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Development of 3D Augmented Reality Assemblr Edu Media with A Project Based Learning Model Based on Local Wisdom of Cirebon Region to Improve Students' Science Literacy

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ABSTRACT

Scientific literacy is an essential skill that enables students to independently seek, comprehend, and apply scientific knowledge to enhance learning quality according to their needs. This competency encompasses mastery of scientific concepts (content knowledge), procedural skills, and epistemic understanding, which influence effective learning strategies and evidence-based problem-solving abilities. Scientific literacy also includes the ability to construct knowledge, explain natural phenomena, and draw scientific conclusions through critical reasoning. Its early implementation in education, particularly at the elementary level, is crucial for building a strong foundation in scientific understanding. The development of scientific literacy can be facilitated through innovative learning media, ensuring students not only grasp theoretical concepts but also apply them in real-life contexts. Thus, improving scientific literacy significantly contributes to students' academic success and life skills.

This study employs a Research and Development (R&D) approach using the 4D model (Define, Design, Develop, Disseminate). The developed learning media integrates Cirebon's local wisdom and a Project-Based Learning (PjBL) model through traditional Cirebon games (e.g., klitikan) and musical instruments, aligning with the sound-related topics in the Merdeka Curriculum for fifth-grade students. The research was conducted at SDN 2 Pejambon, Cirebon Regency, involving small-scale and large-scale testing groups.

The resulting product is a 3D Augmented Reality (AR) Assembler Edu media with a local wisdom-based PjBL model designed to enhance students' scientific literacy. Key characteristics include: integration of Cirebon's Ethno-STEM elements with PjBL learning steps, sound-related topics from the Merdeka Curriculum linked to local wisdom, such as sound production techniques and acoustic properties from the klitikan traditional game, engaging and realistic 3D animations in a digital format, a step-by-step guide on crafting traditional Cirebon games, educational videos on sound properties to train and apply scientific literacy.

The feasibility assessment of the 3D AR Assembler Edu media with local wisdom-based PjBL yielded an Aiken's V score of 0.942 (very feasible), with sub-scores as follows: material validation has 0.945 scores; language validation has 0.938 scores; media validation has 0.942; practicality test (students) has 87.33%

scores; practicality test (teachers) has 87.50% scores.
The media's effectiveness in improving fifth graders' scientific literacy was confirmed through paired t-test, showing significant differences between pretest and posttest results. N-Gain score of 0.532 with qualified oderate/effective) and get positive student (87.5%) and teacher (88.39%) feedback.
The study recommends that teachers adopt this 3D AR Assembler Edu media with local wisdom-based PjBL to foster scientific literacy, ensuring alignment with the Merdeka Curriculum's learning objectives.

Keywords: 3D Augmented Reality, Assembler Edu, Project-Based Learning, Ethno-STEM, Scientific Literacy.

INTRODUCTION

The rapid advancement of technology and global civilization must be accompanied by significant progress in the education system. Education serves as a primary means for individuals to acquire knowledge and skills through school institutions, which are governed by government-mandated curricula (Angeli & Giannakos, 2020; Guo et al., 2020). Improving the quality of education is closely tied to classroom learning processes, where various instructional activities help students comprehend subject matter and develop essential skills. One critical competency that must be cultivated in learning is scientific literacy.

Scientific literacy enables students to independently seek learning resources and information, enhancing their learning quality in accordance with their academic needs (Dinsmore & Zoellner, 2018; Widyaningrum, 2018). Students with strong scientific literacy skills are better equipped to select effective learning strategies (Bendegard & Hallesson, 2022; Zheng et al., 2019). This competency emphasizes the ability to design, monitor, and evaluate problem-solving processes. Individuals succeed in their learning when they can effectively manage their cognitive abilities, including scientific literacy (Jia et al., 2019; Meher et al., 2020). Strong scientific literacy positively impacts students' academic success.

