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Development of an Augmented Reality-Based History Learning Model to Improve Historical Literacy Among Secondary School Students

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ABSTRACT (9 pt)

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Objective: This study aimed to develop a pedagogically validated Augmented Reality (AR)-based history learning model to enhance secondary school students' historical literacy, motivation, and engagement. This studyresearch addresses the pressing issue of low historical literacy, often exacerbated by conventional teaching methods perceived as monotonous and irrelevant. Method: This study employed a tailored Research and Development (R&D) approach adapted from the Borg and Gall model, encompassing three main phases: needs identification, development, and evaluation. Comprehensive data were collected from 30 students, teachers, and experts throughvia surveys, interviews, observations, and historical literacy tests (pre- and post-tests). Results: The developed AR prototype successfully integrated 3D visualizations, interactive narratives, and gamified quizzes to create an immersive learning experience for students. The model's implementation yielded substantial improvement: the students’ average historical literacy score increased significantly by 22.4% (from 55.0% to 77.4%); furthermore, the model

demonstrated high user acceptance, with a student satisfaction rate of 84%. Expert validation further affirmed the model’s pedagogical soundness, content accuracy, and curriculum alignmentpedagogical soundness, content accuracy, and curriculum alignment of the model. Novelty: This study introduces an integrated AR framework explicitly designed for Indonesian history education, effectively transforming traditional instruction into an interactive and, contextual experience. This approach supports Sustainable Development Goal 4 (SDG 4) objectives by promoting innovative and equitable access to quality education in the country.Objective: This study aims to develop a pedagogically validated Augmented Reality (AR)-based history learning model to enhance secondary school students' historical literacy, motivation, and engagement. The research addresses the pressing issue of low historical literacy, often exacerbated by conventional teaching methods perceived as monotonous and irrelevant. Method: The research employed a tailored Research and Development (R&D) approach adapted from the Borg and Gall model, encompassing three main phases: needs identification, development, and evaluation. Comprehensive data were collected from 30 students, teachers, and experts via surveys, interviews, observations, and historical literacy tests (pre-test and post-test. Results: The developed AR prototype successfully integrated 3D visualizations, interactive narratives, and gamified quizzes to create an immersive learning experience. The model's implementation yielded substantial improvement: the students’ average historical literacy score increased significantly by 22.4% (from 55.0% to 77.4%). Furthermore, the model demonstrated high user acceptance, with a student satisfaction rate reaching 84%. Expert validation further affirmed the model’s pedagogical soundness, content accuracy, and curriculum alignment. Novelty: This study introduces an integrated AR framework explicitly designed for Indonesian history education, effectively transforming traditional instruction into an interactive and contextual experience. This approach supports Sustainable Development Goal 4 (SDG 4) objectives by promoting innovative and equitable access to quality education.

Keywords:

Augmented Reality

Historical Literacy

Educational Technology

Secondary School

Learning Innovation

INTRODUCTION

In recent years, the integration of digital technology into education has transformed the wayhow learners access and interact with knowledge. Among emerging innovations, Augmented Reality (AR) has become a promising educational technology that bridges physical and digital environments, offering interactive and immersive learning experiences. In the context of history education, AR allows students to visualize historical events and cultural artifacts in three dimensions, fostering deeper engagement and a sense of presence in the learning process (Lim and& Lim, 2020). The interactive nature of AR supports multisensorymulti-sensory learning, thereby enhancing memory retention, motivation, and conceptual understanding compared with conventional textbook-based methods (Di Serio et al., 2013).

Despite its potential, AR implementationthe implementation of AR in history education remains limited, particularly in developing countries where pedagogical frameworks and evaluation models are still underdeveloped. Several studies have highlightedhighlight persistent barriers, such as the absence of systematic instructional design, the lack of empirical evidence regarding AR's contribution to historical literacy, and technical constraints related to classroom infrastructure and teachersteacher (Hu et al., 2021; Rejekiningsih et al., 2023; Yang et al., 2021). These limitations hinder educators from effectively integrating AR into the curriculum and from achieving meaningful learning

outcomes that connect historical knowledge with students' everyday contexts.

