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DEVELOPMENT OF PROBLEM-BASED LEARNING SCIENCE E-MODULE INTEGRATED WITH ETHNOSCIENCE OF PENCAK SILAT TO IMPROVE STUDENTS' SCIENCE PROCESS SKILLS

Junartiah[1], Sri Retno Dwi Ariani[2], Umi Fatmawati[3]
[1,2,3]Department of Science Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Jawa Tengah, Indonesia

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ABSTRACT

The integration of local culture into science learning has become increasingly important to enhance contextual understanding, foster student engagement, and strengthen the relevance of scientific concepts in daily life. However, many learning resources still lack meaningful connections between scientific material and students' cultural backgrounds, which may limit their motivation and science process skill development. To address this gap, this study aims to develop and evaluate a science e-module based on the Problem-Based Learning (PBL) model integrated with pencak silat ethnoscience, focusing on the topic of the human respiratory system.to develop a Problem-Based Learning (PBL) e-module integrated with ethnoscience pencak silat to improve students' science process skills in respiratory system material. The development model employed a 4-D model (Define, Design, Develop, Disseminate). The e-module was developed based on the needs analysis results, designed according to the structure and format of digital learning media, and validated by material, media, learning, and language experts. The instrument's validity was analyzed using Aiken's V, with results ranging from 0.84 to 0.91, indicating high validity. The product was tested through limited and medium-scale trials, involving 2–3 teachers and 6–24 students, which resulted in positive responses with average percentages above 87%. The effectiveness test through pretest and posttest in experimental and control classes across three schools showed significant improvements in the experimental class. Data analysis using independent sample t-tests indicated significant differences in posttest scores ($p < 0.05$). The developed e-module proved to be effective, practical, and valid in enhancing students' science process skills, Integrating scientific concepts with local cultural wisdom through pencak silat not only enriches students' contextual understanding of science but also fosters cultural appreciation, strengthens identity, and promotes the relevance of science learning to real-life experiences.

Corresponding Author:
Sri Retno Dwi Ariani
Department of Science Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Jawa Tengah, Indonesia
Email: sriretno71@staff.uns.ac.id

1. INTRODUCTION

Learning science in junior high schools plays a crucial role in shaping students' cognitive abilities, attitudes, and skills to understand natural phenomena scientifically. Science education should not be confined to theoretical transmission but must foster active, inquiry-based, and contextual learning that develops students' science process skills (Sari, 2022) In Indonesia, the Kurikulum Merdeka emphasizes student-centered learning by encouraging exploration, critical thinking, and problem-solving through scientific approaches. However, in practice, science classrooms often still rely on conventional lectures and textbook-based instruction, leading to passive student participation and limited inquiry skill development (Kurniawan et al., 2023). Such traditional approaches risk diminishing students' curiosity and motivation to explore scientific concepts independently (Rahmadani et al., 2024). Moreover, the lack of contextualized learning experiences reinforces the perception of science as abstract and disconnected from real-life situations. Therefore, there is an urgent need for innovative learning media that not only deliver scientific content but also connect it to students' cultural environments and everyday experiences. Such media can significantly enhance engagement, conceptual understanding, and scientific literacy.

One promising strategy is the integration of ethnoscience—local knowledge rooted in cultural practices—into science education (Corebima, 2016). In the Indonesian context, Pencak Silat, a traditional martial art recognized by UNESCO, offers rich ethnoscientific content, particularly in breathing techniques and physical endurance (Wijaya et al., 2021). These practices can be linked to biological concepts of the human respiratory system, making abstract physiological mechanisms more tangible and culturally meaningful for students. At the same time, digital learning tools such as e-modules provide flexible, interactive features that support student engagement and self-paced learning (Putra et al., 2022). However, many existing e-modules remain generic, focusing solely on content delivery without integrating local cultural values or student-centered pedagogies. Parallelly, ethnoscience-based learning approaches have been explored, but they are often implemented in isolation from digital learning tools. Furthermore, numerous studies have demonstrated the effectiveness of Problem-Based Learning (PBL) in improving inquiry skills, problem-solving abilities, and student motivation (Sa'diyah et al., 2023). yet very few have integrated PBL with ethnoscience within a digital learning environment.