Scientific literacy is a fundamental concept that should be applied in daily life. Therefore, this competency must be instilled early in elementary education. It helps students construct, explain, and design knowledge based on scientific evidence (Agussuryani et al., 2022; Pertiwi et al., 2017). According to the OECD (2013), scientific literacy involves generating new questions, acquiring new knowledge, and explaining phenomena through scientific evidence. Students' ability to understand, communicate, and apply science in solving real-world problems is heavily influenced by their scientific literacy (Syofyan & Amir, 2019; Hasasiyah et al., 2019).

Scientific literacy also entails applying scientific principles, describing phenomena, and drawing conclusions from existing problems (Kimianti & Prasetyo, 2019b; Lestari & Siskandar, 2020). It enables students to comprehend natural phenomena and their direct impact on human life (Afni et al., 2018; Wibowo & Ariyatun, 2020). Students with strong scientific literacy not only master conceptual knowledge but also make informed judgments and scientific conclusions (Andriani et al., 2018; Fuadi et al., 2020). Through school-based scientific literacy, students are expected to develop awareness and concern for natural phenomena (Agustina et al., 2020; Nofiana & Julianto, 2018). Thus, teachers must continuously foster students' scientific literacy through appropriate learning media, models, and strategies.

However, empirical evidence indicates that scientific literacy among Indonesian elementary students remains low (Aiman et al., 2019; Lestari & Siskandar, 2020). Contributing factors include inadequate learning resources and ineffective instructional models. Previous studies highlight that reliance on textbook-based learning with rigid instructions leads to monotonous, teacher-centered approaches,

diminishing student engagement (Kimianti & Prasetyo, 2019b; Andriani et al., 2018; Fuadi et al., 2020; Wibowo & Ariyatun, 2020). Science lessons become unappealing when confined to textbooks, resulting in disinterest and poor conceptual understanding (Fuadi et al., 2020; Wibowo & Ariyatun, 2020).

An observational study at SD Negeri 2 Pejambon, Cirebon Regency, revealed limited instructional variety and low student participation in science classes. Many students struggled to grasp complex concepts, such as sound propagation, due to the absence of interactive media. Only 20% scored above 60 on analytical questions, indicating predominance of low-order thinking skills. The school's minimum mastery criterion (KKM) for science is 73, yet only 37.04% (10 students) met this threshold in final assessments, while 62.96% (17 students) failed. This underscores the urgent need for innovative learning media.

Furthermore, scientific literacy development is often restricted to textbook reading, leaving students unmotivated and conceptually confused. The lack of varied instructional strategies further reduces student engagement. Project-based learning (PjBL) incorporating local wisdom remains underutilized in science education, despite its potential to enhance experiential learning. These factors contribute to weak scientific literacy at SD Negeri 2 Pejambon. Strengthening this competency is crucial to fostering active, creative, and knowledgeable students.

One empirically validated solution is Augmented Reality (AR) media, which enhances technological proficiency and makes learning engaging (Lai et al., 2019; Mustaqim & Kurniawan, 2017). Three-dimensional (3D) learning engages multiple senses, supports collaboration, and offers omnidirectional viewing (Mukti, 2018). AR integrates virtual objects into real-world environments in real-time, enriching scientific literacy (Borman et al., 2017; Furht, 2011). However, AR development traditionally requires programming expertise and tools like Unity 3D and Blender. Assemblr Edu, a user-friendly 3D creation platform, addresses this barrier.

Effective media must be paired with appropriate instructional models. Project-Based Learning (PjBL) combined with local wisdom themes is ideal for boosting scientific literacy. Local values in teaching materials instill positive character traits early (Fitriyani et al., 2018) and align with Indonesia's Merdeka Curriculum, emphasizing character education (Fitriani et al., 2018; Widiya et al., 2021). Integrating regional culture, such as Cirebon's traditions, enhances contextual learning (Ismaya & Santoso, 2019). PjBL fosters 21st-century skills (4Cs: critical thinking, creativity, collaboration, communication) through complex, student-driven projects (Renandika & Mahmudi, 2020; Trimawati et al., 2020). It also promotes problem-solving and meaningful learning outcomes (Yulaikah et al., 2022).

