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# Development and Validation of an Augmented Reality-Based Learning Module to Enhance Historical Understanding in Secondary Education

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**Abstract**

The rapid development of digital technology has encouraged the integration of innovative learning media to improve the quality of education. One emerging technology with significant potential in education is Augmented Reality (AR), which provides interactive, immersive learning experiences. This study aimed to develop and evaluate an Augmented Reality-based learning module for history education using the 4-D (Define, Design, Develop, Disseminate) development model. The research employed a research and development (R&D) approach involving expert validation, limited trials, and effectiveness testing with students. Data were collected through validation sheets, questionnaires, and learning outcome tests. The results showed that the developed AR-based learning module met the criteria of validity, practicality, and effectiveness. Expert validation indicated that the module had a high level of content accuracy, instructional design quality, and media feasibility. The practicality test results demonstrated that both teachers and students responded positively to the module's usability and accessibility in classroom learning. Furthermore, the effectiveness test revealed a significant improvement in students' learning outcomes, as indicated by higher post-test scores than pre-test scores. Therefore, the AR-based learning module can be considered an innovative and effective instructional medium to support student-centered learning and enhance learning outcomes in history education. Future research is recommended to examine the long-term impact of AR integration across different subjects and educational contexts.

**Keywords**

Augmented Reality; History Education; Instructional Media; Learning Module; Learning Outcomes

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## 1. INTRODUCTION

The rapid development of digital technology in the era of the Industrial Revolution 4.0 and Society 5.0 has significantly transformed the landscape of education, particularly in the integration of innovative learning media to support meaningful learning experiences. One of the emerging



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technologies that has attracted considerable attention in recent years is Augmented Reality (AR). Augmented Reality is defined as a technology that integrates virtual objects into real-world environments in real time, allowing users to interact with digital content in a more immersive and engaging manner (Azuma, 1997). In the context of education, AR has been widely recognized as a promising tool for enhancing students' learning experiences by providing visual, interactive, and contextually relevant learning environments (Wu et al., 2013).

Learning models utilizing AR technology have been reported to increase learning effectiveness, enhance learners' self-efficacy, and reduce cognitive load by presenting information in a more structured and visually meaningful way(Lee & Hsu, 2021). The visual and interactive nature of AR allows students to engage actively with learning materials, thereby supporting deeper understanding and long-term retention of knowledge (Bacca et al., 2014; Delgado et al., 2020). Furthermore, research indicates that the potential application of AR in practical learning environments can effectively combine online and offline learning activities, enabling a more flexible and adaptive learning process (Lambrecht et al., 2021). This flexibility is particularly relevant in the current educational context, where blended learning and digital-based instruction have become essential components of modern teaching practices (Garzón & Acevedo, 2019)

In addition, Augmented Reality technology is not limited to education but has also demonstrated significant potential across professional sectors, including engineering, architecture, and construction management. For example, AR technology has been shown to accelerate data processing workflows and improve efficiency in project management and operational tasks (Delgado et al., 2020). These findings suggest that AR technology possesses strong practical value and relevance for preparing students to face real-world challenges in the digital era. Therefore, integrating AR into the learning process can contribute not only to improving academic performance but also to developing students' digital literacy, problem-solving skills, and technological competence(Radianti & et al., 2020).

In the context of history education, the challenges faced by teachers and students are often related to the abstract nature of historical events and the limitations of traditional teaching methods. History learning is frequently delivered through narrative explanations and textbook-based instruction, which tend to be less engaging and less interactive for students. As a result, students often perceive history as a monotonous subject that requires memorization rather than critical understanding (Radu, 2014). This condition can lead to low learning motivation, reduced interest in history subjects, and limited comprehension of historical concepts (Di Serio et al., 2013). Moreover, many historical objects, events, and cultural heritage artifacts cannot be directly observed by students due to geographical, temporal, or physical constraints, making it difficult for them to visualize historical realities (Cheng & Tsai, 2013).

