



Development of Augmented Reality-Based Learning Media Using Assemblr EDU for Introducing Indonesian Traditional Musical Instruments in Junior High School Music Education

Yanti Nur Aprianti*, Uus Karwati, Sandie Gunara

Art Education Study Program, Graduate School, Universitas Pendidikan Indonesia.

*Corresponding Author. Email: yantinurapr@upi.edu

Abstract: This study aims to develop and validate an Augmented Reality (AR)-based learning medium using Assemblr EDU for introducing Indonesian traditional musical instruments in Grade VIII music education. This study employed a Research and Development (R&D) method based on the 4D model, which consists of four stages: Define, Design, Develop, and Disseminate. The research was conducted at SMP Negeri 6 Banjar, West Java, involving 20 eighth-grade students. Data were collected through interviews, expert validation instruments, questionnaires, and post-tests, and analyzed using descriptive percentage analysis techniques. The developed product integrates 3D visualization, annotations, audio narration, and AR features that can be accessed through mobile devices. The validation results showed that the learning media achieved a score of 98.75% from media experts and 100% from subject matter experts, indicating a highly valid category. The implementation results demonstrated that the media was feasible for classroom use and facilitated interactive learning about traditional musical instruments from various regions of Indonesia. These findings indicate that AR technology has the potential to transform traditional music learning by enabling students to interact directly with virtual representations of musical instruments. Consequently, AR-based learning media can provide a more immersive, accessible, and meaningful learning experience while supporting efforts to preserve Indonesia's traditional musical heritage.

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Introduction

Indonesia possesses a rich cultural heritage reflected in the diversity of its traditional musical instruments. These instruments function not only as musical media but also as symbols of cultural identity and vehicles for transmitting cultural knowledge across generations (Junussova et al., 2024; Wikarsa et al., 2015). Each region has developed distinctive instruments with unique forms, functions, and playing techniques that represent local cultural values (Megantara & Utami, 2023). However, globalization and the dominance of modern musical practices have reduced young people's interest in traditional musical instruments, threatening the sustainability of Indonesia's musical heritage (Junussova et al., 2024). This condition highlights the need for effective educational strategies to support cultural preservation among younger generations.

Formal education plays a strategic role in preserving traditional music. Music education supports students' cultural and intellectual development, while the integration of traditional music into the curriculum contributes to cultural preservation efforts (Supriatna et al., 2025). In Indonesia, the diversity of traditional musical instruments is taught at the junior



high school level. However, limited access to traditional instruments, learning resources, and instructional media often hinders effective learning experiences (Escalante, 2025). As a result, instruction frequently depends on textbooks and static visual materials, which may reduce student engagement and understanding. Therefore, the use of effective learning media is essential to enhance conceptual understanding, motivation, and meaningful learning interactions (Muhlis et al., 2023; Damayanti & Putra, 2024).

The advancement of digital technology has transformed educational practices and created opportunities for more interactive learning environments. Among emerging technologies, Augmented Reality (AR) has attracted considerable attention in education due to its ability to integrate virtual objects into real-world settings and enable real-time interaction with digital content (Ardiansyah et al., 2024). By combining virtual and physical environments, AR can enhance visualization, foster curiosity and motivation, and facilitate the understanding of complex concepts (Apaydın & Şentürk, 2024; Dee Jean, 2020; Jamil et al., 2023; Vashisht & Sharma, 2024). Consequently, AR has been increasingly applied across various educational fields, including science, mathematics, language learning, history, and geography.

Recent research has increasingly explored the application of Augmented Reality (AR) in music education. AR enables the integration of virtual objects with real-world environments, creating interactive and multimodal learning experiences (Nijs & Behzadaval, 2024). Studies have shown that AR can improve student engagement, motivation, creativity, and learning outcomes (Mazzuco et al., 2022; Oktaviani et al., 2023). In music education, AR has been applied to traditional instrument learning, music history instruction, and early childhood music education (Guclu et al., 2021; Permana et al., 2024). These findings indicate the significant potential of AR to support cultural heritage learning and enhance music education practices.