Given these challenges and solutions, this study aims to develop Augmented Reality media using Assemblr Edu, integrated with local wisdom-based PjBL, to enhance elementary students' scientific literacy in Cirebon Regency. The research will assess the validity, practicality, and effectiveness of this innovative approach.

LITERATURE REVIEW

Project-Based Learning (PjBL) and Scientific Literacy

Project-Based Learning (PjBL) is an instructional model that engages students in constructing knowledge through real-world projects. This study adapts PjBL by integrating Augmented Reality (AR) technology with Cirebon's local cultural elements, where students create klitikan (a traditional Cirebon toy) as a final project in learning about sound waves (Grade IV). This approach is novel, as prior research has not explored AR-assisted PjBL with culturally contextualized projects in elementary science education.

Empirical studies strongly support PjBL's effectiveness in enhancing scientific literacy. Afriana et al. (2016) demonstrated that PjBL integrated with STEM significantly improved students' scientific literacy, with moderate gains (N-Gain: 0.36–0.31) in knowledge and competencies. Gender differences were insignificant in cognitive aspects, though female students showed higher scientific attitudes. Similarly, Anggreni & Diputra (2020) found that PjBL with portfolio assessment significantly boosted scientific literacy among high school students (*p* = 0.022 <0.05). Ramdani (2023) further confirmed that PjBL outperformed conventional methods, with experimental groups scoring higher (mean = 41.52 vs. 29.62 in controls).

PjBL's Impact on Active Learning and Scientific Skills

PjBL fosters active, collaborative, and inquiry-based learning. Anafi & Agustina (2018) noted that PjBL enhances academic performance by engaging students in project design and problem-solving. Lukman et al. (2015) emphasized that PjBL's problem-driven structure improves learning outcomes by encouraging creativity, collaboration, and hands-on experimentation. Faridah et al. (2022) and Nuraini & Waluyo (2021) corroborated these findings, showing that PjBL classes achieved higher post-test scores than traditional instruction, underscoring its efficacy in promoting scientific explanation, investigation design, and data interpretation—key indicators of scientific literacy (Setiawan et al., 2020).

Augmented Reality (AR) and Cultural Integration in PjBL

This study innovates by combining AR technology (developed via Assemblr Edu) with PjBL, addressing prior limitations in interactive media for science education. AR's immersive 3D visuals enhance engagement (Lai et al., 2019; Mustaqim & Kurniawan, 2017), while local cultural projects (e.g., klitikan toys) contextualize learning, aligning with Indonesia's Merdeka Curriculum (Fitriani et al., 2019). Wijanarko et al. (2017) highlighted that PjBL's scientific inquiry phases—problem identification, hypothesis formulation, and product creation—strengthen literacy by connecting theory to real-world applications.

This study highlights the potential of integrating Augmented Reality (AR) technology with Project-Based Learning (PjBL) to enhance scientific literacy among elementary students, specifically at SD Negeri 2 Pejambon, Cirebon. By incorporating local cultural elements—such as the creation of klitikan (a traditional Cirebon toy) as a final project—the research introduces an innovative approach that bridges modern technology with contextual learning.

The literature review underscores that PjBL significantly improves scientific literacy by fostering active, inquiry-based, and collaborative learning. Empirical evidence demonstrates that students engaged in PjBL exhibit stronger abilities in explaining scientific phenomena, designing investigations, and interpreting data—key components of scientific literacy. Furthermore, the integration of AR technology enhances engagement, facilitates visualization of abstract concepts (e.g., sound waves), and supports interactive learning experiences.

The uniqueness of this study lies in its combination of AR-assisted PjBL with cultural relevance, a novel contribution to science education research. By grounding the learning process in local wisdom, the approach not only strengthens scientific understanding but also preserves cultural identity. The findings from prior studies suggest that this model can increase student motivation, creativity, and academic performance, addressing the current challenges of low scientific literacy in Indonesian elementary schools.