To address these challenges, innovative learning approaches are needed to create more engaging and meaningful learning experiences in history education. One potential solution is the use of AR-based learning media that can visualize historical objects, environments, and events in three-dimensional (3D) formats. Through AR technology, students can interact with digital representations of historical artifacts, ancient buildings, or cultural heritage sites, enabling them to explore historical information in a more immersive and contextual manner (Bacca et al., 2014). For instance, the use of prehistoric design learning media related to historical tombs can reveal facts, conditions, phenomena, forms, meanings, and historical contexts that are relevant to contemporary society (Salamun., dkk., 2023). This approach not only enhances students' understanding of historical content but also fosters curiosity and appreciation for cultural heritage.

Another important factor in selecting appropriate learning models is the accessibility and practicality of learning media. In modern education, learning resources are expected to be flexible, cost-effective, and easily accessible anytime and anywhere. Learning models that support digital access to instructional materials can significantly reduce time and financial constraints while promoting independent learning and self-regulated learning behaviors among students (Rohman et al., 2020). AR-based learning media can meet these requirements because they can be accessed through mobile devices, such as smartphones and tablets, which are widely used by students in today's digital society (Elmqaddem, 2019). Consequently, AR technology has the potential to support inclusive and equitable learning opportunities by providing accessible educational resources for diverse learners.

Despite growing recognition of AR technology in education, its implementation in history learning practices remains relatively limited, particularly in secondary education settings. Many schools still rely on conventional teaching methods and traditional instructional media, such as textbooks, printed images, and lecture-based instruction. These approaches often fail to provide interactive and experiential learning opportunities that are necessary for developing higher-order thinking skills (Garzón et al., 2020). In addition, teachers may face challenges in integrating AR technology into classroom instruction due to limited technical skills, insufficient training, and a lack of institutional support (Cabero-Almenara et al., 2019). The absence of clear guidelines and systematic models for developing AR-based learning media further contributes to the low adoption of AR technology in educational settings (Dunleavy & Dede, 2014).

Based on preliminary observations and existing literature, several key problems can be identified in the implementation of history learning. First, students' interest in learning history remains relatively low because the materials presented are predominantly narrative, less visual, and teacher-centered. Second, students experience difficulties understanding abstract, unobservable historical concepts. Third, the availability of innovative and interactive learning media in history education is still limited, as conventional teaching tools largely dominate instructional practices. Fourth, teachers' competence in developing and integrating AR-based learning technologies is relatively low due to limited professional development opportunities and limited access to technological resources. Finally, there is a lack of systematic models or frameworks that can guide educators in designing AR-based learning media that align with curriculum standards and learning objectives in history education.

The urgency of conducting this research, therefore, stems from the need to improve the quality of history learning through the integration of innovative digital technologies. Augmented Reality technology offers a promising solution for enhancing students' learning engagement, motivation, and understanding of historical concepts (Ibáñez & Delgado-Kloos, 2018). Furthermore, the integration of AR into history education can contribute to the development of students' digital literacy skills, which are essential competencies in the twenty-first century (Lee & Hsu, 2021). By providing interactive, immersive learning experiences, AR technology can transform history learning from a passive memorization process into an active, meaningful exploration of historical knowledge.

In addition, this research is expected to provide both empirical and pedagogical contributions to the field of educational technology and history education. Empirically, the study will generate evidence regarding the effectiveness of AR-based learning models in improving students' learning outcomes and engagement in history subjects. Pedagogically, the research will offer practical guidance for teachers in designing and implementing AR-based learning media that are relevant to students' needs and curriculum requirements. The findings of this research may also serve as a reference for policymakers and educational institutions in developing strategies to integrate emerging technologies into classroom instruction.

Based on the background described above, this study focuses on the application of an Augmented Reality-based learning model in the context of history learning. Specifically, this research aims to examine the potential of AR technology to support online and blended learning in history education.

## 2. METHODS

This study employed a Research and Development (R&D) design to develop and evaluate an Augmented Reality (AR)-based learning module for history education. The development process followed the 4-D model proposed by Sivasailam Thiagarajan, which consists of four stages: Define, Design, Develop, and Disseminate. The study was conducted at a senior high school in Tanah Toraja Regency, Indonesia, involving 15 eleventh-grade students in a limited field trial, one history teacher, and two expert validators (one material expert and one media expert). During the define stage, needs analysis, learner analysis, task analysis, and formulation of learning objectives were conducted to identify instructional gaps in history learning. The design stage involved developing storyboards, integrating multimedia, and developing assessment instruments. In the develop stage, the prototype module was validated by experts and revised before being implemented in classroom learning. The dissemination stage included final revision and preparation of the module for broader use.