Historical literacy is a crucial component of civic and cultural education that, enablesenabling learners to interpret historical sources, analyze evidence, and construct reasoned narratives about the past (Levstik & Barton, 2010; Wineburg, 2001). However, recent surveys have revealedreveal that many secondary students still perceive history as monotonous and irrelevant, resulting in low motivation and poor conceptual understanding (Setyaningsih et al., 2024). Furthermore, teachers often rely on didactic instruction and lack engaging media that can stimulate analytical thinking or emotional connectionsconnection to historical events. Addressing these challenges requires the adoption of technology-enhanced learning models that combine pedagogical design, historical accuracy, and interactivity to improve students' literacy and appreciation of their national heritage.

Building upon previous research that applied game-based and 3D immersive learning approaches to enhance cognitive engagement (Kurniawan & Pradatama, 2021), this study focuses on developing an AR-based history learning model tailored to the needs of Indonesian secondary-educationsecondary education. The model integrates visual, auditory, and interactive elements with gamification features to provide an engaging learning environment that is aligned with curriculum goals and the Merdeka Belajar framework.

Therefore, this studythe objective of this research aimedis to design, develop, and validate a pedagogically grounded AR-based history learning model aimed at improving students' historical literacy, motivation, and engagement. ThisThe study also seeks to evaluate the model's effectiveness in enhancing learning outcomes and its potential contribution to achieving Sustainable Development Goal 4 (SDG 4): Quality Education, which promotes inclusive and equitable access to innovative learning experiences.

RESEARCH METHOD

This study employed a Research and Development (R&D) design adapted from the (Gall et al. (, 2003), which emphasizes the systematic and iterative development of educational products. The model consisted of three primary phases: (1) problem identification and data collection, (2) model design and development, and (3) model evaluation and testing. Each phase was designed to ensure the pedagogical validity, technical feasibility, and user acceptance of anthe Augmented Reality (AR)-based history learning model.

The research was conducted at a public secondary school in West Java, Indonesia, involving three participant groups: (1) 30 tenth-grade studentsstudents from the tenth grade enrolled in a national history course, (2) three history teachers serving as implementers and observers, and (3) two experts, consisting of one specialist in history education and the otheranother in educational technology, who acted as external validators. The participants were selected purposively to represent typical classroom conditions and to ensure relevance to the study objectives.

Four primary instruments were used: 1) surveySurvey questionnaires to capture students' perceptions, motivation, and usability responses before and after implementation; 2) interviewInterview protocols for teachers and experts to collect qualitative feedback on pedagogical integration, historical accuracy, and media design; 3) observationObservation sheets to record student engagement and learning behavior during AR-based lessons; and 4) historicalHistorical literacy tests (pre-test and post-test) designed to measure conceptual understanding, analytical ability, and contextual reasoning.

The AR learning model was developed collaboratively between the research team and media designers using the Unity 3D and Vuforia SDK platforms. Historical events and

artifacts were reconstructed in 3D to create interactive experiences enriched with narration and gamified quizzes. After initial validation by experts, the prototype was implemented in the classroom forover three instructional sessions. Teacher observers ensured that the implementation aligned with the lesson objectives and classroom time constraints.

Quantitative data from literacy tests and satisfaction surveys were analyzed using descriptive statistics (mean, percentage gain, and improvement rate) to determine the model's effectiveness. Furthermore, inferential statistics, specifically a paired-samples t-test, were employed to compare pre-pre-test and post-test scores and confirm the statistical significance of the historical literacy improvement. Qualitative data from interviews and observations were analyzed usingthrough thematic coding, highlighting recurrent patterns related to student engagement, motivation, and usability. The integration of both data types enabled triangulation and strengthened the findings' validitythe validity of the findings. The interpretation of the results focused on comparing pre-pre-test and post-test performance, correlating user satisfaction with learning outcomes, and assessing expert validation scores to ensure pedagogical reliability of the tool.

