# Augmented Reality Application for Teaching the History of the Petilasan Damarwulan Cultural Heritage Site

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| Article Info | ABSTRACT |
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| | This study aims to develop a historical learning media application utilizing augmented reality technology to introduce the cultural heritage site of Petilasan Damarwulan. The research addresses the declining reading interest among younger generations and the lack of interactive media in preserving local culture. A research and development (R&D) approach was employed, following ten stages from needs analysis to product evaluation. The application was built as a web-based platform to ensure compatibility with mobile devices, offering features such as image scanning, three-dimensional visualization, and narrative descriptions of the cultural site. Implementation results indicate that the application enhances users' understanding of local history and culture. Functional testing using the black-box method confirmed that all features operated as intended. In conclusion, the application proves to be an effective tool for interactive learning and holds potential as a means of supporting digital cultural preservation within primary education environments. |

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## 1. Introduction

Advances in computer technology have had a significant impact on education, transforming conventional learning methods. The use of computers in the educational process has transformed perspectives on learning, creating challenges and opening up new opportunities for student knowledge development[1]. Essentially, technology is a process aimed at adding value to products, thereby enhancing their utility[2]. In the world of education, technology has had a significant impact, transforming systems, the roles of educators, educational staff, and students' daily lives. Therefore, if someone fails to keep pace with technological developments, they will have difficulty accessing information and risk being left behind in pursuing various development opportunities[3]. Therefore, creating a digital-based educational environment is crucial to meet the ever-increasing public demand for quality educational services[4].

The academic assessment process in many schools is still conducted manually, requiring teachers to enter and calculate student grades in writing before finally summarizing them on printed report cards. This method is often time-consuming, prone to recording errors, and inefficient in storing and distributing information[5]. In addition, parents of students often experience difficulties

593

in obtaining information about their children's academic development in real time, because they still rely on the distribution of report cards at the end of the semester[6].

Along with the development of information technology, the implementation of e-Report Cards (e-Report Cards) has become a relevant solution for increasing efficiency and accuracy in student grade management. E-Report Cards enable teachers to manage and communicate student learning outcomes digitally, thereby reducing the possibility of administrative errors and expediting the academic evaluation process. Furthermore, this system also facilitates access for parents to monitor their children's academic progress through an integrated portal or application. [7]

Research[8] has shown that e-Report Cards play a crucial role in increasing the efficiency and effectiveness of learning in schools. This system facilitates teachers' assessments, provides feedback, and provides comprehensive information on student learning progress. Despite its numerous benefits, the implementation of e-Report Cards still requires review, particularly regarding its alignment with the Independent Curriculum, challenges encountered, and improvements to optimize its use.

Research[9] indicates that e-Report Cards offer a digital innovation solution aimed at accelerating and simplifying the process of managing academic data in schools, replacing manual systems that still rely on paper-based recording. With features such as data collection, assessment, and scheduling, e-Report Cards helps schools provide more effective and efficient academic services. Furthermore, the implementation of this system also supports the school's image as an institution that is adaptive to technology and focused on improving the quality of education. [10]

However, in reality, many schools in Indonesia, particularly elementary schools in Bekasi Regency, West Java, still do not have an e-Report system. This lack of a system prevents these schools from experiencing the significant benefits of digitalization in academics. This is due to the limited knowledge and skills of educators and educational staff in developing and implementing digital systems. [11] One such school is Burangkeng 05 Public Elementary School.

Burangkeng 05 Public Elementary School is an elementary school in Bekasi Regency, located in the Bekasi Timur Regency housing complex. Established in 2022, the school now has 232 students and 7 teachers. Its development has gradually improved over the years, including easy access to the school, adequate infrastructure, and the implementation of the national curriculum. However, to date, Burangkeng 05 Public Elementary School still does not have an e-Report system for managing academic data. Student grade management has been carried out manually so far, namely by using the Microsoft Excel application.

The lack of an e-Report system at Burangkeng 05 Public Elementary School (SD Negeri Burangkeng 05) limits the recording and reporting of academic data. The process of recapitulating grades, compiling academic records, and reporting student learning outcomes is still carried out conventionally, often leading to delays in data processing and difficulties in comprehensive academic evaluation. Furthermore, the lack of a digital system also hinders the school's ability to provide accurate and well-documented academic data for accreditation and educational development purposes.