Data were collected through expert validation sheets, student and teacher response questionnaires, and pre-test and post-test assessments. Validation and practicality data were analyzed using descriptive statistics based on mean scores and percentage criteria. To determine effectiveness, a paired-samples t-test was conducted to examine differences between pre-test and post-test scores at the 0.05 significance level. Learning improvement was further analyzed using the normalized gain (N-gain) formula and effect size (Cohen’s d) to measure the magnitude of instructional impact. Ethical approval was obtained from the school administration, and student participation was voluntary with confidentiality maintained.

## 3. FINDINGS AND DISCUSSIONS

### Findings

The media development procedure used in this study is the Thiagarajan development model, known as the 4-D model, with the following stages: definition, design, development, and deployment (dissemination) (Semmel, Semmel, & Thiagarajan, 1974). The product developed will then be tested to find out the results of teacher and student responses.

***Overview of Augmented Reality (AR) Module Development Needs***

***a. Preliminary Analysis***

The initial analysis identified problems faced by teachers and students during lectures, which became a concern, especially in the subject of learning media development. Based on the results of the implementation of learning media development at Tanah Toraja Regency High School, students need support in understanding the material due to disparities in their basic computer knowledge and their inability to keep pace with the teacher's rhythm. Therefore, one solution is to develop an Augmented Reality (AR) module. Through the Augmented Reality (AR) module, students can easily learn to absorb and understand the material presented by the lecturer, both in and out of the classroom. This module is expected to make students more active in independent learning and to increase their motivation to achieve learning goals.

***b. Student analysis***

Student analysis is conducted to identify students' characteristics to inform the design and development of lectures. Based on the results of the researcher's interview with the school, namely the teacher in the History Subject Learning Task, several explanations about the characteristics of students were obtained, namely; 1) the average age of students is 18 years old; 2) they have different ethnic backgrounds; 3) students' abilities obtained in history education subjects, some have not reached the cumulative achievement index; 4) lack of interest and motivation of students in paying attention to the explanation of the material; 5) The media used by lecturers is less innovative so that students are less motivated to participate in learning; 6) In general, students' learning styles are more inclined to technological developments.

***c. Task Analysis***

Based on the concept of learning media development for learning materials, an analysis focused on learning outcomes was conducted. Competence directs students to understand better and master learning materials related to the development of learning media, and to complete assignments after the learning process, thereby achieving lecture objectives. Each student must pay close attention to the learning material using the Augmented Reality (AR) module.

***d. Analysis of Learning Objectives***

The analysis of learning objectives is prepared based on the learning outcomes of graduates as determined. Based on the learning materials, namely, 1) Introduction to Augmented Reality (AR), 2) Making animations, 3) Making media about history education, 4) Introduction to action scripts, 5) Making quizzes, and 6) Inserting sounds. The results of the analysis at the stage of determining the initial analysis, student analysis, task analysis, and the specification of learning objectives through observation and discussion with teachers in charge of history education subjects are to obtain illustrations of the use of learning media that are not optimal. Lectures tend to be dominated by teachers, so students are not effective during the lecture. Given this problem, it is necessary to develop Augmented Reality (AR) Modules to achieve learning outcomes determined by the results.

***Overview of Augmented Reality (AR) Design***

Overview: Several stages are carried out during the design stage, including developing an idea, conducting concept analysis, creating an initial description, and creating flowcharts and storyboards. These stages can be explained below.

***a. Design Stage***

Based on the needs analysis, it is important to develop Augmented Reality (AR) for learning media development courses to support the implementation of the learning process. This stage aims to design a prototype of an Augmented Reality (AR) module for troubleshooting. The results of each activity in the design stage are described as follows:

*1) Media Selection*

Media selection is carried out to identify media that are relevant to the characteristics of the material. In addition, the selection of media is guided by concept and assignment analyses, as well as by the characteristics of media use that help students achieve learning goals—learning media used in the learning process, using Augmented Reality (AR) modules that allow each student to use them.

