in Indonesia. This serves as an example of the application of innovative and creative technology in the world of education [10].

This research will directly integrate augmented reality applications as cultural art learning media. Where students are assisted to learn innovatively and can directly interact with traditional weapons in Indonesia virtually. This helps teachers in providing learning about weapons without having to worry about the dangers of physical weapon use later on [11].

The use of smartphones as information media and also as a tool for parents or educators to convey information and learning about Banjar culture using augmented reality is expected to make children more interested in getting to know the culture and preserving it if possible [11], [12]. Indonesia is a country rich in abundant natural resources. Not only that, but Indonesia also has numerous cultures, customs, and legacies left by ancestors. One example is traditional weapons, which almost every region possesses. Although Indonesia has a plethora of traditional weapons, only a few people are knowledgeable about their names, origins, and forms, especially among elementary, middle, and high school students, and even university students, due to the lack of learning media available to introduce these traditional weapons [13], [14].

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In this study, traditional Indonesian weapons will be analyzed as objects to be integrated into an augmented reality (AR) application. Subsequently, the design and development of an Android-based AR application will be carried out to visually display images and information related to traditional Indonesian weapons in the virtual world. This augmented reality-based traditional weapons recognition application is created with the aim of supporting the preservation of culture and traditions in Indonesia [15], [16].

The development of technology has led to various research studies on the application of augmented reality (AR) in education. For instance, Pramono and Setiawan's research on "Pemanfaatan Augmented Reality sebagai Media Pembelajaran Pengenalan Buah-Buahan" focused on using AR to teach fruit recognition to elementary school students. Similarly, Alifah et al.'s study on "Pemanfaatan Augmented Reality untuk Koleksi Kain Tapis (Studi Kasus: UPTD Museum Negeri Provinsi Lampung)" utilized ISO25010 as a quality measurement model. In contrast, this study employed System Usability Scale (SUS) to evaluate the learnability, efficiency, and error matrix. The main difference lies in the focus of the research. While other studies focused on specific topics like fruit recognition or textile collections, this study aimed to develop an AR application for construction building education. Additionally, the use of Agile Development as a method in this study distinguishes it from other research that employed different methodologies.

For implementing augmented reality, the delivery of information can become easier to understand, as users can gain a more detailed understanding through the utilization of 3D objects. The use of augmented reality is expected to increase users' motivation to enhance interest and curiosity about traditional weapons, thus ensuring that this heritage remains preserved and not forgotten [17], [18].

2. RESEARCH METHODOLOGY

2.1 Research Stages

Augmented reality is described as a bridge between the physical reality and the virtual world that occurs in real-time. According to Haller, Billinghurst, and Thomas, research on augmented reality aims to develop technology that allows the integration of real-time digital content created by computers with the real-world environment. With augmented reality, users can perceive virtual objects, whether in two or three dimensions, seamlessly integrated with the real environment simultaneously[19], [20].

Augmented Reality based on markers is a type of Augmented Reality (AR) that recognizes and identifies patterns from a marker to add virtual objects into the real environment [21]. A marker in this context is a visual representation in the form of a two-dimensional image used to display virtual objects into the real world. Markers can be square images with black and white colors, featuring thick black borders, or displaying black patterns in the center of a square with a white background. Additionally, markers can also be images of desired objects according to the needs of the Augmented Reality application [17].

Unity is an integrated application used to create both two-dimensional (2D) and three-dimensional (3D) objects in the context of video games or other interactive environments, such as architectural visualization or real-time 2D and 3D animation. The Unity development environment can be operated on the Microsoft Windows and Mac OS X operating systems. Additionally, applications developed with Unity can run on various platforms, including Windows, Mac, Xbox 360, Playstation 3, Wii, iPad, iPhone, and Android platforms [20].