The implementation of an e-Report system is a solution that can improve the efficiency and accuracy of information delivery and academic data management at SD Negeri Burangkeng 05. Through this system, the school can simplify archiving, expedite administrative processes, and provide more transparent and accessible access to information. An integrated information system will also help the school minimize errors that often occur in manual processes. Based on the background of the problem, the research aims to build an e-Report system at SD Negeri Burangkeng 05. It is hoped that with the e-Report system, schools can improve the quality of educational services and facilitate the delivery of academic information, so that SD Negeri Burangkeng 05 can be better prepared to face challenges in the digital era.

## 2. Research Method

Based on a literature review, this approach has been proven to be an effective approach in developing technology-based products, including Augmented Reality technology. The R&D process emphasizes systematic development through organized stages, from initial exploration and design to development,

through testing and refinement. This approach not only ensures the creation of innovative products but also ensures that the final product meets the desired learning needs. The R&D method offers flexibility, allowing for continuous revision and development, making the final product more adaptable and relevant to user needs. [12]

The following are the stages of the R&D method applied in developing the Augmented Reality-based Learning Media Application for the History of the Damarwulan Cultural Tourism Site:

a.  Research and Initial Information Collection

This stage is the crucial first step in this research, involving two main processes: in-depth literature review and field observation. In the literature review stage, various reference sources, such as books and national and international journals, are used to gather relevant information related to the topic being researched. Through this literature review, researchers can understand existing theories and previous findings related to the problem being addressed in this research [12].

Furthermore, field observations are conducted to identify pressing problems or needs directly at the research location. These observations allow researchers to collect data that is more contextual and relevant to the reality on the ground, and provide a deeper understanding of the issue being studied.

The results of this stage will be recorded and analyzed further in Chapter IV, specifically in point 4.3. Data Analysis Results, which includes the research results and initial information collection obtained through the R&D research method, as well as the data required for this study..

b.  Planning

In the planning stage, researchers formulate specific and measurable product development objectives. These objectives are clearly formulated to ensure that development results can be measured and evaluated objectively. The determination of the main features of the product to be developed is also carried out at this stage, taking into account user needs and technical aspects relevant to the product development objectives. The selected features must support the product's primary objectives and provide effective solutions to the problems identified during the research and information gathering phase.

The results of this planning will be presented in Chapter IV, specifically point 4.4, User Interface Design Results, which will explain in more detail the planning results in the context of R&D research methods, as well as the user interface (UI) design developed based on this planning.

c.  Product Draft Development

In the product draft development stage, researchers design an initial prototype based on the results of previous research and planning. This prototype serves as an initial representation of the product to be developed, which can take the form of a mock-up, blueprint, or conceptual model. The purpose of this prototype is to test the planned ideas and concepts and to see how the product will look and function in real life. This prototype also assists in the process of refining and perfecting the product before mass production or further development [14].

The results of the product draft development will be explained in more detail in Chapter IV, specifically in point 4.4, User Interface Design Results, which covers the results of the product draft development within the context of R&D research methods. The following is the data from the product draft development, including the initial design and the main features implemented in the prototype.

Figure 1. Borg and Gall R&D methods

Information management about the Petilasan Damarwulan cultural heritage site in Megaluh District, Jombang Regency, is still carried out conventionally through print media, oral presentations, and static information boards on-site. This one-way, non-interactive delivery of information hinders the public from fully understanding the historical and cultural values contained within the site. [15]

To identify the problem more objectively, researchers conducted a survey by distributing questionnaires to residents around Petilasan Damarwulan with diverse professional backgrounds (farmers, students, teachers, university students, and entrepreneurs) from June 8–16, 2025. The number of respondents included 14 people before using the application and 13 people after using the application.

## 3. Result and Discussion

Overall findings from the distributed questionnaires indicate that the public still faces various obstacles in understanding the historical and cultural information about the Damarwulan Site. The relatively boring presentation of information, limited visualization, and lack of interaction in the learning process have diminished public interest, particularly among the younger generation, in learning about this cultural site. This reinforces the importance of providing more engaging, interactive learning media that aligns with current technological developments. To address these challenges, this study designed and developed an Augmented Reality (AR)-based learning media application for the history of the Damarwulan Site Cultural Tourism Site. Through this application, users can scan specific images and immediately see vivid and informative 3D representations of cultural objects. Users are presented with not only visuals but also historical and cultural narratives presented in a simple and easy-to-understand manner. [16]

It is hoped that with this more modern and enjoyable approach, the experience of learning about local culture will become more meaningful and relevant for today's society. This application is also expected to rekindle the public's curiosity and awareness of their own cultural heritage.