*2) Format Selection*

The format of the semester process plan is adjusted to include the learning plan, time allocation, materials, methods, learning steps, activities, learning facilities, and infrastructure. Augmented Reality (AR) was developed for history education subjects in accordance with the learning outcomes of graduates.

*3) Initial Design*

After determining the semester learning plan according to the needs, the researcher designed an Augmented Reality (AR) module. The initial range is an overview prototype of the Augmented Reality (AR) module design. The initial design of this Augmented Reality (AR) is a prototype to be developed, and the result is a design obtained. The prototype, the Augmented Reality (AR) module as a medium lecture, was then developed through validation, revision, and limited stage trials. The initial design of learning media is described as follows:

4) Teaching Materials/Lecture Materials

The initial design of this teaching material is made in a material. This teaching material is designed to support students' knowledge related to learning media development materials, which include several materials in each meeting, namely, 1) Introduction to Augmented Reality (AR), 2) Making animations, 3) Making media about history education, 4) Introduction to action scripts, 5) Making quizzes, and 6) Inserting sounds.

5) Designing an Augmented Reality (AR) Module

The design of learning media or modules for Augmented Reality (AR) begins with the design of media covers.

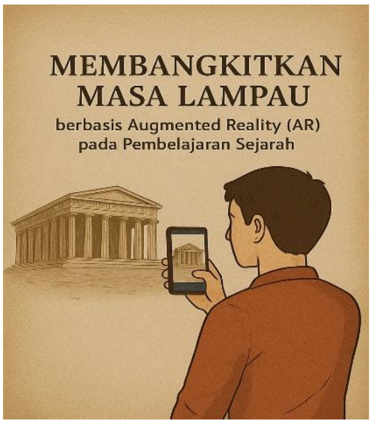


**Figure 1.** Cover Module Augmented Reality (AR)

Figure 1 shows the front cover. This section provides information on module titles for the module's synopsis, designed to be engaging and enhance the appeal of the Augmented Reality module for process learning.


**Figure 2.** Augmented Reality (AR) Content Page

Based on Figure 2, the module above displays the content in the Augmented Reality (AR) module. The module includes pictures, explanations, and practice activities, making it easier for students to understand the material and more engaging. Based on the cover of the storyboard for the Augmented Reality (AR) content page, while still considering the learning process in using the Augmented Reality (AR) module.

6) Teacher Response Sheet

The teacher response aims to determine the teacher's response to the Cost of learning media development courses using Augmented Reality (AR) implemented for teachers and students, and to assess the level of teacher response in a limited classroom trial.

7) Student Response Sheet

Student responses aim to determine how students respond to the Augmented Reality (AR) Modules implemented by teachers in a limited classroom trial. The initial design of the Augmented Reality (AR) was the result of a temporary learning medium (hypothesis) that two experts would assess.

***Level of Validity, Practicality, and Effectiveness of Augmented Reality (AR) Module***

The development stage is the final stage of the Augmented Reality (AR) module, providing a clear view of the level of validation, practicality, and effectiveness. Further details will be explained as follows:

***a. Development Stage***

At this stage, it aims to produce a revised learning media based on expert input and limited trials. The steps in the development stage are as follows:

*1) Validation*

One of the main criteria for determining whether learning media is suitable is validation results. Expert validation involves two experts: one material expert and one media expert. As for those who act as validators in assessing the validity of existing instruments by keeping the names of existing expert validators, they are coded V1 to maintain the code of ethics, namely:

*2) Validator 1 (V1)*

Professors at Makassar State University who are competent in studying media development materials. Based on the results of material validation by experts. The results of the assessment/validation of materials in the development of the Augmented Reality (AR) module provided by the validator are presented in Table 1 below.

