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Development of Deep Learning-Oriented Augmented Reality Multimedia for Elementary School Teacher Education Students

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Abstract

The integration of deep learning principles into technology-enhanced learning remains limited, particularly in the development of Augmented Reality (AR) media that simultaneously promote cultural literacy and digital literacy. This study aimed to develop and validate a Deep Learning-Oriented Augmented Reality Multimedia for Elementary School Teacher Education students. The novelty of this study lies in the integration of the three core dimensions of deep learning Meaningful Learning, Mindful Learning, and Joyful Learning within an AR-based multimedia environment contextualized through Balinese cultural content. This research employed a Research and Development (R&D) approach using the Plomp model, encompassing preliminary investigation, design, realization, and evaluation stages. Product validity was assessed by nine experts consisting of three media experts, three learning experts, and three language experts. Data were collected using validation questionnaires and analyzed using Aiken's V coefficient. The developed multimedia integrates instructional videos, interactive AR visualizations, project-based learning activities, gamified assessments, and cultural literacy materials into a unified learning ecosystem. The results indicate that the multimedia achieved a very high validity level across media, learning, and language aspects, demonstrating its feasibility for implementation in higher education. The findings suggest that integrating deep learning principles with AR technology can create meaningful, reflective, and enjoyable learning experiences while strengthening students' cultural awareness and digital competencies. This study contributes an innovative instructional design framework for culturally contextualized and technology-enhanced learning in teacher education.

Keywords: augmented reality, deep learning approach, multimedia learning, digital literacy, joyful learning, mindful learning, meaningful learning, interactive learning media, project-based learning.

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1. Introduction

The rapid development of science demands that lecturers be able to apply technology in the educational realm so that the material delivered can be absorbed as well as possible and students become more understanding so that the transfer of knowledge becomes easy and enjoyable. The ease of technology access by the public is due to the public's very high interest in smartphones, based on data from Hootsuite We Are Social as of January 2020, it states that 94% of device ownership in Indonesia uses smartphones or smart phones (Nugroho et al., 2025). According to the results of national research conducted by the Indonesian

Internet Service Providers Association (APJII) and the University of Indonesia (UI) Study Center (2014), the majority of internet users in Indonesia are in the 18-25 year age range. The number of young users in this age group is almost half (49%) of the total number of internet users in Indonesia which reached 88.1 million in 2014. This age range is usually at the university level. Students' use of digital technology needs to be utilized wisely to support their development through appropriate guidance, supervision, and guidance from their environment, including lecturers and parents (Lindriany et al., 2022; Mauluddian & Yulindrasari, 2024). Based on this phenomenon, technology-based learning needs to be applied to learning in higher education in order to avoid the negative impact of technological developments on students.

Digital-based educational transformation has become a strategic priority to ensure that education systems are able to meet the continuously evolving needs of society (Saepullah, et al., 2025; Aldhafeeri & Alotaibi, 2023). In Indonesia, educational transformation still faces various challenges. Although the government has promoted digitalization in the education sector, its implementation has not yet been evenly distributed or fully effective. Issues related to infrastructure, digital literacy, and teacher readiness remain major barriers to achieving inclusive and sustainable educational transformation (Wang et al., 2023). Furthermore, educational transformation in Indonesia must take into account its complex socio-cultural context.

On the other hand, the use of digital learning media also has impacts that require careful consideration. Dependence on technology may create new problems, such as access disparities resulting from unequal technological infrastructure across regions. In addition, excessive exposure to digital devices may affect students' mental and physical health (Zutiasari, 2025; Domoff, et al., 2019). Therefore, a holistic approach is needed to maximize the benefits of digital learning media while mitigating their potential negative effects (Yadav, 2024; Waang, 2023). Beyond these issues, the limited use of contextual learning resources, the dominance of transmissive lecture-based instruction, and the prevalence of drill-oriented exercises focused primarily on memorization hinder the learning process from optimizing students' potential in an authentic and holistic manner. These practices also result in minimal engagement in critical and creative thinking (Rahiem, 2020).

The problem in the use of technology by students in learning also demonstrated by observations and interviews conducted with Elementary School Teacher Education students in Bali Province, which showed that 1) approximately 90% of students have social media accounts, but only 25% use them for educational or work purposes. The rest use social media accounts to update status, watch videos on TikTok or Instagram about something that is currently viral, and other things outside of education; 2) lack of learning that relates to local culture; 3) still minimal learning that uses technology, although the use of zoom in lectures has been increasingly used, but in practice the use of technology-based media is still little implemented; 4) many students are not yet able to operate technology or learning applications; 5) lack of student interest in finding out about local culture, more of whom like kpop or other foreign cultures to follow trends.

Based on these issues, it is crucial to develop technology-based learning media. Media have become an indispensable tool in the learning process, playing a crucial role in helping teachers communicate instructional messages more clearly to students (Putra &

Pratama, 2023; Kustyarini, et al., 2020). Media can also represent concepts that may be difficult for teachers to convey through words or specific verbal explanations alone (Arsyad, 2024; Vu, et al., 2021). Therefore, the role of educational media as facilitators and supports in learning activities is highly significant. By selecting appropriate media, the teaching and learning process can be presented in a more engaging and interactive manner, thereby generating positive impacts on students' understanding and academic achievement (Opoh, et al., 2021; Lubis, 2023; Kamran, et al., 2023; Qirem, et al., 2022).