In conclusion, this use case diagram illustrates the user's interaction with an Augmented Reality (AR) application to scan an image using the "Scan Image" feature. After a successful scan, the user can access two main features: "View" to view the scan results (3D objects)[17].

Activity Diagram

This diagram illustrates the workflow of a process, including the sequence of actions or decisions within the system. Activity diagrams are useful in illustrating how data access is made, how system processes are executed, and how the system's procedural logic is implemented[18].

This activity diagram shows the interaction flow between the user and the system in an Augmented Reality (AR) application. The flow begins when the user opens the application. Once the application is opened, the system will display the main menu. The user then selects the 'Scan Image' button which will start the scanning process. Once the scan begins, the system will check whether the scanned image is valid or not. If it is valid (Yes), the system will display the associated

596

media, such as a 3D object or video[4]. If it is invalid (No), the system will not display any media, and the user can return to the previous step. This diagram helps illustrate the process that occurs from the user and system perspectives, providing clear guidance for developers regarding the workflow that needs to be implemented in the AR application[3].
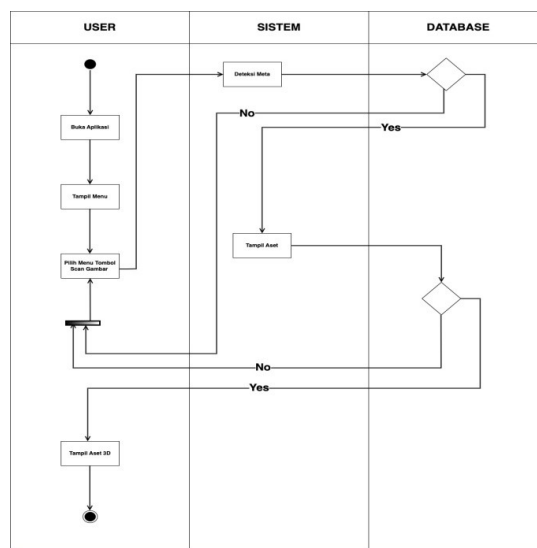


**Figure 2.**  Activity Diagram

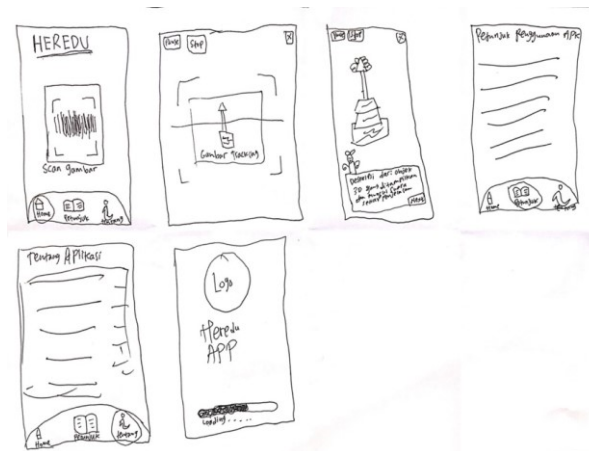The following is a picture of the planning results in the R&D research method:



Figure 3. Planning Results in the R&D research method

In the figure, the initial design shows the application screen display, including the area for image scanning, control buttons (Pause, Stop), and other features that will facilitate user interaction with the application. Although still in the form of hand-drawn sketches, this design provides a clear basis for the features and functions to be achieved in the application. Evidence included in this planning includes hand-drawn images of the application design, which will be used as a basis for further development. After this planning stage, the application will be tested and refined based on user feedback to produce a functional and user-friendly final product. With this design evidence, it shows that the planning stage has been carried out carefully and systematically, in accordance with the principles of the Borg and Gall R&D method.[14][19].