The interpretation of results focused on comparing pre-test and post-test performance, correlating user satisfaction with learning outcomes, and assessing expert validation scores to ensure pedagogical reliability.

RESULTS AND DISCUSSION

Results

The development of the Augmented Reality (AR)-based history learning model followed the three main stages of the R&D process: (1) problem identification and data collection, (2) model design and development, and (3) evaluation and testing.

During the needs-analysis phase, survey and interview data revealed that more than 70 %

of students perceived history classes as monotonous, while teachers identified the lack of interactive media as the main obstacle to improving students' historical literacy. To address these issues, the research team designed an AR prototype that integratesintegrating 3D visualization, narrative audio, and gamified quizzes to create immersive learning experiences.

Expert validation byinvolving two specialists confirmed that the developed AR model met pedagogical and technical feasibility standards. The validatorsValidators rated the model as "valid" in terms of content accuracy, pedagogical alignment, and usability.

Table 1. Expert Validation

No	Aspects Assessed	Validator	Assessment Results	Rekomendation
1	Historical Content Accuracy	History Expert	Valid	Additional contextual narrative needed
2	Pedagogical Suitability	Education Expert	Valid	Align with the "Merdeka Belajar" curriculum
3	Technical Aspects	Media Expert		

Satisfactory

Need to optimize AR performance on mid-range smartphones

4

Interactive Map

Navigation between historical locations

Connecting spatial context

Need to develop more comprehensive and specific 3D modeling

ClassroomThe classroom implementation produced significant learning gains. The average pre-test score was 55.0 %, increasing to 77.4 % (post-test), indicating a 22.4 % improvement in students' historical literacy. In addition, 84 % of the students reported satisfaction with the learning experience, 10 % were neutral, and 6 % were dissatisfied, suggesting high acceptance of the AR-based model.

Table 2. Average History Literacy Scores of Students

Category

Average Score (%)

Pre-test

55.0

Post-test

77.4

Figure 1 shows a graph comparing the pre-pre-test and post-test scores.

Figure 1. Comparison of Pre-test and Post-test Scores

Furthermore, the observation records showed that the students actively interacted with the virtual objects and collaborated in answering gamified questions. The AR application succeeded in increasing students' concentration, curiosity, and peer discussion frequency during lessons.

The application interface and examples of its visualizations are shown in the can be seen in figuresFigures below.

Figure 2. Main Menu

Figure 3. Visual Introduction

Figure 4. Narrative of Conflict

Figure 5. Actions to Burn Down Buildings

Figure 6. Details and Reasons for Burning Buildings

Figure 7. Evacuation of Residents

Figure 8. Nasution Command Post

Figure 9. Impact & Transformation (Bandung 1946)

Figure 10. Impact & Transformation (Bandung 2025)

Figure 11. Quizzes and Reflections Menu

Figure 12. Quiz Questions and Reflections

Discussion

Discussion The integration of Augmented Reality (AR) technology in history education yielded a significant improvement in student outcomes, confirming its efficacy in transforming conventional learning methods. The substantial 22.4% gain in historical literacy scores demonstrates that the AR model moved beyond mere factual comprehension to foster higher orderhigher-order thinking. This improvement is theoretically attributed to the immersive learning environment created by the AR prototype. By presenting complex historical narratives (e.g., Bandung Lautan Api) through 3D

visualization and interactive scenarios, the AR model effectively managed the cognitive load often associated with abstract historical concepts. This multisensorymulti-sensory approach is consistent with prior studies that emphasize AR's role in improving both cognitive and affective learning outcomes through enhanced presence and contextual reasoning (Di Serio et al., 2013; Jesionkowska et al., 2020). The high acceptance rate further suggests the model's success in increasing intrinsic motivation.

The high satisfaction rate (84%) reflects positive user perception, confirming that gamified learning elements can motivate students by combining enjoyment and challengeschallenge (Lampropoulos et al., 2022). The inclusion of interactive narratives and visual reconstructions also promotes empathy and contextual understanding of historical events, qualities that are often missing from conventional history instruction.