There has been much development and previous research on technology-based learning, such as the use of Quizizz, Kahoot, Google Classroom, Edmodo, and other applications. However, few have addressed the importance of real-world learning (O'Neill & Short, 2023). Real-world learning can be adapted to technology. One multimedia tool that can immerse students in real-world learning is Augmented Reality. Augmented Reality is a technology that combines real-world elements with virtual ones, creating a rich and immersive experience for users (Indahsari & Sumirat, 2023). By utilizing hardware such as cameras, sensors, and graphic displays, AR can present additional information in real time over physical objects (Dargan, et al., 2022; Syed, et al., 2022). This technology allows users to see and interact with the real world, enhanced by virtual elements. Furthermore, Augmented Reality also allows for the visualization of objects that are difficult to see, such as human organs and similar objects (Venkatesan, et al., 2021; Cieri, et al., 2021). AR also makes the teaching and learning process not tied to class hours or classrooms, as students can study the material anywhere and anytime (Nistrina, 2021). The multimedia characteristics of Augmented Reality, which can immerse students in real-world situations, can be oriented using a Deep Learning approach. Deep learning, in an educational context, refers to a learning approach that involves a deep understanding of the material being studied (Kovac, et al., 2025; Elbashbishy, 2024). Unlike traditional learning, which tends to focus on mastering facts or memorization, deep learning prioritizes the development of critical, analytical, and reflective thinking skills that enable students to process, integrate, and apply knowledge in new situations (Putri, 2024). This approach has the primary goal of improving the quality of student learning through social interaction, the development of higher-order thinking skills, and the application of knowledge in broader contexts. Deep learning is considered a cognitive process that involves the ability to connect new knowledge with existing ones and enrich understanding through the application of learned concepts in real life or new situations.

In learning focused on deep learning, technology and online platforms can play a crucial role. With the help of technology, students can be faced with various challenges that require them to think creatively and innovatively in solving problems. Online learning platforms and technology-based collaboration tools help students work together more effectively, a crucial component of the deep learning approach (Naseer et al., 2024; Akmal et al., 2024). Similarly, the use of technology in education can provide opportunities to design more personalized and adaptive learning models.

The implementation of deep learning encompasses learning principles that are fundamental to the characteristics of deep learning. This approach is based on three fundamental elements, the first of which is meaningful learning. This process involves integrating new information with students' existing knowledge. This cognitive process does not simply add new information but creates a

complex and integrated network of understanding. When students actively connect new phenomena with existing knowledge, they develop deeper and more lasting understanding, unlike rote learning, which tends to be superficial (Hafidzhoh et al., 2023). Mindful Learning, in a deeper sense, as the second element, plays a crucial role in developing students' awareness and active involvement in the learning process. Students engaged in Mindful Learning tend to be better able to analyze information in depth, evaluate multiple perspectives, and generate innovative solutions to problems (Wang et al., 2023). Joyful Learning, in an enjoyable sense, as the third element, provides an important emotional dimension to the learning process. A cheerful and conducive learning environment can foster students' intrinsic motivation, making them enthusiastic and eager to face academic challenges. Lecturers can choose from a variety of methods, such as game-based learning, where lesson concepts are taught through engaging educational games (Mutmainnah et al., 2025).

Based on this, this research will develop Deep Learning-oriented Augmented Reality multimedia. Augmented Reality multimedia will be designed to make learning more realistic, in line with the concept of meaningful learning. Furthermore, Augmented Reality multimedia will increase student active engagement, in line with the Deep Learning principle of mindful learning. The third component of Deep Learning, "joyful learning," will provide innovation by providing interactive games/quizzes at the end of the lesson to students, enabling them to focus more on their learning and answer the quizzes.

Several previous studies have explored the use of Deep Learning-oriented Augmented Reality multimedia to better connect learning concepts to a more concrete level. A study by Indahsari & Sumirat (2023) entitled "Implementation of Augmented Reality Technology in Interactive Learning" showed that Augmented Reality implementation can bring significant benefits to students in terms of conceptual understanding, engagement, and motivation. While there are challenges to overcome, the development of Augmented Reality technology promises significant potential to enhance the learning experience and help create a more interactive and engaging educational environment. Other supporting research is conducted by Sele et al. (2024) entitled “Empowering Teacher Digital Literacy Through Augmented Reality Training”. The evaluation results revealed an increase in teachers' digital literacy. Before participating in this activity, the average digital literacy score of SMPN Fatumfaun teachers was 63.14, which is considered good. After participating in this activity, the average digital literacy score of SMPN Fatumfaun teachers was 76.43, which is considered good. This indicates a 21.05% increase in teachers' digital literacy.

Another supporting study was conducted by Epik et al. (2025) entitled "Improving Literacy Skills through Deep Learning in Fourth Grade Students of UPT SDN 8 Pinrang." The results showed that implementing Deep Learning can effectively improve students' literacy skills. Through the right approach, students become more active in understanding texts, discussing discussions, and developing their critical thinking skills. Taqiyya et al., (2025) research entitled “Development of Web-Based Interactive Multimedia to Improve Cultural Literacy and Digital Literacy in Elementary Schools” shows that the results of this research and development produce a web-based interactive multimedia product, the resulting product is suitable for use based on validation from experts and potential users, and is effective for improving students'

cultural literacy and digital literacy based on product effectiveness testing using the T-test.

Based on the above background, it is important to conduct development research with the title "Development of Deep Learning-oriented Augmented Reality Multimedia to Improve Cultural Literacy and Digital Literacy of Elementary School Teacher Education Students of State/Private Hindu Religious Universities in Indonesia".

2. Method

a. Research Design

This type of research is research and development (R & D). The development model used is the Plomp development model. The development procedure follows the stages in the Plomp development model which consists of preliminary investigation, design, realization/construction, test, evaluation, and revision, and implementation. However, in this study it is limited only to the test, evaluation and revision stage.

b. Participant

The participants of this study consisted of 2 experts from lecturers for the content validity test, 9 experts for the product content validity test consisting of 3 language experts, 3 civics learning experts, and 3 media experts.

c. Material

The data collection technique for the instrument content validity test, the product content validity test. The assessment aspects of the content validity instrument by media experts are 1) layout design; 2) text/typography; 3) image; 4) audio; 5) video; 6) packaging; 7) use. The assessment aspects of the learning expert instrument are 1) the suitability of multimedia with learning outcomes and learning objectives; 2) breadth of material; 3) depth of material; 4) accuracy of material; 5) accuracy of concept; 6) accuracy of examples; 7) suitability of images/illustrations with material; 8) activating student involvement; 9) potentially increasing student cultural literacy; 10) Potentially increasing student digital literacy. The assessment aspects of the language expert instrument are 1) accuracy of sentence structure; 2) effectiveness of sentences; 3) standardization of terms; 4) understanding of messages or information; 5) spelling accuracy. The content validity of the instrument uses the Gregory formula, with the results of all instruments having a score of 1 which means valid with a very high category.

d. Procedure

The research and development procedure in this study employed the Plomp Model, which consists of the stages of preliminary investigation, design, realization, testing, evaluation, and revision. The stages of the research and development process based on the Plomp Model are described as follows.