**Table 1.** Material Validation Results

| No. | Aspect | | Validator Value |
|---|---|---|---|
| **A** | **Theory** | | |
| | 1 | Conformity with learning objectives | 4 |
| | 2 | Determination in choosing material | 4 |
| | 3 | Sufficient material to achieve learning objectives depth | 3 |
| | 4 | Material presented | 3 |
| | 5 | The order of the material is in accordance | 4 |
| | 6 | The subject matter of the examples presented | 4 |
| | 7 | Clarity of language in the material | 4 |
| | 8 | Relevance of the material to the subject | 4 |
| | The average validity of each criterion on the material aspect | | 3,7 |
| **B** | **Learning** | | |
| | 1 | Conformity of competency standards and basic | 3 |
| | 2 | Competencies: clarity of goals to be achieved | 3 |
| | 3 | The suitability of indicators with basic competencies | 4 |
| | 4 | The learning sequence is clear and easy to follow | 4 |

| No. | Aspect | Validator Value |
|---|---|---|
| | The average validity of each criterion on the aspect of attractiveness | 3,5 |
| **The average validity of each criterion on the aspect of attractiveness** | | **3,6** |

Source: Material Validation Data Analysis, 2025

Based on the validator's assessment of the material aspect, an average score of 3.6 was obtained, indicating that this aspect falls in the very valid category. The material aspect received an average score of 3.7, indicating it is in a very valid category. An average score of 3.5 was obtained in the learning aspect, indicating that it falls into a very valid category. The earlier problem was the absence of applied materials related to postgraduate learning outcomes. An expert validator's advice: the material can be developed by including explanations and values relevant to technological developments.

*3) Validator 2 (V2)*

Lecturer at the Faculty of Teacher Training and Education, Pejuang University of the Republic of Indonesia, Makassar. He was chosen as a media expert validator because; competent in media learning. Here are the results of the module expert validation. The results of the media assessment for the Augmented Reality (AR) module, provided by the validator, are presented in Table 2.

**Table 2.** Media Validation Results

| No. | Aspect | | Validator Value |
|---|---|---|---|
| **A** | **Appearance** | | |
| | 1 | The accuracy of the selection of letters in the text | 4 |
| | 2 | The accuracy of choosing the image | 4 |
| | 3 | Background color compatibility with text color | 4 |
| | 4 | The accuracy of visualizing the material | 3 |
| | 5 | Module design view | 3 |
| | 6 | Content image display | 4 |
| | 7 | Clarity of content | 3 |
| | The average validity of each criterion on the appearance aspect | | 3,5 |
| **B** | **Design** | | |
| | 1 | It can be understood well | 4 |
| | 2 | Easy to use and simple to understand | 4 |
| | 3 | Accuracy in selecting designs for material development | 4 |
| | 4 | Ease of interaction with the module | 4 |
| | 5 | Clarity of choosing a design | 3 |
| | The average validity of each criterion in the design aspect | | 3,8 |
| **Average total validation of media assessment instruments** | | | **3,6** |

Source: Media Validation Data Analysis, 2025

Based on the validator's assessment of the display's quality, an average score of 3.5 was obtained, indicating that this aspect falls into the very valid category. An average score of 3.8 was obtained for the design aspect, indicating it is in a very valid category. The average validation score for the

Augmented Reality (AR) module is 3.6, indicating it is in a very valid category. The problem identified earlier is that the module design can be more appealing to the validator's recommendations: it should be as attractive as possible, with a graphic design feel, to attract students' interest in reading.

4) *Results of Assessment/Validation of Lecturer Response Instruments*

The results of the assessment/validation of the lecturer response instrument for the development of the Augmented Reality (AR) module are shown in Table 3.

**Table 3.** Results of Validation of Teacher Response Instrument

| No. | Aspect | | V1 | V2 |
|---|---|---|---|---|
| A | **Instruction** | | | |
| | 1 | Instructions for filling out the questionnaire are clearly stated | 4 | 4 |
| | 2 | The choice of the teacher's response is stated clearly | 4 | 4 |
| | The average validity of each criterion in the instruction aspect | | 4,0 | 4,0 |
| B | **Language** | | | |
| | 1 | The use of language in terms of the use of Indonesia language rules | 3 | 4 |
| | 2 | Clarity of instructions/directions, comments, and problem-solving | 3 | 4 |
| | 3 | The simplicity of sentence structure | 3 | 4 |
| | 4 | The language used is communicative | 4 | 4 |
| | The average validity of each criterion on the language aspect | | 3,2 | 4,0 |
| C | **Contents** | | | |
| | 1 | The purpose of using the questionnaire is clearly stated and measurable | 4 | 3 |
| | 2 | The statements in the questionnaire can capture all the user responses to the Augmented Reality (AR) module | 4 | 3 |
| | 3 | The statements submitted are in accordance with the measurement objectives | 3 | 4 |
| | 4 | The formulation of the questions on the questionnaire uses words/commands/statements that require a response from the teacher | 4 | 3 |
| | The average validity of each criterion in the contents aspect | | 3,7 | 3,2 |
| **Average total validation of media assessment instruments** | | | **3,6** | **3,7** |