Despite the growing body of literature, several gaps remain evident. First, most AR studies in music education have focused on specific instruments, particular regions, or limited cultural contexts. Research that comprehensively introduces the diversity of Indonesian traditional musical instruments through AR remains scarce. Second, many existing AR applications have been developed using sophisticated software platforms such as Unity and 3DS Max (Nugraha et al., 2014), which often require advanced technical expertise and may limit their adoption by teachers. Third, previous studies have primarily emphasized technical development aspects, while relatively little attention has been given to the use of accessible AR platforms that can be independently utilized by educators in classroom settings. Poor interface design and limited content availability further exacerbate the problem, as teachers struggle to find AR applications that align with their teaching needs (Nijhawan et al., 2025; Joshi & Shukla, 2026).

To address these limitations, an accessible AR platform is needed to support the introduction of traditional musical instruments in educational settings. Assemblr EDU offers a practical solution for developing Augmented Reality (AR)-based learning media. As a web-based 3D AR platform, it enables users to create interactive educational content without advanced programming skills, while integrating 3D objects, animations, and other interactive elements into learning materials (Hamidah et al., 2016; Joseph et al., 2025). Its accessibility and ease of use make it suitable for classroom implementation and support the integration of technology-enhanced learning within the Indonesian curriculum.

To address this gap, this study aims to develop and validate an accessible AR-based learning media using Assemblr EDU that comprehensively introduces the diversity of



Indonesian traditional musical instruments in junior high school settings. The novelty of this study lies in the use of Assemblr EDU as an easily accessible web-based AR platform for developing interactive learning materials that showcase traditional musical instruments from various regions in Indonesia. Unlike previous studies that focused on musical instruments from specific regions or required advanced AR development tools, this study presents a practical approach that enables teachers to independently create and implement AR-based cultural heritage lessons without the need for advanced programming skills.

Research Method

This study employs a Research and Development (R&D) method using the 4D model, which consists of the Define, Design, Develop, and Disseminate stages (Waruwu, 2024). The Define stage includes needs analysis, curriculum analysis, and identification of student characteristics. The Design stage focuses on the design of AR-based learning media and the development of instructional materials. The Develop stage includes media production using Assemblr EDU, expert validation, and revisions. The Disseminate stage involves limited implementation with students. This study was conducted at SMP Negeri 6 Banjar, West Java. The participants were 20 eighth-grade students from class VIII-A selected through purposive sampling as the trial group. The validation process involved one media expert and one music education expert to evaluate the quality and suitability of the developed product.

The implementation of this developed media used a One-Shot Case Study design, in which students participated in the learning process using AR-based media and then took a final test to evaluate their learning outcomes. This design was chosen because the primary objective of this study was to assess the feasibility and initial implementation of the developed product, rather than to compare improvements in learning outcomes between pre-test and post-test conditions. Data were collected through interviews, expert validation sheets, questionnaires, and post-learning tests. The post-learning tests were implemented after the students used the AR-based learning media that had been developed as part of the One-Shot Case Study design to evaluate their understanding of traditional Indonesian musical instruments.

The research instruments consisted of an interview guide, an expert validation sheet, a student response questionnaire, and post-instruction test items. The expert validation sheet and student response questionnaire used four points Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The media validation tool assessed four aspects: display, integration, balance, and benefits, while the content validation tool evaluated material quality, integration, and usefulness of the material. Quantitative data obtained from the validation sheets and questionnaires were analyzed using descriptive percentage techniques to determine the validity and practicality of the developed media. Meanwhile, qualitative data from interviews and expert suggestions were analyzed through data reduction, data presentation, and drawing conclusions.

The student feedback questionnaire measured students' perceptions of the appeal, ease of use, usefulness, and overall learning experience of the AR-based learning media that had been developed. The scores from validators were analyzed using a percentage Formula 1, and the results were categorized based on validation criteria proposed by Riduwan (2013) and Riduwan (2018) for practicality criteria as in Table 1.

$$\text{Percentage} = \frac{\text{Maximum Score}}{\text{Obtained Score}} \times 100\%$$

**Table 1. Criteria for Data Interpretation**

Percentage (%)	Validity	Practicality
80.00 – 100	Very Valid	Very Pratical
60.00 – 79.99	Valid	Practical
50.00 – 59.99	Quite Valid	Quite Practical
0.00 – 49.99	Invalid	Impractical

Results and Discussion

Define Stage

a) Results of the Front-end Analysis

A front-end analysis identified several challenges in teaching traditional Indonesian musical instruments in 8th-grade Music classes. Although the Merdeka Curriculum requires students to recognize and appreciate the diversity of regional musical instruments, interviews revealed that instruction relies heavily on textbooks because PowerPoint presentations and educational videos are rarely used due to limited school facilities. As a result, students have limited opportunities to explore traditional musical instruments through interactive learning experiences. These findings align with Escalante (2025), who reported that inadequate teaching resources hinder the learning of traditional music. Therefore, AR-based learning media were developed to provide a more interactive and authentic learning experience through three-dimensional visualization.