In the preliminary investigation phase, data and information from the field were collected and relevant problems were identified. This data collection aimed to strengthen the problem background, research objectives, and expected contributions of the study. Data were gathered through interviews, documentation studies, and classroom observations. The activities conducted included: (1) examining the learning process implemented in the classroom, in which the researcher observed both student and lecturer activities during instruction; (2) conducting interviews with PGSD lecturers at PTKHN/PTKHS in Indonesia regarding challenges encountered in the learning process; (3) reviewing the learning instruments used in classroom instruction. Based on the results of the analysis, solutions were formulated by examining supporting

theories and analyzing findings from relevant previous studies.

The second phase is the design phase. The activities in this phase aimed to design solutions to the problems identified during the preliminary investigation. In this phase, the researcher designed a product in the form of Deep Learning–oriented Augmented Reality Multimedia and developed the instrument blueprints for assessing validity.

The third phase is the realization phase. In this phase, the designed solutions were implemented to produce an initial prototype. The resulting prototype was a Deep Learning–oriented Augmented Reality Multimedia product. In addition, instruments for testing validity were developed based on the previously constructed instrument blueprints.

The fourth phase is the Test, Evaluation, and Revision phase. In this phase, the validity of the Deep Learning–oriented Augmented Reality Multimedia prototype was evaluated by nine experts/practitioners, consisting of three media experts, three learning experts, and three language experts. The validity analysis was conducted using Aiken's V.

e. Data Analysis

The data analysis technique for testing the validity of product content uses the Aiken's V formula (Hidayah & Muhtarom, 2023).

$$V = \frac{\sum r - lo}{n(c-1)}$$

Information :

lo = lowest validity assessment value (1)

c = highest validity assessment value (5)

r = value given by the validator

n = number of validators

The Aiken validity criteria are V≤ 0.4, which means low validity, 0.4 < V < 0.8, which means moderate validity, and V≥ 0.8, which means high validity.

3. Result and Discussion

The results and discussion section presents a comprehensive description of the developed product as well as an analytical interpretation of its features in relation to deep learning principles. This section elaborates on how the Deep Learning-Oriented Augmented Reality Multimedia was designed, structured, and implemented to support meaningful, mindful, and joyful learning experiences. Furthermore, each component of the multimedia is analyzed to demonstrate its pedagogical relevance, usability, and contribution to enhancing students' cultural and digital literacy. The presentation of results is supported by visual representations in the form of figures, which are discussed in detail to provide a clear understanding of the system's functionality and instructional design.

a. Deep Learning-Oriented Augmented Reality Multimedia Development Results

Based on the development of a Deep Learning-Oriented Augmented Reality multimedia product, the results of the media development were obtained, incorporating the topic of Balinese cultural diversity in the Basic Concepts of Civics for Elementary Schools course. The learning outcomes were: Students are able to explain Balinese cultural diversity and how to appreciate it. The learning objectives were: 1) Students are able to understand the diversity of Balinese traditional houses; 2) Students are able to understand the diversity of Balinese musical instruments; 3) Students are able to understand the diversity of Balinese crafts; 4) Students are able to understand Balinese traditions; 5) Students are able to understand the factors influencing Balinese cultural diversity and efforts to preserve Balinese culture.

The Deep Learning-Oriented Augmented Reality multimedia was developed using the Canva application, and for the Augmented Reality application, the Assemblr Edu application. The quizzes used a word wall application. The multimedia was developed into several learning activities. Instructions for using the media are also provided. The following are details of the multimedia development.

Figure 1. Initial View

Figure 1 presents the initial interface of the Deep Learning-Oriented Augmented Reality Multimedia, designed to create an immersive and culturally contextualized learning environment. Balinese cultural elements serve as visual stimuli that support meaningful learning by connecting new knowledge with relevant cultural contexts. Functional features such as the Start button and music controls enhance usability and facilitate smooth navigation. Background music contributes to joyful learning by fostering positive emotional engagement (Khairi & Ishafit, 2026). As an orientation stage, the interface guides learners into the learning experience while stimulating curiosity and motivation. Its integration of visual, auditory, and interactive elements supports multimodal learning and knowledge retention.

Figure 2. Main Menu

Figure 2 presents the main menu as the central navigation hub of the multimedia system, structured according to deep learning principles. The Meaningful Learning, Mindful Learning, and Joyful Learning menus represent sequential learning phases that support systematic and self-directed learning (Chosya & Takiddin, 2025). Clear icons and categorized features enhance usability, cognitive clarity, and ease of

navigation. The menu design facilitates scaffolding by guiding learners from conceptual understanding to application and knowledge reinforcement. Supporting features, including instructions and learning outcomes, ensure alignment between objectives and activities. Its modular and user-centered structure provides flexibility for educators while promoting learner autonomy, thereby enhancing overall learning effectiveness.

Figure 3. Instructions for use menu

Figure 3 presents the instructions menu, which supports effective interaction with the multimedia system and reduces the learning curve for users, particularly those unfamiliar with augmented reality applications. It provides comprehensive guidance on learning flow, barcode scanning, button functions, and quiz procedures. These instructions promote mindful learning by helping learners understand and manage their learning processes effectively (Taqiyya et al., 2025). Visual and structured guidance improves accessibility, comprehension, and user experience. Additionally, the menu minimizes errors and confusion, enabling learners to focus on content rather than technical navigation. By reducing unnecessary cognitive load, this instructional scaffolding enhances learning efficiency and ensures that technology supports educational objectives.