Next, after completing the initial design in the form of hand-drawn sketches, the author then designed the initial design using a mockup using the Figma digital platform. The User

597

Interface (UI) design for the Augmented Reality-based Application for Learning Media for the History of the Damarwulan Cultural Tourism Object must be well-designed and user-friendly. [20] This aims to make it easier for users to access the various augmented reality-based learning features available within the application. An intuitive and interactive design will support learning effectiveness and increase user engagement in learning cultural materials through modern technology. [21] [22]

The following are several elements that must be considered in the User Interface design for the Augmented Reality-based Application for Learning Media for the History of the Damarwulan Cultural Tourism Object.:



Figure 4.  Loading Screen Page Design

Figure 4. The Loading Screen page shows the user interface (UI) design of the HEREDU application. On this page, users are greeted with a striking application logo, accompanied by visual elements depicting Indonesian cultural themes, such as illustrations of sunsets, mountains, and trees, which create a distinctive atmosphere. At the bottom, there is a progress bar that provides users with information about the application's loading status. This design aims not only to provide an aesthetic appearance, but also to maintain user engagement during the loading process with a clean and informative display.[23].
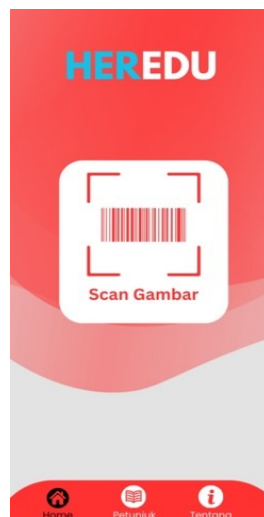


Figure 5. Main Menu Page Design

Figure 5. The Main Menu page displays the user interface design for the HEREDU app's main page. This page focuses on the Image Scan feature, with a prominent barcode scanning icon displayed in the center of the screen. Below the icon, the text "Image Scan" provides users with

598

instructions on how this feature functions. At the bottom of the screen, there is a navigation menu with three main icons: Home, Help, and About, which allows users to easily access various sections of the app.[24].
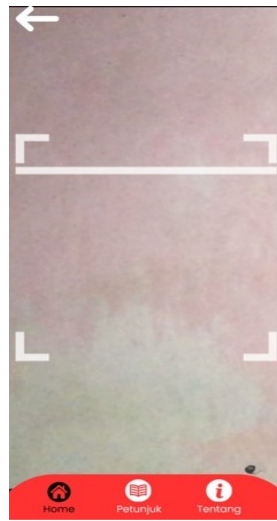


Figure 6. Image Scan Page Designs

Figure 6. The Image Scan page shows the HEREDU app's user interface, which focuses on the image scanning feature. On this page, the scanning area is demarcated by a prominent white line, guiding the user to center the object to be scanned. The page also features a navigation menu at the bottom, consisting of three icons: Home, Help, and About, which provide easy access to various sections of the app. The minimalist and clean design ensures users can focus on the image scanning activity without any other visual distractions. This page is designed to provide an efficient and user-friendly user experience.
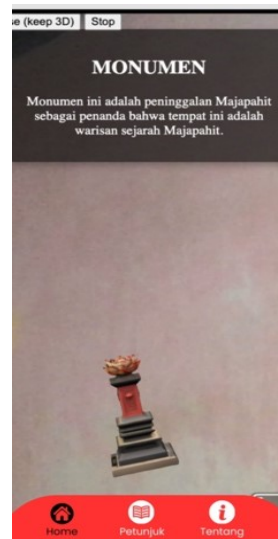


Figure 7. Design of the Scanned Image Results Page

Figure 7. The Image Scan Results page shows the results after the image is scanned using the Image Scan feature in the HEREDU application. On this page, users can view the successfully scanned 3D object, which is a monument with a distinctive architectural design. At the top of the screen, there are options to Pause (keep 3D) or Stop, giving users control over their interaction with the 3D object. Below that, there is a description that provides information about the object, in this case explaining that this monument is a historical relic of Majapahit. The navigation menu remains

599

at the bottom with Home, Help, and About icons, allowing easy access to other features. This design provides an engaging interactive experience for users with advanced image scanning technology.[25].
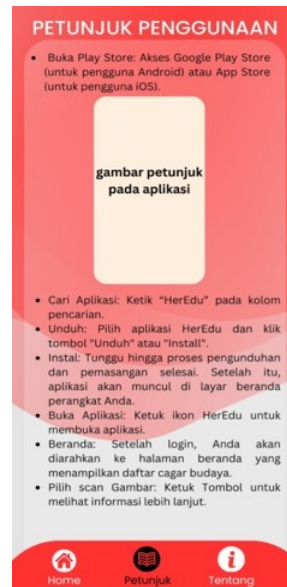