Moving forward, this research provides a foundation for future studies exploring technology-enhanced, culturally responsive pedagogies in STEM education. The results

are expected to offer practical insights for educators seeking innovative methods to improve scientific literacy while fostering students' connection to their cultural heritage.

MATERIALS & METHODS

The development procedure involves creating an interactive media tool called Assembler Edu, based on the Project-Based Learning (PjBL) model integrated with local wisdom from the Cirebon region. The research follows the 4D development model (Define, Design, Development, Disseminate), adapted to the study's specific needs as follows:

1. Define

According to Trianto (2009:190–191), this stage aims to establish and define learning requirements by analyzing the objectives and scope of the developed materials. It consists of five key steps: a) Front-End Analysis: identifies fundamental learning challenges to determine the need for instructional material development. b) Learner Analysis: examines students' prior knowledge and developmental characteristics to ensure the materials align with their academic abilities, age, maturity, motivation, experiences, psychomotor skills, and social competencies. c) Task Analysis: Breaks down instructional content into structured outlines, covering both content structure and procedural analysis.

Concept Analysis: identifies core concepts to assess students' comprehension levels. d) Learning Objective Formulation: establishes objectives as the foundation for designing Assembler Edu, guiding test formulation, media selection, and methodology to ensure alignment with intended outcomes.

2. Design

Trianto (2009:191) states that this stage prepares a prototype of student worksheets through four steps: a) Criterion-Referenced Test Development: Constructs assessments based on defined learning objectives. b) Media Selection: chooses media that effectively support instructional delivery. c) Format Selection: evaluates existing formats to adapt or refine the design. d) Preliminary Design of Assembler Edu: involves drafting, reviewing, and adapting the interactive media framework.

3 Development

This stage transforms design concepts into a physical prototype. Tegeh et al. (2014:43) emphasize that materials, strategies, and assessments planned earlier are materialized here. Trianto (2009:192) notes that the prototype is tested on a broader scale (e.g., different classes/schools) to evaluate effectiveness. Development stage through step: a) Producing/Revising Assembler Edu: the prototype undergoes expert validation (judgment) covering language, media, and content. b) Selecting Optimal Design Combinationsis to ensures the media meets predefined targets. Pribadi (2009:133) outlines critical considerations for development: addressing learners' unique needs, achieving learning objectives, meeting school-specific effectiveness standards.

4. Disseminate

The developed product is implemented to evaluate its impact on learning quality (effectiveness, uniqueness, and efficiency) (Tegeh et al., 2014:43). Pribadi (2009:135) highlights the need to assess: a) the method's effectiveness in delivering content, b) trategies to maintain student engagement. Implementation was conducted at SD Negeri 2 Pejambon, Cirebon, West Java, to measure the product's success against competency benchmarks.

Gain and N-Gain calculations were used to assess the effectiveness of improving students' creative thinking skills after using the developed product. Gain, in this study, represents the change in students' abilities after participating in the learning process. The gain obtained was normalized by the difference between the maximum score and the pretest score. Changes occurring before and after learning were calculated using the Gain factor (N-Gain) formula using Hake's (1998) formula.

$$\langle g \rangle = \frac{Spost - Spre}{100\% - Spre}$$

With category:

Interval (g)	Category
$(g) \geq 0{,}7$	Height Increase
$0{,}7 \geq (g) \geq 0{,}3$	Moderate Increase
$(g) < 0{,}3$	Low Increase

The practicality test was conducted to assess the practicality of the interactive media, assembler edu, using the PjBL model based on local wisdom of the Cirebon region, to improve the scientific literacy skills of fifth-grade elementary school students. After the learning process concluded and the developed product was implemented, students were given student and teacher response sheets to assess the learning process using the interactive media, assembler edu, using the PjBL model based on local wisdom of the Cirebon region. The guidelines for scoring the practicality of the interactive media, assembler edu, using the PjBL model based on local wisdom of the Cirebon region can be seen in table:

Score	Criteria
4	Very good
3	Good
2	Poor
1	Very poor

(Adapted Sugiyono, 2015:166)

RESULT

The development process of the Augmented Reality (AR) Assembler Edu digital learning media began with the definition phase. This initial stage served to identify existing problems and determine the specific needs for the product to be developed. Through problem and needs analysis conducted at SD Negeri 2 Pejambon in Cirebon, key issues were identified, with observations and interviews revealing a significant lack of learning materials integrated with local wisdom. These findings were subsequently processed to strengthen the product development framework.