Source: Data Analysis of Teacher Response Instrument Validation, 2025

As for the results analysis table 3, the validity obtained is 1, or V = 100%. This means that the assessment results of the two validators have "strong relevance," with a validity coefficient of more than 75% (V > 75%), so it can be said that the measurements or interventions carried out are valid.

*Results of the Assessment/Validation of Student Response Instruments in Module Development for Augmented Reality (AR) are shown in Table 4.*

**Table 4.** Results of Validation of Student Response Instrument

| No. | Aspect | | V1 | V2 |
|---|---|---|---|---|
| A | **Instruction** | | | |
| | 1 | Instructions for filling out the questionnaire are clearly stated | 4 | 4 |
| | 2 | The choice of the teacher's response is stated clearly | 4 | 4 |

| No. | Aspect | V1 | V2 |
|---|---|---|---|
| | The average validity of each criterion in the instruction aspect | 4,0 | 4,0 |
| **B** | **Language** | | |
| | 1 The use of language in terms of the use of Indonesia language rules | 3 | 4 |
| | 2 Clarity of instructions/directions, comments, and problem-solving | 3 | 4 |
| | 3 The simplicity of sentence structure | 3 | 4 |
| | 4 The language used is communicative | 4 | 4 |
| | The average validity of each criterion on the language aspect | 3,2 | 4,0 |
| **C** | **Contents** | | |
| | 1 The purpose of using the questionnaire is clearly stated and measurable | 4 | 3 |
| | 2 The statements in the questionnaire can capture all the students' responses to the Augmented Reality (AR) module | 4 | 3 |
| | 3 The statements submitted are in accordance with the measurement objectives | 3 | 4 |
| | 4 The formulation of the questions on the questionnaire uses words/commands/statements that require a response from the student | 4 | 3 |
| | The average validity of each criterion in the contents aspect | 3,7 | 3,2 |
| **Average total validation of media assessment instruments** | | **3,6** | **3,7** |

Source: Data Analysis of Student Response Instrument Validation, 2025

The results of the analysis in Table 4 show that the validity obtained is 1, or V = 100%. This means that the assessment results of the two validators have "strong relevance," with a validity coefficient of more than 75% (V > 75%). Then it can be said that the measurement or interference results are valid.

***b. Limited Trial***

After analyzing the results from the two validators, limited trials were conducted with teachers and objects to collect data on the assessment of the Augmented Reality (AR) module's development. At this stage, 1 lecturer is involved in history education subjects at SMA Tanah Toraja Regency.

*1) Student Response Analysis*

The results of the analysis of student responses to the development of the Augmented Reality (AR) module are shown in each category statement in Table 5.

**Table 5.** Results of Student Response Analysis

| No. | The average score of respondents (1-15 Respondent) | Category |
|---|---|---|
| 1 | 3,25 | Very Practical |
| 2 | 3,50 | Very Practical |
| 3 | 3,75 | Very Practical |
| 4 | 3,33 | Very Practical |
| 5 | 3,58 | Very Practical |
| 6 | 3,33 | Very Practical |
| 7 | 3,58 | Very Practical |

| No. | The average score of respondents (1-15 Respondent) | Category |
|---|---|---|
| 8 | 3,33 | Very Practical |
| 9 | 3,50 | Very Practical |
| 10 | 3,58 | Very Practical |
| 11 | 3,25 | Very Practical |
| 12 | 3,16 | Very Practical |
| 13 | 2,08 | Practical |
| 14 | 3,08 | Very Practical |
| 15 | 3,50 | Very Practical |
| **Related** | **3,32** | **Very Practical** |

Source: Student response data analysis, 2025

Table 5 shows that students responded positively after following lectures using the Augmented Reality module, with a score of 3.32, indicating a strong practical response. It can be concluded that the students' responses strongly support the development and use of Augmented Reality in supporting the lecture process.