Figure 8. Design of the User's Instructions Page

The image above shows the User Guide page, which displays a step-by-step guide to using the HEREDU app. This page provides clear instructions on how to download and use the app, starting with accessing the Play Store or App Store for Android or iOS users, then searching for the HerEdu app. Users are then prompted to download and install the app. Once the installation is complete, the app will appear on the device's home screen, and users can open it by tapping the HerEdu icon. After logging in, users will be directed to the home page, which displays a list of cultural objects. Additionally, there are instructions for using the Scan Image feature to view more information about the scanned object. This design is complemented by navigation icons such as Home, Instructions, and About at the bottom to facilitate user navigation within the app.
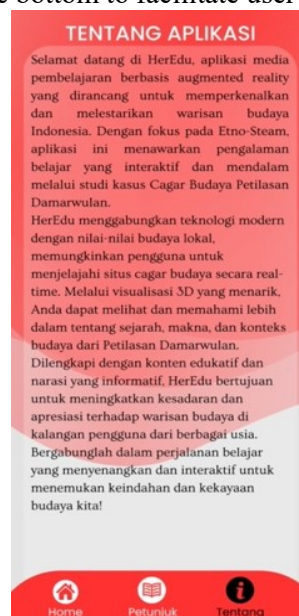


Figure 9. Design of the About Application Page

This image shows the About App page, which displays a complete description of the HEREDU app. This app is an augmented reality-based learning medium designed to introduce and

600

preserve Indonesian cultural heritage. The app's main focus is Ethnno-Steam, which offers an interactive learning experience through a case study of the Petilasan Damarwulan Cultural Heritage. HerEdu combines modern technology with local cultural values, allowing users to explore cultural heritage sites in real-time through engaging 3D visualizations. This page is equipped with informative educational content, aimed at increasing awareness and appreciation of cultural heritage among users of all ages. Users are invited to join a fun and interactive learning journey to discover the beauty and richness of Indonesian culture..

## 4.   Conclusion

Based on the overall development, validation, and evaluation process of the "Augmented Reality-Based Historical Learning Media for the Damarwulan Cultural Tourism Object" application, it can be concluded that the application of AR technology has proven effective in supporting historical literacy and local cultural preservation among elementary school students. Expert validation results indicate that the application is highly suitable for use. Media experts gave it a feasibility score of 91.5%, while material experts gave it a score of 93.3%, both of which fall within the "very suitable" category. This indicates that the application meets good pedagogical and technological standards, both in terms of content and technical aspects.

In a small-scale pilot test with 10 students, an average comprehension score of 83.3% was achieved, indicating that the application is able to introduce historical material in an engaging and easily understood manner for young users. Meanwhile, the pre-test and post-test results of a large-scale trial of 22 students at SDN Mangunan 2 Jombang showed a significant increase in student understanding, from an average of 58.18 (pre-test) to 88.18 (post-test), an increase of 30 points, indicating the application's success as an interactive learning medium. In-depth interviews with students revealed that 90.9% of them felt happy and interested in using the application, and 97% stated that the application conveyed information effectively.

The history of the Damarwulan site is quite comprehensive and engaging. This reinforces the conclusion that presenting material using a visual and narrative approach can increase student learning engagement and literacy interest in local history.

From a technical perspective, system tests showed that the application ran smoothly without errors on most Android devices, and key features such as 3D visualizations, voice navigation, narrative descriptions, and educational quizzes were easily accessible to users. Overall, this research demonstrates that Augmented Reality-based learning media not only delivers historical material in a more contextual and engaging way, but also serves as an innovative alternative to support the digital and educational preservation of local culture. This application successfully fills a gap previously untouched by conventional media by directly addressing the needs of students, teachers, and the context of a local wisdom-based curriculum.

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The author realizes that this report still has shortcomings. Therefore, constructive criticism and suggestions are highly appreciated for future improvements. Hopefully, this Final Project report will benefit all parties in need and become a positive contribution to the development of technology and the preservation of local culture.

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