The decision to adopt Agile development methodology for creating the Augmented Reality application for learning media at MTsN Gema. Agile methodology is a software development framework rooted in incremental and iterative principles. This approach emphasizes continuous planning, development, testing, and regular communication with system stakeholders[15], [22]. Agile methodology prioritizes flexibility, continuous improvement, uncertainty management, and speed in system analysis. It ensures that changes are embraced, and evolving requirements can be readily accommodated, thereby providing clients with a guarantee of adaptability[23], [24], [25]. The research stages conducted are requirement analysis, application design stage, implementation stage, and testing stage.

2.2 Need Analysis

Needs analysis is conducted, which includes both functional and non-functional requirements. Functional requirements encompass the services needed by the system, including responses to input and system behavior. On the other hand, non-functional requirements emphasize the behavioral properties or system services that affect performance and overall characteristics.

Based on figure 1 The need analysis phase involves identifying and recording the precise requirements of the final users. This phase is crucial in understanding the user's expectations and needs through various methods such as interviews, surveys, and focus groups. The collected data is then analyzed to distinguish essential features from desirable ones, resulting in a Requirements Specification Document that outlines the software's purpose, features, and functionalities. This document serves as a guide for the development team and provides cost estimates if needed. The design phase follows, where the development team outlines the software's functionality and aesthetic, resulting in a Software Design Document that details the software's structure, navigation, user interfaces,

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and database design. The implementation phase involves converting the design into tangible code, and the testing phase ensures the software's robustness and reliability through various types of tests.

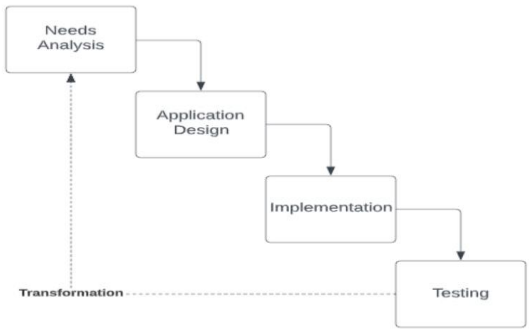

Figure 1. Research Stages

2.3 Application Design

Application design planning is carried out to create the application with a series of logically organized workflow steps. This phase begins with collecting the necessary data to support the design process. The application design process involves the use of UML diagrams and interface design as the main components. The actors involved in the application can be seen in Table 1 below.

Table 1. Actor

Actor	Description
User	The people interacting with the system, namely the users, can utilize all the functions provided by the system..

In this research, the actor described in Table 1. is a user who will use the system in a traditional weapon augmented reality application, thus becoming a need to enhance the functions and features that will be used in the application.

2.4 Implementation

In this Implementation stage, the researcher develops the application based on the prepared interface design. Implementation involves coding and creating the application's displays according to the established design. This includes creating markers as camera targets to display 3D objects. The coding process involves writing the necessary code for the entire system development. The application is materialized by creating system pages according to the design planned in the application design stage.

2.5 Testing

In the testing phase, steps are taken to ensure that the application has been successfully tested and aligns with the plan. This application testing employs a black box approach, where the application is tested without considering its internal structure. The black box testing aims to evaluate whether the application functions according to the established system requirements and can be used for the next phase. The utilization of the System Usability Scale (SUS) in this research aims to assess the usefulness of the AR application. The research objective is to measure the usability level of the application and analyze the test results to evaluate its effectiveness. Testing is conducted through a SUS questionnaire consisting of 10 statements, with responses using a Likert scale.

3. RESULT AND DISCUSSION

During this phase, interaction takes place with the purpose of gathering information relevant to the desired software from the user. The main goal of this interaction is to acquire guidance and constraints that will steer the software development process. The purpose of this interaction is to obtain guidance and constraints that will guide the software development process. This data is obtained through interviews, literature studies, and direct surveys. The collected information is then analyzed to obtain the data needed by users.

3.1 Need Analysis

Functional requirements pertain to the services that the system must offer, encompassing its response to specific inputs and behavior in various scenarios. In the case of an Android-based application for learning about traditional weapons using augmented reality technology, the functional requirements include marker detection, displaying

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3D objects on the AR Camera, providing descriptions of objects, showcasing information about the application owner, presenting usage instructions, and directing users to the marker download page. Non-functional requirements refer to the requirements used in developing and running the application to be built. These requirements pertain to the devices used and their specifications in full detail. Non-functional requirements can be seen in the following table 2.