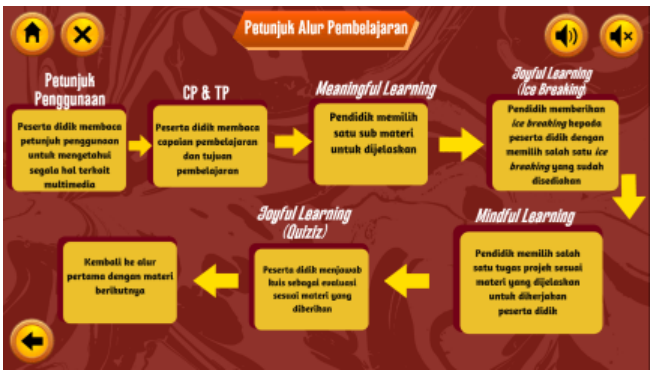


Figure 4. Learning Flow Instructions

Figure 4 illustrates a structured learning flow designed according to deep learning principles. The sequence includes orientation, understanding objectives, engaging with materials, participating in interactive activities, and completing evaluations, ensuring alignment between objectives, activities, and assessments. Grounded in

constructivist learning theory, the flow integrates Meaningful Learning, Mindful Learning, and Joyful Learning to address cognitive, metacognitive, and affective domains simultaneously (Andriyani et al., 2025). Its cyclical design encourages reinforcement and reflection by allowing students to revisit materials after quizzes, supporting deeper understanding and mastery. The framework also provides flexibility for educators while maintaining consistency, demonstrating how structured instructional design enhances learning effectiveness through interaction, reflection, and engagement.

Figure 5. Augmented Reality Barcode Scan Instructions Menu

Figure 5 presents the Augmented Reality (AR) barcode scanning instructions, which facilitate seamless access to AR content and connect physical and digital learning environments. Multiple scanning methods enhance accessibility and accommodate diverse user needs and technological capabilities. Pedagogically, AR supports experiential and meaningful learning by enabling students to interact with virtual objects in real-world contexts, making abstract concepts more concrete and understandable (Utomo et al., 2025). The instructions promote learner autonomy and digital literacy by ensuring independent access to AR features. Additionally, AR integration supports multimodal learning through visual, spatial, and interactive elements, enhancing engagement and cognitive processing while minimizing technical barriers and improving learning effectiveness.

Figure 6. AR Barcode Scan Method 1

Figure 6 explains the first AR barcode scanning method, which uses a web-based approach that does not require additional application installation. This enhances

accessibility for users with limited device storage or technical constraints (Khusnani et al., 2026). Clear step-by-step instructions help minimize errors and improve the user experience. From an educational perspective, the method promotes inclusivity by ensuring equal access to AR content regardless of device capabilities. Its simplicity encourages exploration, experimentation, and independent learning, which are essential aspects of deep learning. The web-based design also supports scalability across diverse educational settings. Overall, this approach demonstrates how flexible technology can enhance learning accessibility and effectiveness

Figure 7. AR Barcode Scan Method 2

Figure 7 presents the second AR barcode scanning method using the Assemblr Edu application, which provides a more advanced and interactive AR experience than the web-based approach. Users can manipulate 3D objects dynamically, enhancing immersion, spatial understanding, and realistic visualization of learning materials. Additional features such as object rotation support experiential and inquiry-based learning by encouraging active exploration. The use of a dedicated application also helps develop students' digital literacy and familiarity with emerging technologies. Together with the web-based option, this method reflects a balanced design that combines accessibility and advanced functionality, accommodating diverse user needs while enriching learning experiences.

Figure 8. Button Usage Instructions

Figure 8 presents the button usage instructions within the multimedia system, serving as a guide for efficient and intuitive navigation. Clearly defined functions for buttons such as the main menu, back, next, music control, and submenu navigation ensure smooth interaction throughout the learning process. These instructions reduce cognitive load by helping learners focus on content rather than technical operations, consistent with human-computer interaction principles. They also support mindful learning by increasing awareness of digital tool usage. Furthermore, structured guidance promotes independent learning and self-directed exploration. Consistent icon design reinforces familiarity and usability, contributing to a more effective, engaging, and user-friendly learning experience.

Figure 9. Quiz Instructions

Figure 9 presents the quiz instructions, which prepare students for evaluation activities through clear guidance on accessing and completing quizzes via the Wordwall platform. Step-by-step explanations help learners understand quiz procedures, including answering questions and interpreting feedback. From a pedagogical perspective, these instructions reduce test anxiety and increase confidence by clarifying the evaluation process, supporting the joyful learning principle. Immediate feedback through correct and incorrect indicators strengthens formative assessment by helping students identify mistakes and improve understanding (Chosya & Takiddin, 2025). The integration of Wordwall also introduces interactive and gamified learning elements. Overall, clear quiz instructions enhance student engagement, learning outcomes, and assessment effectiveness.

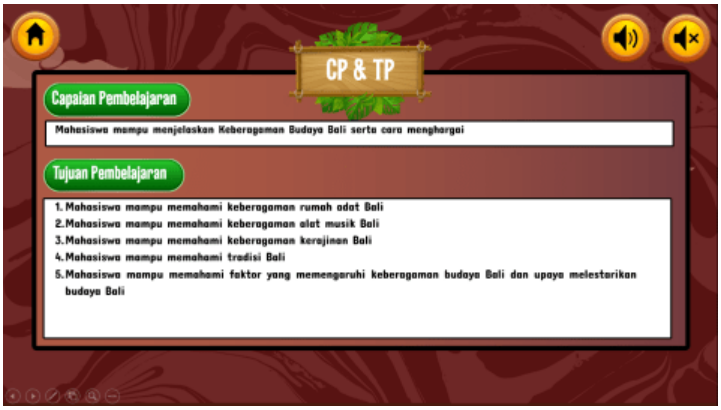


Figure 10. Learning Outcomes and Objectives Menu

Figure 10 presents the Learning Outcomes (CP) and Learning Objectives (TP) that guide the instructional process and ensure alignment between expected competencies and learning activities. Clearly defined outcomes help students understand learning goals, increasing motivation and focus. From an instructional design perspective, this supports constructive alignment by connecting objectives, activities, and assessments into a coherent framework. Specific and measurable objectives facilitate incremental learning, enabling students to monitor their progress and develop self-regulation skills, consistent with the mindful learning principle. The culturally contextualized objectives also enhance relevance by promoting understanding, awareness, and appreciation of Balinese culture, thereby supporting meaningful and effective learning experiences.