*2) Teacher Response Analysis*

In addition to the students' responses in this limited trial, it also involved one teacher in charge of the history education course, who provided informational feedback on the development of the Augmented Reality module. This assessment is used to determine the teacher's response after carrying out the learning process, which can be seen in Table 6 as follows:

**Table 6.** Results of Teacher Response Analysis

| No | The Average Score of Respondents (1-15 respondents) | Response |
|---|---|---|
| 1 | The Augmented Reality module is very practical | 4 |
| 2 | The Augmented Reality module is easy to use | 3 |
| 3 | The Augmented Reality module can make it easier for lecturers | 4 |
| 4 | The Augmented Reality module makes it easier for lecturers to explain the material | 4 |
| 5 | The Augmented Reality module adds interaction between the teacher and students | 3 |
| 6 | The Augmented Reality module can help students learn independently | 4 |
| 7 | The Augmented Reality module is easy to understand | 4 |
| 8 | The Augmented Reality module can activate lecturers in the teacher process | 3 |
| 9 | The Augmented Reality module uses an attractive graphic design | 3 |
| 10 | The Augmented Reality module makes it easier for students to understand the material presented by the teacher | 4 |
| 11 | The Augmented Reality module can develop student talent | 3 |
| 12 | The Augmented Reality module can improve student academic achievement | 4 |

| No | The Average Score of Respondents (1-15 respondents) | Response |
|---|---|---|
| 13 | The Augmented Reality module has a clear, systematic description | 4 |
| 14 | The Augmented Reality module can always be developed with technological developments | 4 |
| | Rerata | 3,64 |

Source: Student response data analysis, 2025

Based on Table 6, which shows the teacher's response after conducting a process study using the Augmented Reality module, the average score was 3.64, indicating that the teacher's response falls in the very practical category. It can be concluded that the teacher's response stated that using Augmented Reality modules to support the learning process is very practical. Based on the results of development, with consideration of where modules are developed based on needs in the learning process, to be able to provide benefits for schools, teachers, and students.

***c. Effectiveness of Augmented Reality (AR)***

In general, teachers and students consider that the development of Augmented Reality (AR) modules is well qualified. In the next stage, to determine the effectiveness of the Augmented Reality (AR) module, field tests are conducted on students using pre-tests and post-tests. Pre-tests are given to students before the application of Augmented Reality (AR) modules in the learning process, and post-tests are given after the application of Augmented Reality (AR) is carried out. The following is the data on the pre-test and post-test scores achieved by the students in Table 7. As follows:

**Table 7.** Student pretest and posttest score

| Number Respondent | Pretest Score | Posttest Score |
|---|---|---|
| 1 | 55 | 88 |
| 2 | 54 | 88 |
| 3 | 54 | 90 |
| 4 | 55 | 90 |
| 5 | 55 | 88 |
| 6 | 57 | 90 |
| 7 | 60 | 88 |
| 8 | 56 | 85 |
| 9 | 56 | 90 |
| 10 | 63 | 98 |
| 11 | 50 | 90 |
| 12 | 55 | 90 |
| 13 | 60 | 88 |
| 14 | 55 | 85 |
| 15 | 55 | 90 |
| Rerata | 56,00 | 89,20 |

Source: Analysis of the student pre-test and post-test data, 2025

Table 7 shows that the pre-test scored an average of 56.00%, while the post-test scored an average of 89.20%. This means that the results of the learning process before and after using the Augmented Reality module differ. In other words, there is a significant difference in student learning outcomes before and after the use of Augmented Reality modules in the learning process. In the limited trial, students' and teachers' activities during the learning process fall into the active category, indicating that the Augmented Reality module meets the criteria of validity, practicality, and effectiveness for use in the learning process.