Table 2. Minimum Hardware Spesifications

No	Hardware	specifications
1	Processor	CPu with SSE2 Compability
3	Memori	RAM 2 GB or More
4	Hard Drive	Min 4GB
5	GPU	GPU with DirectX 10 Compability
6	OS	Windows 7SPI+, Or newer

In Table 2, the minimum specifications of a computer device required to run the Unity software application are shown. Meanwhile, the minimum specifications of an Android device required to run the augmented reality application can be seen in the following Table 3.

Table 3. Minimun Android Spesfications

No	Hardware	specifications
1	Graphic AS	OpenGL ES 3.x & Vulkan
2	RAM	2 GB or More
3	Engine Vuforia	NDK r21+, Gradle 6.7.1+, 30.0.3+,
4	OS	Android Version 8.0 (Oreo) or Later

Based on Table 2, the minimum smartphone requirements for running an augmented reality application are at least a smartphone with 2GB of RAM and Android 8.0 or higher, ensuring a more comfortable and better experience when running this traditional augmented reality application. An application can operate optimally if the user has the capability to run the said application. To run the augmented reality application as a learning media for traditional weapons based on Android, users should possess at least:

a. Having experience operating an Android smartphone.
b. Ability to run applications on an Android device.
c. Capable of using instructions or help menus within the application.
d. Proficiency in the Indonesian language.
e. Understanding how augmented reality works.

3.2 Application Design

The design of an Augmented Reality application can be executed by implementing an object-oriented approach using Unified Modeling Language (UML).

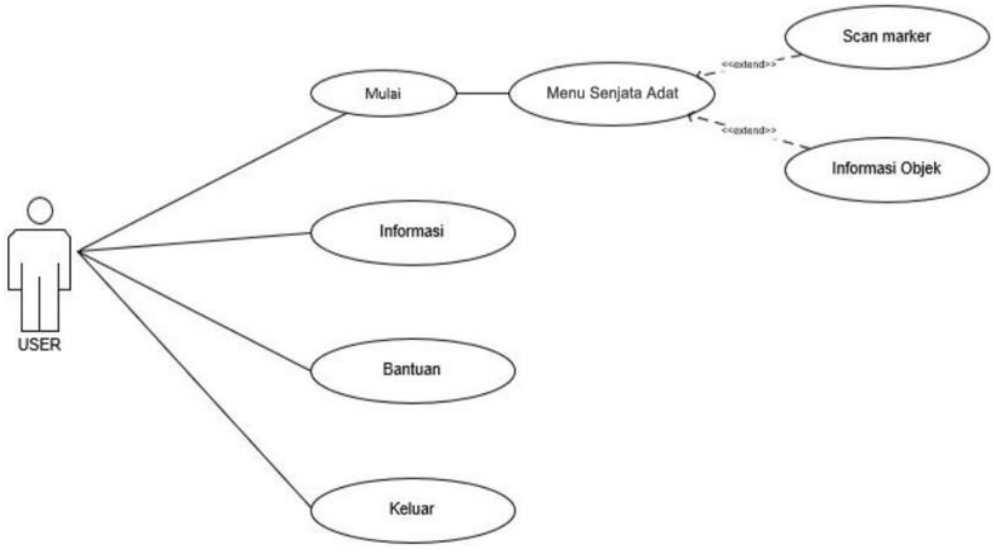

Figure 2. Use Case Diagram

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The above use case diagram illustrates how the application can be utilized by users, serving as a fundamental reference for system planning and implementation. Furthermore, the functions of each use case depicted previously are described in the table 4.

Table 4. Use Case Deskription

No	ID	Use Case	Description
1.	UC-1	Mulai	This Use Case depicts the user initiating the application on the system.
2.	UC-2	Informasi	This Use Case depicts the user viewing information related to the application on the system.
3.	UC-3	Bantuan	This Use Case depicts the user accessing help regarding how to use the application on the system.
4.	UC-4	Keluar	This Use Case illustrates the user exiting the application on the system.
5.	UC-5	Scan Marker	This Use Case illustrates the user needing to scan the marker to display traditional weapon objects.
6.	UC-6	Informasi Objek	This Use Case describes the user viewing information about the scanned object.