Figure 11. Meaningful Learning Menu (Teaching Materials)

Figure 11 presents the Meaningful Learning menu, which contains the core instructional materials designed to promote deep conceptual understanding through structured and contextualized content. Five thematic topics on Balinese culture provide comprehensive coverage aligned with learning objectives. Each topic follows a consistent sequence, including introductory videos, detailed explanations, and augmented reality integration, creating a multimodal learning experience that enhances comprehension and retention (Nugroho et al., 2025). Real-world cultural contexts strengthen meaningful learning by connecting new knowledge to prior experiences. The inclusion of a bibliography supports independent learning and higher-order thinking skills. Additionally, flexible material selection encourages learner autonomy and

personalized learning pathways, fostering meaningful engagement.

Figure 12. Video Presentation Display

Figure 12 presents video-based introductions that serve as entry points to each learning topic. The use of YouTube videos provides dynamic and authentic representations of content, helping students understand abstract concepts through visual and auditory information. Pedagogically, videos activate prior knowledge and prepare learners for deeper engagement with the material. They effectively illustrate real-life examples, cultural practices, and contextual situations that may be difficult to explain through text alone, supporting meaningful learning (Taqiyya et al., 2025). Video-based instruction also accommodates diverse learning styles and enhances student engagement. Positioned at the beginning of each topic, the videos provide a comprehensive overview that supports scaffolding, comprehension, and progressive learning.

Figure 13. Material with AR Barcode

Figure 13 demonstrates the integration of augmented reality (AR) into instructional materials through barcode scanning. This feature transforms static content into interactive three-dimensional experiences, enabling students to explore cultural artifacts such as traditional houses more authentically. From a cognitive perspective, AR enhances spatial visualization and experiential learning, helping learners understand complex structures that may be difficult to explain through text or images alone. Barcode

scanning simplifies access to AR content, making the technology user-friendly and reducing technical barriers (Andriyani et al., 2025). Furthermore, AR supports innovative learning environments by encouraging active participation and exploration. As a result, it creates meaningful, engaging, and effective learning experiences.

Figure 14. AR View of Aling-Aling

Figure 14 presents a 3D augmented reality visualization of an *aling-aling*, a traditional Balinese architectural element. This feature enables students to examine the structure in detail, including its form, orientation, and cultural significance, while the 360-degree rotation provides a more comprehensive understanding than static images. From an educational perspective, it supports experiential and inquiry-based learning by encouraging active exploration, curiosity, and engagement. The realistic representation strengthens cultural contextualization, helping students connect theoretical concepts with authentic cultural artifacts and enhancing cultural literacy (Alim et al., 2025). Additionally, the interactive nature of AR promotes long-term retention through visual, spatial, and kinesthetic interactions, creating immersive and meaningful learning experiences.

Figure 15. Project Task View

Figure 15 illustrates project-based assignments within the Mindful Learning component, designed to promote active participation and the practical application of

knowledge. Each project is aligned with specific learning materials, ensuring consistency between content and assessment (Chosya & Takiddin, 2025). From a pedagogical perspective, project-based learning develops higher-order thinking skills, including analysis, synthesis, and evaluation. Students create products such as drawings, posters, or reports to demonstrate their understanding, fostering deeper engagement and meaningful learning. These activities also enhance creativity, communication, and problem-solving skills. Clear project instructions support self-regulated learning and task completion. Overall, the integration of project-based activities encourages active, reflective, and meaningful learning experiences.

Figure 16. Instructions for Project Assignment

Figure 16 presents detailed instructions for a project-based assignment requiring students to create a representation of a traditional Balinese house. These instructions clarify expectations, procedures, and expected outcomes, providing structured guidance that supports effective task completion. From a pedagogical perspective, explicit instructions reduce ambiguity and promote mindful learning by helping students understand each step of the learning process (Taqiyya et al., 2025). The assignment encourages active knowledge construction by transforming conceptual understanding into tangible products, such as drawings or visual representations. Its cultural context also strengthens cultural literacy through engagement with Balinese architecture. Overall, clear instructional scaffolding supports independent learning while fostering cognitive, creative, and reflective skills.

Figure 17. Joyful Learning Display (Ice Breaking & Quiz)

Figure 17 presents the Joyful Learning menu, which integrates ice-breaking activities and quizzes to create an enjoyable and engaging learning environment. This component supports the affective dimension of learning by maintaining student motivation and reducing cognitive fatigue during extended learning sessions. Ice-breaking activities re-energize learners and prepare them for subsequent tasks, while quizzes reinforce understanding through interactive assessment. The combination of these elements reflects a holistic approach that addresses emotional, cognitive, and social aspects of learning simultaneously (Andriyani et al., 2025). Additionally, the menu offers flexibility for educators to adapt activities to classroom needs. Overall, this design enhances student engagement, motivation, and learning effectiveness.

Figure 18. Ice Breaking Sub Menu

Figure 18 presents the ice-breaking submenu, which offers various activities designed to enhance student engagement and interaction. Activities such as “Elephant, Ant, Snake, Worm” and “Connect Words” are simple yet effective in energizing learners and accommodating diverse classroom contexts. From a pedagogical perspective, ice-breaking activities improve classroom dynamics by reducing tension, increasing participation, and fostering a positive learning atmosphere, consistent with the joyful learning principle (Alim et al., 2025). They also encourage social interaction, communication, and teamwork, which are essential for collaborative learning. By integrating traditional ice-breaking techniques into digital multimedia, the system promotes engagement, motivation, and meaningful social interaction within technology-enhanced learning environments.

Figure 19. Joyful Learning (Quiz) Display

Figure 19 presents the quiz selection interface, allowing students to choose quizzes based on specific learning topics. This design supports personalized learning by aligning assessments with instructional content and enabling learners to evaluate their understanding according to their needs. From an assessment perspective, the feature promotes formative evaluation in a low-stakes environment and encourages repeated practice for knowledge reinforcement and mastery (Mahardhika et al., 2025). The integration of the Wordwall platform adds gamification elements that make assessment more engaging and enjoyable. Clear quiz categorization enhances navigation and usability, consistent with user-centered design principles. Overall, the interface strengthens both learning motivation and assessment effectiveness.