During the curriculum analysis phase, the researcher examined the Merdeka Belajar curriculum, including student and teacher handbooks. To better understand educators' and learners' needs, interviews and observations of students' capabilities were conducted. The results highlighted a critical gap in locally contextualized materials.

The material analysis process involved exploring and reconstructing potential project-based activities that could incorporate Cirebon's cultural elements. For the sound-related learning module, the researcher selected the traditional klithikan game, which has become increasingly rare among students due to the prevalence of digital devices. This traditional game was integrated to develop science materials enriched with local wisdom. Additionally, the researcher reviewed previous studies on elementary teaching materials to inform the current development process.

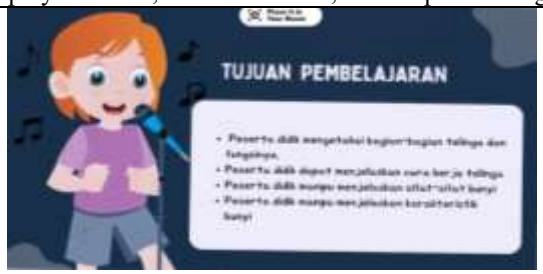
The second stage focused on design. Based on the needs analysis from the definition phase, the AR Assembler Edu media was conceptualized as a 3D augmented reality product compatible with smartphones and laptops. This innovative media combines sound-related content with local wisdom, specifically integrating the klithikan traditional game to analyze sound properties while enhancing fifth-grade students' scientific literacy. The initial design was subsequently transformed into a functional 3D augmented reality prototype ready for development.

a. The finalized 3D AR Assembler Edu media, infused with local wisdom, exhibits several distinctive characteristics:
b. Modern-Local Fusion: Combines contemporary AR technology with contextual local wisdom elements;
c. Cultural Integration: Incorporates the traditional klithikan game as a learning tool;
d. Engaging Animations: Features captivating visual elements to enhance learning;

e. Digital Format: Packaged in an accessible digital platform;
f. Instructional Videos: Includes demonstrations of klithikan game creation;
g. Immersive AR Experience: Presents sound properties through realistic augmented reality to foster scientific literacy;
h. Science Literacy Focus: Explicitly designed to develop students' scientific literacy skills.

The detailed instructional media design is presented in Table:

The opening screen displays the title, class animation, main topic headings, class, and semester.



Contains learning objectives for the science and sciences (IPAS) material on sound based on the guidelines of the independent curriculum.

The visual images presented appear truly realistic, with 3D objects showing the inner parts of the ear in detail.

The material is structured based on the PjBL model syntax, with an engaging media display. The 3D media also uses comprehensive captions and explanatory audio.

Each piece of content integrates Cirebon's unique local wisdom, including background music, traditional games, and examples of traditional Cirebon musical instruments.

Examples are presented contextually with additional 3D images.

Project instructions: The media contains clear project instructions accompanied by steps for creating a coherent project.

This innovative approach bridges technological advancement with cultural preservation, offering an engaging solution to address the identified gaps in locally relevant STEM education.

The first step after the media was realized was to test it through expert judgment. Expert judgment was conducted to assess the media's suitability in terms of material, language, and media. The expert judgment was conducted by five experts: Prof. Dr. Eko Handoyo, M.Si, Prof. Dr. Haryadi, M.Pd, and Dr. Nuni Widiarti, M.Si, lecturers in Elementary Education at the Postgraduate Program at Semarang State University; Ms. Elis Maryanti, M.Pd, a material expert at Permata Indonesia University; and Mr. Ade Uken Wahyudin, S.Pd., a fifth-grade teacher at SDN 1 Pejambon.