Next, an activity diagram is depicted, illustrating the activities occurring within the system and the steps involved in the system's workflow process. Activity diagram application augmented reality can be seen in table below.

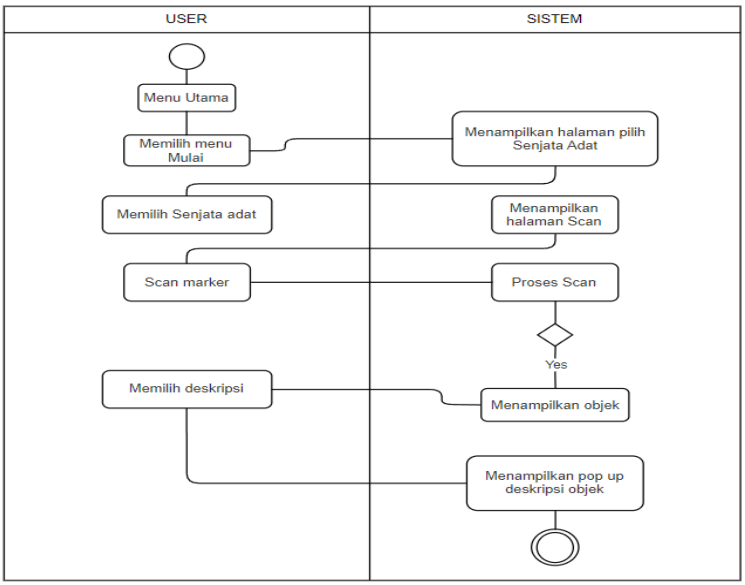

Figure 3. Activity Diagram

Based on Figure 3 The application starts by opening the application, then selecting the 'Start' menu, which will display the scan page. Next, it will direct the user to the available markers, displaying a 3D model of the weapon itself for further description and explanation. To view the description, users can press the 'Description' button, which will display the description of the traditional weapon on the smartphone screen. Interface design focuses on creating a system interface that is aesthetically pleasing, easy to understand, and includes menus that are easily comprehensible.

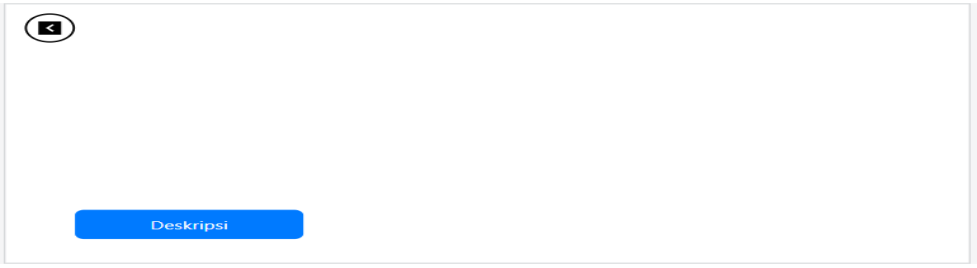

Figure 4. Scan Design

Implementation of design involves translating the interface design that has been created into program code that can be executed by the system. This entails creating interface elements such as buttons, menus, and layouts, as well as setting up the logic behind user interactions with the system.

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3.3 Testing

In this phase, Testing is conducted to ensure quality and identify weaknesses in the software. Testing of this AR Traditional Weapon application employs the black box method. Black box testing is carried out to verify if the developed system aligns with what is outlined in the system's functional specifications. The results of black box testing can be seen in Table 5.