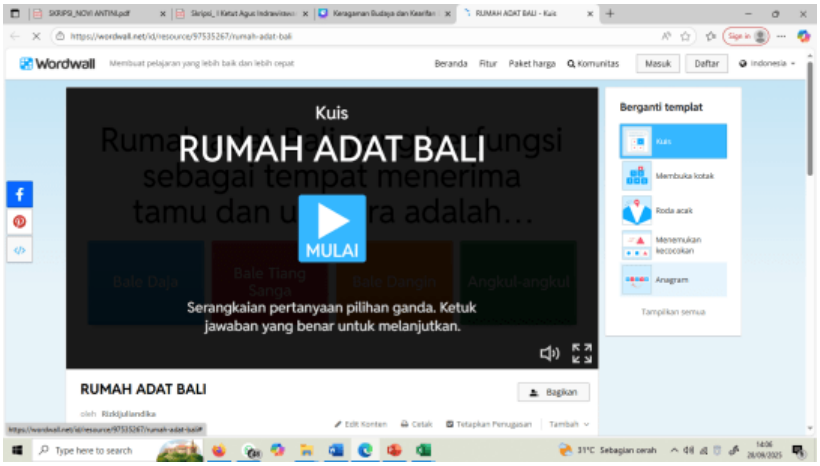


Figure 20. Initial View of the Quiz

Figure 20 presents the initial quiz screen, where students begin the assessment by clicking the "Start" button. The simple and intuitive interface enables learners to access evaluation activities quickly and efficiently. From a usability perspective, the minimalist design reduces cognitive load and helps students focus on quiz content rather than navigation. The clear call-to-action enhances user experience and provides immediate guidance. Pedagogically, this screen serves as a transition from learning to assessment, preparing students for evaluation while reducing anxiety. The consistent quiz format across topics also promotes familiarity, confidence, and efficiency. Overall, the design supports effective, comfortable, and user-friendly digital assessment experiences.

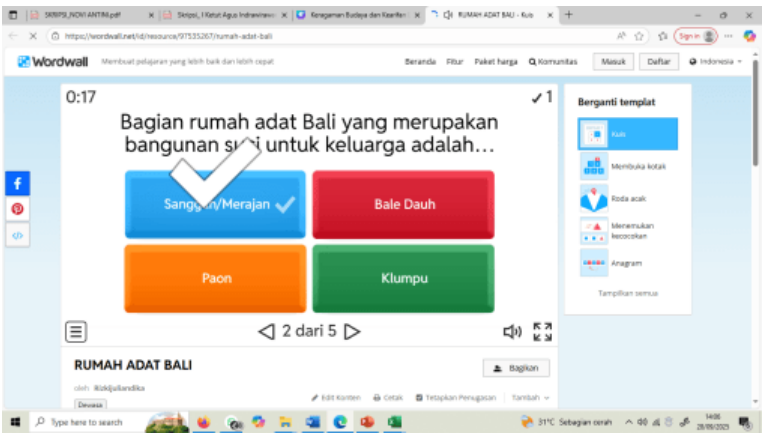


Figure 21. Answering the Quiz

Figure 21 illustrates the quiz-answering process, including an immediate feedback mechanism using checkmarks and crosses to indicate correct and incorrect responses. This feature supports formative assessment by providing students with instant information about their performance. From a learning perspective, immediate feedback reinforces correct understanding and helps learners identify and correct misconceptions, leading to deeper learning. The interactive quiz format encourages active participation, consistent with constructivist learning principles. Additionally, automatic progression to subsequent questions maintains continuity, focus, and engagement throughout the activity. Overall, this feedback-driven assessment design enhances learning effectiveness by promoting active involvement, reflection, self-correction, and continuous improvement.

Figure 22. Developer Profile View

Figure 22 presents the developer profile, providing information about the individuals involved in creating the multimedia. This feature enhances credibility and transparency by allowing users to identify the academic and professional backgrounds of the developers. From an academic perspective, it reflects research accountability and intellectual ownership, increasing trust in the quality and reliability of the multimedia content. The profile also demonstrates collaboration between lecturers and students, highlighting the integration of research, teaching, and innovation in higher education. Furthermore, it supports academic networking and recognition by enabling educators and

researchers to connect with the developers for future collaboration and knowledge-sharing opportunities.

b. Results of the Validity Test of Deep Learning-Oriented Augmented Reality Multimedia Content

The development product in the form of deep learning-oriented augmented reality multimedia that has been produced is then validated by several experts from the perspective of learning, media, and language. The content validation test from the perspective of elementary school PPKn learning was carried out on 3 experts, namely: (i) Prof. Dr. Dewa Bagus Sanjaya, M.Sc.; (ii) Dr. Ni Nyoman Kurnia Wati, M.Pd.; and (iii) Dr. Gusti Ngurah Arya Yudaparmita, M.Pd. The recapitulation of the results of the learning expert validity test is as follows:

Table 1. Content Validity of Development Products for Learning Aspects

No	Indicator	V	Validity Qualification
1	Alignment with Learning Outcomes and Learning Objectives	0,889	Very high
2	Breadth of Material	0,778	High
3	Depth of Material	0,944	Very high
4	Conceptual Accuracy	1,000	Very high
5	Accuracy of examples	0,889	Very high
6	Suitability of images/illustrations to the material	0,889	Very high
7	Contextuality	0,830	Very high
8	Activating student engagement	0,944	Very high
9	Potentially improving student cultural literacy	0,944	Very high
10	Potentially improving student digital literacy	1,000	Very high
Average		**0,919**	**Very high**

Based on these results, the development product, a deep learning-oriented augmented reality multimedia product, achieved a content validity score of 0.919 for the learning aspect, qualifying as very high. However, the validity score for the breadth of material indicator was lower than the others, with a score of 0.788 for the high category. This also aligns with expert comments, namely: (i) students need to understand the relationship between concepts and the learning environment, and (ii) the depth of the material should be considered because the media will be applied to students. These scores and comments formed the basis for revising the development product for the learning aspect.