Media validation was conducted using a material validation instrument developed by the researchers. The material validation instrument included five aspects: appropriateness of media layout, appropriateness of letter arrangement, appropriateness of content layout, typography and animation, typography and animation, appropriateness of content illustrations, and completeness of the media.

After obtaining the results of the material and language validation test, media validation test, and practicality test on the 3D Augmented Reality Assembler Edu media based on the project-based learning model with local wisdom of the Cirebon region, the researcher averaged it to obtain the percentage and criteria for the feasibility of the learning media. The results of the feasibility assessment of the teaching materials can be seen in table:

Tests Conducted	Test Results
Material Validation	94,50%
Language Validation	94,20%
Media Validation	94,20%
Practicality Test by Students	87,33%
Practicality Test by Teachers	87,50%
Feasibility Percentage	91,55%
Criteria	Very Feasible

The feasibility of the 3D Augmented Reality Assembler Edu media based on the PjBL model was obtained from the results of the material and language validation tests, media validation tests, and practicality tests. The material validation results obtained a percentage of 94.50%, categorizing it as very valid. The language validation results obtained a percentage of 94.20%, categorizing it as very valid. The media validation results obtained a percentage of 94.20%, categorizing it as very valid. The practicality test by students yielded a score of 87.33%, categorized as very practical. The practicality test by teachers yielded a score of 91.55%, categorized as very practical. An average was then conducted to determine the feasibility of the 3D Augmented Reality Assembler Edu media based on the PjBL model. The average feasibility score was 91.55%, categorized as very feasible, with several suggestions and improvements from experts and users.

The material in the 3D Augmented Reality Assembler Edu media was also aligned with the learning outcomes and objectives of the independent curriculum. The material must also be tailored to the learning needs of students. The content of the developed learning media must also be tailored to students' needs and related to their age development (Muhammad et al., 2023; Hikmah et al., 2023; Ariansyah et al., 2024). The material developed by researchers is presented with 3D, interactive, and attractive digital diorama images to help students become interested and understand each material and develop students' literacy skills regarding the media and materials that have been developed (Destriana et al., 2023; Wangi & Bukhori, 2023; Aryani et al., 2023). The content of the material in the 3D Augmented Reality Assembler Edu media is arranged completely and systematically, from the opening section, learning objectives, material descriptions, and question descriptions (Cholifah 2024; Hikmah et al., 2023; Yuamita & Amalia, 2023; Estuhono et al., 2023; Destriana et al., 2023). The language used in the 3D Augmented Reality Assembler Edu media has been adapted to student development, EYD (Indonesian Traditional Indonesian Dictionary), and KBBI (Indonesian Big Indonesian Dictionary) to ensure ease of understanding (Hapizd & Safitri, 2023; Ariansyah et al., 2024).

The 3D Augmented Reality Assembler Edu learning media developed is adapted to local wisdom to meet the needs of teachers and students through contextual-based learning (Hadi et al., 2015; Maziyah et al., 2023). Furthermore, the development of 3D Augmented Reality Assembler Edu media is crucial because it is supported by engaging animations, audio, and video. Engaging animations, audio, and video can help students focus and engage with learning (Lesmana et al., 2025**)**. In addition to animated images and audio, the 3D Augmented Reality Assembler Edu media also includes two types of videos: an analysis of the sound-producing process through the making of traditional Klitikan toys, typical of the Cirebon region, and a video performance of traditional Cirebon musical instruments. The process of making traditional Klitikan toys, typical of the Cirebon region, and the video material on light and sound are intended to improve students' understanding of the human auditory and visual systems. Interesting videos can also improve students' understanding of the material being studied (Fajarisman et al., 2021; Legiowati et al., 2023; Husniyah et al., 2022; Pratiwi et al., 2023). The design used is adapted to student characteristics, attractive, proportional, and the selection of fonts, images, and layout (Pradana & Uthman, 2023).