Table 5. Blackbox Testing

No.	Scenario	Expectation Result	Result
1.	Marker Detection	The System directly display 3D object on AR Camera	Success
2.	Displaying 3D object on AR Camera	The system displays a 3D object corresponding to the marker.	Success
3.	Displaying Information Pages	The system displays an information page.	Success
4.	Displaying Help Pages	The system displays an Help page.	Success

In this research, testing was also conducted using the black box method, which yielded findings indicating that the system can operate fully in accordance with the established functional requirements, achieving a success rate of 100%. Furthermore, testing was carried out with 10 students from MTsN Gema as one of the steps to accurately assess the effectiveness of learning media utilizing Augmented Reality (AR) in enhancing interest and ease in learning traditional Indonesian weapons based on Android.

The testing process involves dividing students into two sample groups: the experimental group, which receives Android-based media learning, and the control group, which does not use this media. At the end of the sessions, both experimental and control groups are given a post-test to evaluate the extent of cognitive changes in students after receiving the learning treatment.

The utilization of the System Usability Scale (SUS) in this research aims to evaluate the usefulness of the AR application. The research objective is to measure the level of usability of the application and analyze the test results to evaluate its effectiveness. Testing is conducted through a SUS questionnaire comprising 10 statements, with responses rated on a Likert scale. Evaluation involves 10 participants, with statements arranged so that values at odd-numbered positions are calculated using the formula (xi-1), and at even-numbered positions using the formula (5-xi), where xi refers to the value selected by the respondent on the Likert scale.

Table 6. System Usability Score (SUS)

Rep	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
1	3	4	3	4	3	3	4	4	3	3	34
2	3	5	3	3	4	2	4	4	3	3	34
3	3	3	4	3	3	3	3	3	3	4	32
4	4	3	4	3	3	3	4	3	3	4	34
5	5	3	3	3	4	3	3	3	4	4	35
6	5	3	4	3	3	2	3	3	3	3	32
7	3	4	5	4	3	2	4	4	5	5	39
8	3	4	5	5	3	3	3	4	3	3	36
9	3	3	3	5	4	2	3	4	4	3	34
10	3	3	4	5	3	3	3	3	3	3	33

In Tabel 6 this research results of the scores from the respondents who have used the application directly will be provided, followed by a questionnaire. The questionnaire data will be processed again. The next step is to calculate the total score for each statement, then multiply the result by 2.5. This process is repeated for each respondent.

Avarage Score of SUS = $\frac{\sum x}{n} = \frac{857.5}{10} = 85.75\ \%$

Based on the results, data interpretation is carried out on the average score using the SUS score interpretation scale, which is 85.75%. This can be seen in Figure 4.19 below.

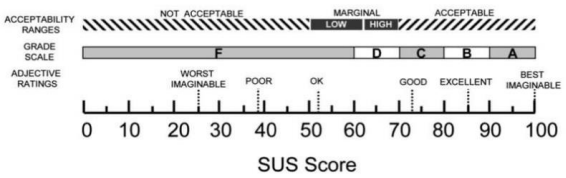

Figure 5. SUS Score

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In Figure 5, the SUS Score is used as a parameter to determine whether the learning using interactive applications such as augmented reality is “good” or “bad”. The application is considered good if it reaches a percentage above 50%, and the higher the percentage, the better the application is considered. Based on figure 5, with a calculated result of 85.25%, it can be interpreted that the research findings on the augmented reality application for traditional weapon learning media are “excellent”. This means that the application is well-received by students at MTsN Gema and provides the best innovation in traditional weapon learning media.

4. CONCLUSION

Research and development of augmented reality applications has become a topic that must be rapidly developed in Indonesia. This serves as an example of the application of innovative and creative technology in the field of education. The decision to adopt Agile development methodology for creating the Augmented Reality application for learning media at MTsN Gema. Agile methodology is a software development framework rooted in incremental and iterative principles. Testing in this research uses black box testing with a system success rate of 100% in accordance with the specified functional requirements. The System Usability Scale (SUS) testing, obtained from 10 respondents, resulted in an average SUS score of 85.75%, falling into the acceptable category with a class B rating and an "Excellent" description. It is hoped that this application can enhance innovation in improving learning media, especially in traditional weapon learning, thereby stimulating students' curiosity in the teaching and learning process.

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