Next, a content validation test from a media perspective was conducted with three experts: (i) Prof. Dr. Gde Wawan Sudatha, S.Pd., S.T., M.Pd.; (ii) Dr. I Ketut Suparya, M.Pd.; and (iii) Dr. Komang Trisna Mahartini, M.Pd. The summary of the media expert validity test results is as follows:

Table 2. Content Validity of Development Products for Media Aspects

No	Indicator	V	Validity Qualification
1	Layout design	0,944	Very high
2	Text/typography	0,889	Very high
3	Image	0,963	Very high
4	Audio	0,944	Very high
5	Video	1,000	Very high
6	Packaging	1,000	Very high
7	Usage	0,956	Very high
Average		**0,956**	**Very high**

Based on these results, the product development, a deep learning-oriented augmented reality multimedia product, achieved a content validity score of 0.956 for the media aspect, qualifying as very high. However, several expert recommendations were provided for product improvement, including: (i) brief descriptions should be provided at each deep learning stage before students begin working on an activity; (ii) the barcode layout should be adjusted to accommodate brief descriptions or instructions for student actions; (iii) images should not be identical if they represent the material presented to students; (iv) this medium only emphasizes the principle of experiential learning; (v) instructional flow instructions, instructions for using the Augmented Reality barcode scanner, and quizzes should be provided. These recommendations formed the basis for revising the product development in the media aspect. Below are some examples of results before and after media revisions.

Table 3. Revision of Deep Learning-oriented Augmented Reality Multimedia by Media Experts

Before Revision	After Revision
 Initially only 1 instruction for using the button was provided.	 After being revised, 4 user instructions are available, consisting of 1) learning flow instructions, 2) instructions for using the Augmented Reality barcode scan, 3) instructions for using the buttons, and 4) instructions for completing the quiz.

In the next stage, content validation testing was carried out from a language perspective against 3 experts, namely: (i) Dr. Kadek Wirahyuni, S.Pd., M.Pd.; (ii) Dr. Komang Puteri Yadnya Diari, S.S., M.Pd.; and (iii) Dr. A. A. Pt. Suari, S.S., M.Hum. The recapitulation of the results of the language expert validity test is as follows:

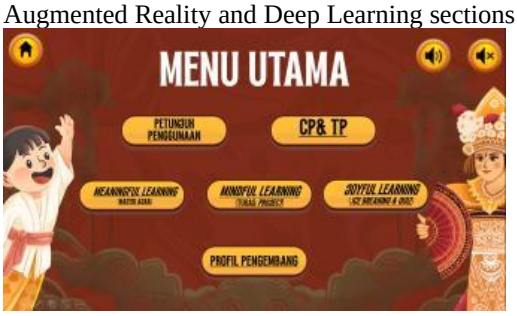
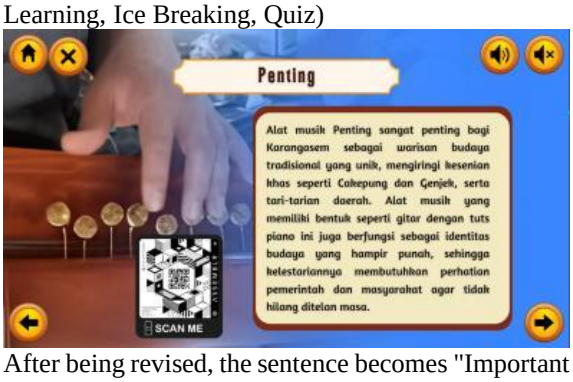
Table 4. Content Validity of Development Products for Language Aspects

No	Indicator	V	Validity Qualification
1	Straightforward	0,852	Very high
2	Communicative	1,000	Very high
3	Dialogic and Interactive	1,000	Very high
4	Appropriateness to student development	1,000	Very high
5	Appropriateness to language rules	0,889	Very high
6	Use of terms, symbols, or icons	0,778	high
	Average	**0,899**	Very high

Based on these results, it can be seen that the development product in the form of deep learning-oriented augmented reality multimedia obtained a content validity score from the language aspect of 0.899 with a very high qualification. However, the validity results on the indicator of the use of terms, symbols, or icons were lower than the others with a score of 0.778 with a high qualification. This is also in accordance with comments from experts, namely: (i) correct several foreign words that should be italicized and consistent; (ii) there are language that must be corrected and the use of prepositions;

(iii) there are still some punctuation marks that are not quite right; (iv) local Balinese terms are given the correct translation so that students outside Bali understand the terms; and (v) correct terms that are still not quite right, such as "Bale Meten" instead of "Bale Manten". These scores and comments are the basis for revising the development product in the language aspect.

Table 5. Revision of Deep Learning-oriented Augmented Reality Multimedia by Media Experts

Before Revision	After Revision
 Before revision, the foreign language is upright	 After revising the foreign language italics, namely the Augmented Reality and Deep Learning sections
 Before the revision, the foreign term still stands	 After being revised, the writing of Meaningful Learning, Mindful Learning, Joyful Learning, project, ice breaking, quiz is written in italics.
 Sebelum direvisi tulisan asing masih tegak	 After revision of italic foreign writing (Joyful Learning, Ice Breaking, Quiz)
 Previously there was a word that had a close meaning that needed to be written better to avoid double meanings, namely "Important musical instruments are very important...."	 After being revised, the sentence becomes "Important musical instruments are a unique traditional cultural heritage..."

Deep Learning-oriented Augmented Reality Multimedia is created using the Canva application. Syahrir et al. (2023) stated that Canva plays a very important role as a learning medium that involves creating designs or worksheets equipped with various animation features, templates, and page numbering to encourage innovation and creativity while reducing costs. In addition, Canva can also save teachers or students' time in designing documents that can be used as presentation materials in the form of slides, mind maps, and posters (Jamaludin & Sedek, 2023; Hasriadi, et al., 2023). On the other hand, Canva has several advantages, namely: (1) available in application and web versions; (2) very complete functions for videos, photos, PowerPoint and documents; (3) very complete tools, including templates, fonts, and others; (4) very complete features for editing and creating designs; (5) its use is very simple compared to other applications or platforms; (6) results can be downloaded in various formats such as JPG, PDF and others; (7) can automatically save design results.

Flexibility is one of the advantages of the Canva application. This is because students can collaborate with other students or team members to create designs (Pedroso, et al., 2023; Rahma, et al., 2024). On the other hand, students can share design links with other team members via Gmail, WhatsApp, and other social media. With every advantage, there are certainly disadvantages, and the Canva application is one of them. Canva's weaknesses show that not all design platforms are perfect to use. Some of the disadvantages are: (1) must be online or use an internet connection; (2) sometimes requires a stable internet connection to open the Canva application or website; (3) not all features and tools are available for free or require a paid account (Hidayati, et al., 2024).