Expert validation results further indicatedindicate that the developed model achieved a balanced integration ofbetween pedagogy and technology. The model adhered to curriculum objectives and encouraged higher-order thinking, consistent with Hu et al. (2021), who emphasized that successful AR learning depends on alignment with the principles of instructional designinstructional design principles. However, technical constraints, such as limited smartphone performance and teacher readiness, were identified. These issues were mitigated through lightweight design optimization and short-term training, ensuring practical feasibility in diverse school environments.

Table 3. Summary of Expert Feedback and Improvement Actions

No.

Aspect Assessed

Expert Validator

Assessment Result

Feedback / Recommendation

Improvement Action Taken

1

Historical Content Accuracy

History Education Expert

Valid

Add contextual narration for events and their local relevance.

BackgroundAdded background narratives emphasizing the socio-cultural context were added.

2

Pedagogical Suitability

Education Expert

Valid

Align the content with the Merdeka Belajar curriculum standards.

Revised learning objectives and mapped to the current curriculum.

3

Technical Performance

Multimedia/Media Expert

Satisfactory

OptimizingOptimize app performance for mid-range smartphones.

Reduced 3D texture complexity and improved applicationapp load time.

4

Interactive Design and Navigation

Instructional Designer

Valid

Enhance interactivity between scenes and user navigation.

HotspotAdded hotspot transitions and an interactive map for scene control were added.

5

Gamification and Engagement

Educational Technologist

Very Good

AdaptiveInclude adaptive quizzes for reflection and retention were included.

Integrated scoring and feedback system for each learning stage:.

Overall, thisthe study confirms that AR-based learning can transform traditional history instruction into a more interactive, inclusive, and meaningful experience. Beyond academic improvement, thisthe approach aligns with the Sustainable Development Goal 4 (SDG 4): Quality Education, promoting innovative and, equitable access to technology-enhanced learning.

Figure 4. Pedagogical Framework Model for AR-Based Historical Literacy Learning

CONCLUSION

Fundamental Findings: This study concludes that the Augmented Reality (AR)-based history learning model developed through the Research and Development (R&D) approach ishas proven effective in improving students' historical literacy and engagement. The integration of 3D visualization, interactive narration, and gamified quizzes successfully addressed the monotonous nature of conventional history teaching methods. Quantitative analysis showed a 22.4% increase in historical literacy scores, andwhile 84% of students reported satisfaction with the learning experience. Expert validation confirmed that the model was pedagogically appropriate, technically feasible, and aligned with the curriculum objectives. Implications: The findings demonstrate that AR can serve as a powerful instructional tool in history education, transforming abstract historical narratives into tangible and, immersive experiences. The model aligns with Indonesia's Merdeka Belajar policy and contributes to the realization of Sustainable Development Goal 4 (SDG 4) on quality education. In practical terms, the AR-based approach offers an innovative pathway for educators to foster critical thinking, motivation, and a sense of national identity among students. For policymakers and curriculum developers, it provides an evidence-based

justification for integrating emerging technologies into history learning.

Limitations : Although the model performed effectively, several challenges were observed during implementation. Technical limitations, such as device compatibility, internet stability, and limited teacher familiarity with AR tools, constrained the scalability of the program. Furthermore, the study was conducted within a single institutional context, which may limit the generalizability of the findings to other schools or regions with differing infrastructures.

Future Research : Further studies should explore the large-scale implementation of AR-based learning models across diverse educational settings to assess their adaptability and long-term impact. Future developments could integrate collaborative multiplayer features, and VR immersion to enhance the sense of presence in historical contexts.

FutureCrucially, future research should explore the integrationintegrating of adaptive assessment mechanisms and AI-driven feedback systems specifically designed to evaluate and improve students' historical analysis, interpretation of evidence, and contextual reasoning skills. Additionally, research should examine the effectiveness of AR for students with special educational needs to, ensureensuring equitable access to innovative digital learning environments.

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