DISCUSSION

The effectiveness of the Augmented Reality Assemblr Edu media, based on PjBL (Problem-Based Learning) and Cirebon Local Wisdom, developed to train fifth-grade elementary school students in scientific literacy, was determined based on the analysis of pre- and post-test results from a large-scale trial. The test instrument was designed based on scientific literacy indicators, including content knowledge, procedural knowledge, and epistemic knowledge (OECD, 2019). Furthermore, the test instrument also assessed students' knowledge of the local wisdom of Cirebon Regency, specifically regional musical instruments and the traditional game klitikan, as part of a project to analyze sound sources and properties.

The average pretest score was 53.93, with a minimum score of 35 and a maximum score of 70. Based on the test instrument outline (attachment) and scoring guidelines (attachment), students lacked knowledge about the properties of sound, regional musical instruments, and traditional games of Cirebon, particularly other than klitikan. Furthermore, students struggled to understand the questions and explain their answers accurately. Some students also lack understanding and analysis of questions on content knowledge, procedural knowledge, and epistemic knowledge in science learning. Therefore, it can be seen that the scientific literacy of fifth-grade students at SDN 2 Pejambon Cirebon is still lacking. Therefore, it is crucial and an important requirement to support successful learning in the classroom: teachers who can facilitate learning that engages students and provide learning instruments in the form of learning resources that contain indicators of scientific literacy so that the learning atmosphere is enjoyable, attracts students' enthusiasm and interest in learning, and is able to improve students' scientific literacy (Sari, et al., 2017; Ermawati et al., 2023; Nursa'idah et al., 2022; Faradilla et al., 2021; Álvarez, et al., 2024; Struminger, 2021; Bendegard., et al., 2022; Ronderos., et al., 2024). After using PjBL-based augmented reality assemblr edu media with local wisdom of Cirebon that has been developed, the average posttest score was 78.44 with a minimum score of 60, and a maximum score of 90. Based on the test instrument grid (attachment), and scoring guidelines (attachment), students already know about local wisdom, especially those related to Cirebon regional musical instruments and the traditional Cirebon klitikan game. The material presented is integrated with local wisdom in the students' environment so that the learning process becomes contextual so that they continue to preserve and develop their local wisdom (Asfuriyah & Nuswowati, 2015; Sutrisno & Rofi'ah, 2023; Suttrisno et al., 2020; Karsiwan et al., 2023; Syamsijulianto et al., 2022). Integrating local wisdom into science learning media has created an active learning environment for students (Indrawan et al., 2021; Dhey et al., 2024; Widyaningrum, 2018; Adnyani et al., 2025; Khasna et al., 2024). Furthermore, some students have been able to understand questions, analyze them, and explain their answers correctly. Students have mastered how to explain questions related to content knowledge, procedural knowledge, and epistemic knowledge in science learning, in accordance with scientific literacy indicators. This aligns with the constructivist theory that students acquire knowledge through experiences in their environment (Suparlan, 2019; Suryana & Harto, 2022; Abdiyah, 2021). This is because many fifth-grade students at SDN 2 Pejambon are unfamiliar with traditional musical instruments and traditional games typical of Cirebon, which are nearly extinct.

According to Situmorang (2016), the criteria for evaluating cognitive aspects based on scientific literacy include: (1) comprehensive question coverage; (2) presentation of questions in the form of data and information; (3) relationships between concepts; (4) demands for problem analysis and justification in the form of arguments; (5) variation in question representation; and

(6) integration of application contexts relevant to science, technology, environment, and society (STEM) issues.

After obtaining the data, a paired t-test was conducted, first fulfilling the analysis requirements, namely normality and homogeneity tests, to examine the differences in the average results of students' pretest and posttest. The results of the normality test indicated that the data were normally distributed, while the homogeneity test proved the equality of variance between groups. Thus, the paired t-test could be conducted. The analysis results showed a significant difference between pretest and posttest scores. Furthermore, an n-gain test was conducted to evaluate improvements in student learning outcomes, resulting in a score of 0.532, indicating moderate improvement. This research proves that the Augmented Reality Assemblr Edu media, based on PjBL and incorporating Cirebon's Local Wisdom, is effective in developing students' scientific literacy.