**Discussion**

The learning product developed by the researcher on the Augmented Reality module is considered suitable because the validity level of the two validators has a strong relevance to this validity coefficient of more than 75%, with the level of practicality after giving a limited trial to students who get a very practical category, with an average score of 3.32%. The effectiveness of the Augmented Reality module is evident in field trials with students, with average pre-test scores of 56.00% and post-test scores of 89.20%, indicating that the module can help teachers and students improve the learning process. This result is consistent with previous research, which also uses modules to present various materials (Cramer et al., 2018; Supriharyanti et al., 2020)

The findings of this study demonstrate that the developed Augmented Reality (AR)-based module is valid, practical, and effective in enhancing students' historical understanding. The significant increase in mean scores from pre-test to post-test indicates that AR integration contributed substantially to learning improvement. This result confirms that immersive visualization can reduce abstraction barriers in history learning, where students often struggle to imagine past events and contexts (Küçük et al., 2016; Wu et al., 2013b). The use of three-dimensional representations, animation, and interactive activities appears to facilitate deeper cognitive processing and better conceptual retention (Cai et al., 2014; Chiang et al., 2014; Uljarević et al., 2023).

From a theoretical perspective, these findings align with constructivist learning principles, which emphasize active knowledge construction through meaningful interaction with learning materials (Piaget, 1972; Vygotsky, 1978). The AR module enabled students to interact with historical content experientially rather than passively receive textual explanations, thereby supporting deeper engagement and meaning-making (Dunleavy & Dede, 2014b; Ladson-Billings, 1995). Furthermore, this outcome is consistent with cognitive load theory, suggesting that well-designed multimedia elements can reduce extraneous cognitive load while increasing germane processing for schema construction (Mayer, 2014; Sweller, 2011).

The effectiveness of the AR module is also consistent with previous empirical studies reporting positive impacts of AR on motivation, engagement, and academic achievement across educational settings (Garzón & Acevedo, 2019b; Ibáñez & Delgado-Kloos, 2018b). Compared to traditional textbook-based instruction, AR provides contextual immersion that bridges abstract historical narratives with tangible learning experiences, thereby strengthening both emotional and cognitive engagement (Huang et al., 2016; Kamarainen. This immersive learning feature is essential in history education where contextualization supports historical empathy and critical thinking (Makransky & Lilleholt, 2018; Parong & Mayer, 2018).

In terms of practicality, results indicated high usability and instructional relevance. Positive teacher and student responses confirm that AR-based modules can serve as effective pedagogical support tools rather than replacements for teacher roles (Cabero-Almenara et al., 2019). Instead, the technology enhances explanation clarity, classroom interaction, and student autonomy, supporting experiential learning theory, which posits that learning occurs through concrete experience and reflective observation (Di Serio et al., 2013b; Kolb, 1984). The module design allowed students to explore content independently while still receiving structured instructional guidance.

Despite these encouraging results, this study has limitations. The sample size was relatively small and limited to one school context, which may affect generalizability (Garzón & Acevedo, 2019b; Radu, 2014b). Additionally, the study employed a limited trial rather than a full experimental design with a control group. Future research should involve larger, more diverse samples, employ quasi-experimental or randomized controlled designs, and investigate long-term retention effects. Further exploration is also needed to examine how AR integration influences higher-order thinking skills (e.g., historical analysis and interpretation). Nevertheless, this study adds to the body of evidence that AR-based instructional materials offer a viable and innovative approach to improving history education in secondary schools (Radianti & et al., 2020).

## 4. CONCLUSION

This study aimed to develop and validate an Augmented Reality (AR)-based learning module for history education using the 4-D development model. The findings indicate that the developed AR module meets the criteria of validity, practicality, and effectiveness in supporting the learning process. Expert validation results demonstrate that the module is highly valid across content accuracy, instructional design, and media presentation. In addition, responses from teachers and students indicate that the module is practical for classroom use and can be implemented with minimal technical difficulties.

Furthermore, the effectiveness test results reveal a significant improvement in students' learning outcomes after using the AR-based module, as indicated by the increase in post-test scores and normalized gain values. The interactive and visual features of Augmented Reality technology enable students to better understand abstract historical concepts, increase motivation to learn, and promote active engagement in the learning process. These findings confirm that AR-based learning media can serve as an innovative instructional tool to enhance the quality of history education in secondary schools.

Therefore, the development of AR-based learning modules is recommended as an alternative learning resource to support digital-based and student-centered learning in the era of Education 4.0. Future research is suggested to involve a larger sample size, diverse educational settings, and long-term implementation to examine further the sustainability and broader impact of Augmented Reality integration in education.

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