Augmented Reality can be used through the Assemblr Edu application. Assemblr Edu is a learning platform that has the ability to free students from the limitations of text and provide new learning experiences (Hasanah, 2022; Damayanti & Putra, 2024; Triyana Hariyastuti, 2024). The features contained in this application include class features, topic features containing various learning materials, scan features, 3D and AR creation features (Agustin, 2023; Tania, et al., 2023). Suwardi et al. (2024) stated that Augmented Reality is a technology that connects the real environment and virtual objects (3D) that can be used as a tool for students to provide meaning to each lesson given. Augmented Reality (AR) technology can be used as an alternative learning media by viewing objects in real three-dimensional (3D) form, which can attract attention so that students' learning outcomes increase (Baeha et al., 2025). The advantages of this media include: 1) easy to use because it only requires a smartphone, 2) has a variety of media designs, 3) learning is carried out interactively which can build students' interest in learning, 4) the media is presented in a more attractive way because it displays 3D objects with the real world, 5) can explain material abstractly.

Based on the developed Multimedia Augmented Reality prototype, the results obtained are several icons on the main menu: Instructions for Use, CP & TP (Learning Achievements and Learning Objectives), Mearning Learning (Teaching Materials), Mindful Learning (Project Assignments), and Joyful Learning (Ice Breaking & Quizzes), as well as the Developer Profile. In Meaningful Learning (teaching materials), at the beginning of the lesson, a presentation of material is displayed linked to YouTube to provide a general and more realistic overview of the material being studied. Bahtiyar et al. (2021) stated that YouTube received a good response from students because the learning media displays content in the form of videos, thus providing real-life examples. In Mindful Learning, students are given project assignments so that learning more actively engages students in

learning. Utomo et al. (2025) stated that giving project assignments can train someone to develop several skills. The skills in question are thinking skills, communication skills through presentations, management skills, problem-solving skills in the form of investigations, self-assessment and reflection skills, and group work skills.

The Joyful Learning menu provides learning through Ice Breakers and Quizzes created through a wordwall application. This aims to make learning enjoyable. Haryati & Puspitaningrum (2023) stated that the ice breaking technique is a fun way to achieve learning objectives. By implementing ice breaking, students will automatically become more active and engaged in learning activities (psychomotor). In line with this statement, Zakiyyah et al. (2022) stated that ice breaking can certainly provide refreshment and cool the brain that continues to work during the learning process. Ice breaking is changing conditions from boring, to sleepy, and tense, finally changing to relaxed, enthusiastic, and preparing students to continue learning and motivating students to learn.

Based on the learning flow of Meaningful Learning, Mindful Learning, and Joyful Learning developed in multimedia, deep learning can be achieved effectively. Fitriani & Santiani (2025) state that Deep Learning is a learning approach that provides students with hands-on experiences. Students are not overloaded with theoretical concepts, but rather, the deep learning approach leads to the contextualization of knowledge. The theories learned by students can be applied in real life.

Based on the content validity test results, learning experts, linguists, and media experts all stated that the Deep Learning-oriented Augmented Reality multimedia had very high validity. This indicates that the developed multimedia is suitable for use and implementation with students. However, during the expert validity test process, several inputs were received to further refine the developed multimedia.

Input from media experts, namely the user guide icon, which initially only contained instructions for using buttons, after being given input, became 4 instructions, namely instructions for learning flow, instructions for scanning augmented reality barcodes, instructions for using buttons and instructions for completing quizzes. Faradila (2024) stated that providing instructions for learning stages is important because it functions as a guideline so that the learning process is structured, efficient, and directed for students, improves the quality of teaching, saves time and resources, and facilitates the evaluation of the success of achieving learning objectives. Clear instructions help students understand what is expected, motivate them, and support the systematic development of skills towards the final learning goal.

In addition to media improvements, there was also input from learning experts, namely that the material needed to be deepened because it was intended for students. To follow the course based on the provisions of the principle of adequacy, there are several points that must be met, namely: suitability for students, adequacy of variation, and the burden of learning material. This principle is important to fulfill, because the material to be taught should be sufficient to help students master the basic competencies being taught. If this principle is not met, it will create a turbulence that can affect the stability of learning activities, so that it can cause discomfort for students in learning, this occurs because students are not yet able to absorb the material to be given (Almuhaimin, et al. 2023).

In addition to media and learning experts, linguists also suggested that foreign language writing should be italicized. This is because some multimedia texts in foreign languages are not italicized. This is important in accordance with the General Guidelines for Indonesian Spelling (PUEBI). Agan &

Puspitoningrum (2021) state that foreign language words in Indonesian texts can be categorized as unfamiliar words. This applies to foreign language words that are not widely known by Indonesian speakers. Therefore, these foreign language words should be written differently from Indonesian vocabulary. These writing methods include underlining or quotation marks when using a typewriter, and italics whenever possible, for example, when using a computer or printed.

4. Conclusion

Based on the research results, it can be concluded that deep learning-oriented Augmented Multimedia is developed with several icons on the main menu that can later be accessed, namely the user guide menu, the Learning Outcomes And Learning Objectives menu, the Meaningful Learning menu (teaching materials), the Mindful Learning menu (project assignments), the Joyful Learning menu (ice breaking and quizzes), and the developer profile menu. Learning in the form of augmented reality can be seen in the Meaningful Learning menu (teaching materials). There is a barcode scan that can be used by students then show the material in real form by scanning on a cellphone then a 3D image of the material will appear on the cellphone screen. The results of the content validity test of deep learning-oriented augmented reality multimedia products by learning experts showed an average of 0.919 with a very high category. While the results of the content validity test by media experts showed an average of 0.956 with a very high category. The results of the content validity test by language experts showed an average of 0.899 with a very high category. So it can be concluded that deep learning-oriented Augmented Multimedia is suitable for use by elementary school students.

Teachers are encouraged to develop enjoyable learning experiences using multimedia that can make learning more concrete and thereby facilitate students' understanding. In addition, future researchers are recommended to conduct similar studies by incorporating different variables. The limitation of this study is that it was restricted to testing the validity of the developed product. Future research is expected to extend this work by examining the practicality and effectiveness of the Deep Learning–oriented Augmented Reality multimedia product.

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