b) Results of Learner Analysis

Learner analysis showed that many students had difficulty recognizing traditional musical instruments from regions outside their own, resulting in low levels of engagement when learning relied solely on textbooks and static images. However, all students own mobile devices and are already accustomed to digital technology, indicating a high level of readiness to use mobile-based learning media. These findings support previous research showing that students of the digital generation respond positively to interactive, visual learning environments (Apaydınlı & Şentürk, 2024), making AR an appropriate approach for this context.

c) Results of Task Analysis

The task analysis identifies the competencies students are expected to achieve, including recognizing, classifying, describing, and appreciating traditional Indonesian musical instruments based on their origins, characteristics, sound sources, and playing techniques. These competencies form the basis for developing learning content and interactive features integrated into AR media. Assemblr EDU was chosen because this platform allows teachers to develop AR learning materials without requiring advanced programming skills, thus offering a more accessible alternative compared to platforms such as Unity and 3DS Max (Nugraha et al., 2014).

d) Results of Concept Analysis

This concept analysis categorizes the learning material into five main topics: the names of musical instruments, their regions of origin, characteristics, classification, and playing techniques. These concepts serve as the foundation for designing AR learning media, in which each topic is supported by three-dimensional visualizations, annotations, and audio to facilitate contextual understanding.

e) Results Specifying Instructional Objectives

Based on a curriculum analysis, the learning objective is for students to be able to recognize and appreciate the diversity of traditional Indonesian musical instruments.



Therefore, this AR tool was developed to help students identify musical instruments, understand their characteristics and playing techniques, and actively explore the learning material through interactive three-dimensional representations.

Design Stage

The design stage implements the findings from the define stage into the initial design of AR-based instructional media. This stage includes the development of assessment instruments, the selection of media, the selection of formats, and the initial design of the media.

a) Results of Constructing Criterion-Referenced Test

Assessment instruments were developed in accordance with the learning objectives identified in the define stage. These assessments measure students' cognitive, affective, and psychomotor achievements related to traditional Indonesian musical instruments. The alignment between learning objectives, achievement indicators, domains of learning, and assessment formats is presented in Table 2.

Table 2. Learning Objectives, Achievement Indicators, Domains, and Assessment Formats

Learning Objectives	Achievement Indicators	Domain	Test Format
Students are able to recognize various traditional musical instruments in Indonesia.	1.1 Name traditional musical instruments from various regions in Indonesia	Cognitive	Multiple choice, short answer
	1.2 Identify the region of origin of musical instruments		
	1.3 Classify musical instruments based on their sound source		
Students are able to appreciate the diversity of cultures and regional music in Indonesia.	2.1 Showing interest in learning traditional musical instruments through AR	Affective	Reflection journal, open-ended questions
	2.2 Expressing opinions about the importance of preserving traditional musical instruments		
	2.3 Showing awareness of the importance of preserving traditional musical heritage.		
Students are able to recognize and interact with traditional musical instruments through digital media.	3.1 Using the Assemblr EDU application to explore musical instruments	Psychomotor	Practical tests through demonstrations, observation of performance when using the application
	3.2 Displaying a simple simulation of how to play musical instruments based on AR visualization		

b) Results of Media Selection

Based on an analysis of learning needs, Assemblr EDU was selected to develop AR-based learning materials. This platform supports the integration of 3D objects, text, audio, and interactive features, while remaining accessible via web browsers and mobile devices. These features allow students to explore traditional musical instruments in a more interactive way than conventional learning materials. Compared to platforms such as Unity and 3DS Max, Assemblr EDU is more accessible because it allows teachers to develop AR learning content without requiring advanced programming skills (Nugraha et al., 2014).



c) Results Format Selection

This learning media is designed as an interactive 3D/AR project that includes learning objectives, instructional materials, 3D models of traditional Indonesian musical instruments, descriptions of their origins and characteristics, and assessment activities. The Assemblr EDU 3D Library facilitates the development of visually rich learning content by integrating 3D objects, text, audio, and AR features into a single learning environment, thereby supporting student understanding through interactive exploration.

d) Initial Design Results

An initial prototype of AR-based educational media was developed using Assemblr EDU by integrating 3D models of traditional Indonesian musical instruments with educational features. This media showcases musical instruments from various regions in Indonesia, allowing students to explore the country's cultural diversity through interactive visualizations. This prototype combines 3D objects selected from the Assemblr EDU library, arranged within the editor environment, and supplemented with annotations explaining the name, region of origin, characteristics, and playing techniques for each musical instrument (Figure 1–4).