Furthermore, each aspect of scientific literacy improved: (1) content knowledge increased from 38% (very low criteria) in the pretest to 65.93% (moderate criteria) in the posttest; (2) procedural knowledge increased from 14.64% (moderate criteria) to 61.07% (moderate criteria); and (3) epistemic content increased from 33.81% (very low criteria) to 74.88% (moderate criteria). These results align with findings (Martalia et al., 2022; Muflikatun et al., 2021; Suttrisno & Putri, 2024; Febrianti, 2021) that digital teaching materials can increase student motivation in learning, thus positively impacting scientific literacy.

The 3D Assembler Edu learning media, developed using the Project-Based Learning (PjBL) model, has been integrated with the Ethno-STEM approach. Ethno-STEM is a learning approach that combines local cultural elements with the disciplines of science, technology, engineering, and mathematics to develop students' scientific thinking skills and scientific literacy (Sudarmin, et al., 2017; Idrus & Suma, 2022; Atmojo, 2021; Risnawati, 2020). Based on various research results, the Ethno-STEM approach has proven effective in increasing student learning motivation while preserving local cultural values through its application in the classroom learning process (Sartika et al., 2022; Sumarni et al., 2022; Karim et al., 2022). In the development of this Ethno-STEM-based 3D Assembler Edu media, the cultural aspect that is integrated is the process of making the traditional klitikan game. The integration of the traditional game-making process into learning aims to: (1) explore the scientific concepts contained in the making process, (2) introduce traditional Indonesian games and musical instruments, and (3) raise awareness to preserve this cultural heritage (Febrianti & Indrawati, 2021; Hasanah et al., 2021; Christopher et al., 2019; Priyatnomo et al., 2016).

CONCLUSION

Based on the development of 3D augmented reality assembler edu media using a project-based learning model based on local wisdom from Cirebon to improve the scientific literacy of fifth-grade elementary school students, the following conclusions were drawn:

1) The 3D augmented reality assembler edu media, using a project-based learning model based on local wisdom from Cirebon to train students' scientific literacy, has several characteristics. These characteristics include: the media contains Ethno-STEM content from Cirebon Regency, with learning activities using a project-based learning model; the sound material developed in the Merdeka curriculum is integrated with local wisdom, including the procedures for making sounds and the sound properties of the traditional game klitikan; engaging and realistic 3D animation; the media is packaged in digital form; it includes the process of making traditional Cirebon games; and a video about the properties of sound to practice and apply scientific literacy.

2) The feasibility of developing 3D augmented reality assembler edu media with a PjBL model based on Cirebon's local wisdom to improve scientific literacy obtained an Aiken's V score of 0.942, a very feasible criterion. This was obtained from the average results of material validation with an Aiken's V score of 0.945; language validation with an Aiken's V score of 0.938; media validation with an Aiken's V score of 0.942; practicality test results by students obtained a percentage of 87.33%; practicality test results by teachers obtained a percentage of 87.50%.
3) The effectiveness of 3D augmented reality assembler edu media with a PjBL model based on Cirebon's local wisdom to improve scientific literacy training for fifth-grade elementary school students was declared effective by the results of a paired t-test showing an average difference in pretest and posttest data, and the n-gain results obtained a score of 0.532 with moderate/effective criteria. 4) The results of the student response questionnaire after the use of 3D augmented reality assembler edu media with the PjBL model based on local wisdom of the Cirebon region obtained a percentage of 87.5%; and the results of the teacher response questionnaire after the use of 3D augmented reality assembler edu media with the PjBL model based on local wisdom of the Cirebon region obtained a percentage of 88.39%. The results of student and teacher responses obtained very positive criteria.

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