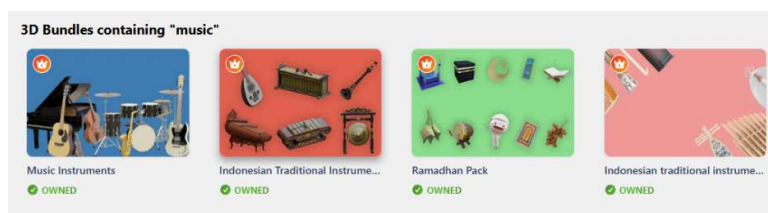


Figure 1. 3D Bundles View in Assemblr EDU

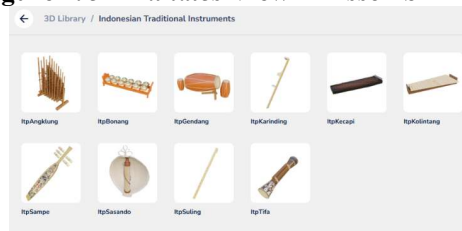


Figure 2. Various Types of Traditional Indonesian Musical Instruments at Assemblr EDU

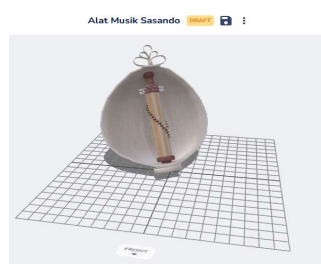


Figure 3. Editor Display

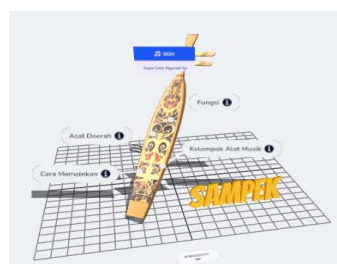


Figure 4. 3D Object Display with Annotations

The resulting prototype integrates 3D visualizations, written explanations, audio, and AR interactions into a single learning environment. This prototype was then evaluated through validation by experts before being implemented in classroom instruction.

Develop Stage

The AR-based learning media developed in this study are presented as 3D/AR projects accessible via QR codes. During the development phase, the prototypes and research instruments (final tests and student feedback questionnaires) were evaluated by media experts



and subject-matter experts. Their feedback was used to revise and refine the products before they were implemented in the classroom. The results of the validation by media experts are presented in Table 3.

Table 3. Summary of Media Expert Validation

No	Aspect	Validity Percentage	Criteria
1	Display	100%	Very Valid
2	Integration	95%	Very Valid
3	Balance	100%	Very Valid
4	Benefit	100%	Very Valid
Overall percentage		98,75%	Very Valid

The media received a very valid rating, indicating that it meets the essential principles of instructional media design. This result can be attributed to the systematic needs analysis conducted during the Define phase, as well as the integration of 3D visualization, annotations, audio, and QR code-based access within Assemblr EDU. These features create an interactive and accessible learning environment that supports both teachers and students. The slightly lower score on the integration aspect indicates a small opportunity to improve synchronization among the multimedia components. Similar findings were reported by Mazzuco et al. (2022), who highlighted the effectiveness of immersive AR visualizations in enhancing learning engagement, as well as by Joseph et al. (2025), who emphasized the practicality of Assemblr EDU for educational purposes. The results of the content expert validation are presented in Table 4.

Table 4. Summary of Content Expert Validation

No	Aspect	Validity Percentage	Criteria
1	Material Quality	100%	Very Valid
2	Integration	100%	Very Valid
3	Usefulness of Materials	100%	Very Valid
Overall percentage		100%	Very Valid

Content validation also achieved the very valid category, indicating that the learning materials align with the 8th-grade music curriculum and accurately depict traditional Indonesian musical instruments. These results reflect the systematic organization of the learning content based on the musical instrument's name, region of origin, characteristics, classification, and playing techniques. The combination of textual explanations, 3D objects, and audio further supports contextual learning by connecting students to Indonesia's cultural heritage. These findings align with the research by Oktaviani et al. (2023), which reported that AR-based media enhances students' understanding of cultural arts, as well as with Nijs and Behzadaval (2024), who emphasized the role of AR in creating meaningful multimodal learning experiences.

After undergoing a validation and revision process, the media was refined for implementation. As shown in Figure 5, this learning media integrates 3D models of traditional Indonesian musical instruments with annotations, audio, and AR features that can be accessed via a QR code using students' mobile devices.



Figure 5. Overview of the AR Based Learning Media

Disseminate Stage

This enhanced AR-based learning resource was implemented with 20 eighth-grade students at SMP Negeri 6 Banjar. During the implementation, the students accessed the learning resource by scanning a QR code and exploring three-dimensional representations of traditional Indonesian musical instruments on their mobile devices. The results showed that the students were able to explore the learning material independently and interact effectively with the AR features provided.



Figure 6. Students Using the AR Based Learning Media Figure

The practicality of the developed media was evaluated using a student response questionnaire. The results are presented in Table 5.

Table 5. Student Response Questionnaire Results

No	Aspect	Percentage	Category
1	Ease of use	95%	Very Practical
2	Attractiveness	98%	Very Practical
3	Learning Motivation	96%	Very Practical
4	Content Clarity	94%	Very Practical
5	Usefulness	97%	Very Practical
	Overall Score	96%	Very Practical

This AR-based learning media falls into the very practical category, indicating that it is easy to use, visually appealing, and beneficial to the learning process. The highest score was obtained in the appeal aspect, suggesting that the integration of 3D visualization, annotations, audio, and interactive AR features successfully increased student interest and engagement. The web-based nature of Assemblr EDU also allows students to easily access the learning media through their own devices, thereby reducing technical barriers during classroom implementation. These findings are consistent with the research by Mazzuco et al. (2022) and Oktaviani et al. (2023), which reported that AR-based learning environments increase student motivation and participation through immersive and interactive learning experiences. The effectiveness of the developed media was assessed through a post-test administered after the learning activities. The results are presented in Table 6.

**Table 6. Post-Test Results**

Indicator	Result
Number of students	20
Highest score	100
Lowest score	75
Average score	88.5
Student achieving mastery	18
Mastery percentage	90%

The final test results show that the learning materials developed effectively support students' understanding of traditional Indonesian musical instruments. This high level of learning achievement may be attributed to the use of interactive 3D visualizations, which allow students to observe the characteristics of musical instruments more concretely than in conventional textbook-based learning. This finding aligns with Apaydınlı and Şentürk (2024), who concluded that AR technology enhances conceptual understanding by providing meaningful visual and interactive learning experiences. To facilitate wider dissemination, the refined learning materials are packaged in the form of QR codes that allow direct access to AR content via mobile devices without requiring additional hardware or complicated installation procedures.

**Figure 7. QR Code for Accessing the AR Based Learning Media**

The use of QR code-based access demonstrates the practical potential of inclusive AR platforms, such as Assemblr EDU, for implementation in the classroom. In addition to improving access to learning, this medium allows students to learn about traditional Indonesian musical instruments through interactive exploration, thereby supporting the teaching of cultural heritage in a way that is engaging, contextual, and relevant to today's digital learners.

Conclusion

The validation results showed that the developed media achieved a validity score of 98.75% from media experts and 100% from subject matter experts, indicating that it is highly valid and feasible for implementation in learning activities. The developed media integrates 3D visualization, annotations, audio, and AR technology to provide an interactive learning experience that supports students' understanding of traditional musical instruments from various regions of Indonesia. Unlike previous studies that focused on specific regional instruments or relied on complex development platforms, this study demonstrates the feasibility of using Assemblr EDU as an accessible AR platform for cultural heritage learning in music education. Therefore, the developed media has the potential to enrich music learning and support the preservation of Indonesian traditional musical heritage through technology-enhanced education.



Recommendation

Teachers are encouraged to integrate easily accessible AR platforms, such as Assemblr EDU, into music instruction to provide a more interactive experience and help students better understand traditional Indonesian musical instruments. Curriculum policymakers may also consider supporting the integration of AR-based learning media into arts education by providing training for teachers and adequate digital infrastructure. Future research should examine the effectiveness of these media through broader implementation and experimental designs, as well as expand their content by incorporating more traditional musical instruments and interactive learning features.

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