This situation reveals a clear research gap: while previous studies have separately explored the development of e-modules, the application of ethnoscience, and the implementation of PBL, no research to date has combined all three elements PBL, ethnoscience, and digital e-modules—specifically in the context of the human respiratory system. Addressing this gap, the present study proposes a novel approach that embeds pencak silat breathing practices into problem-based learning scenarios within a culturally responsive e-module. This integration aims to create an inquiry-driven, contextual, and engaging science learning experience for junior high school students. The objectives of this research are to develop and evaluate the validity, practicality, and effectiveness of the proposed e-module in enhancing students' cognitive outcomes and science process skills. Ultimately, the findings are expected to contribute both practically and theoretically: by providing a prototype of culturally contextualized science learning media aligned with the Merdeka Curriculum, and by enriching the literature on how ethnoscience-integrated digital tools,

when combined with PBL, can foster scientific literacy, cultural awareness, and problem-solving abilities in science education.

2. METHOD

This research employed a Research and Development (R&D) approach to design and evaluate a Problem-Based Learning (PBL)-based e-module integrating pencak silat ethnoscience on the topic of the human respiratory system. The development process adopted the 4D model by Thiagarajan, Semmel, and Semmel (1974), which consists of four stages: Define, Design, Develop, and Disseminate. This structured model was chosen because it provides a systematic framework for producing and validating educational media, ensuring that the resulting e-module is both pedagogically sound and practically applicable.

1. Define
   At this stage, preliminary analysis was conducted to identify curriculum requirements, student characteristics, and relevant ethnoscientific elements in *pencak silat*, particularly its breathing techniques. Literature review and field observations were carried out to ensure alignment with the Merdeka Curriculum and to formulate learning objectives focused on science process skills.
2. Design
   The e-module framework was designed by integrating PBL steps (problem orientation, group discussion, investigation, presentation, and reflection) with contextual problems related to *pencak silat* breathing practices. The design included interactive features such as animations, videos, and quizzes to enhance student engagement.
3. Develop
   The prototype e-module was created using digital learning software and validated by three experts: one material expert, one media expert, and one learning practitioner. Revisions were made based on expert feedback. The revised e-module was then tested in a limited trial to evaluate practicality and refined before wider implementation.
4. Disseminate
   The final version of the e-module was implemented in three junior high schools in Bojonegoro District, each involving one experimental class (32 students) and one control class (32 students). The experimental group used the developed e-module, while the control group received conventional instruction.

Research Subjects and Setting

The subjects consisted of 192 eighth-grade students from SMP Negeri 2 Purwosari, SMP Negeri Kasiman, and SMP Negeri 5 Bojonegoro. The study was conducted over one semester (16 weeks) during the 2024/2025 academic year. The data in this study were collected using several instruments designed to ensure comprehensive evaluation of the developed e-module. Validation sheets were employed to obtain expert judgments covering aspects of content accuracy, media design, and overall learning feasibility. To assess practicality, observation sheets were used during classroom implementation, allowing the researchers to document the usability and effectiveness of the e-module in real learning settings. In addition, a science process skills test, consisting of pre-test and post-test items, was administered to measure students' competencies in line with key indicators such as observing, hypothesizing, experimenting, and drawing conclusions. Finally,

student response questionnaires were distributed to capture learners' engagement and perceptions regarding the usefulness and relevance of the e-module.

The data analysis in this study was carried out through a combination of quantitative and qualitative approaches to ensure comprehensive evaluation of the developed e-module. The validity of the product was analyzed by calculating the average scores provided by expert validators on aspects of content, media, and learning feasibility. Practicality was examined using descriptive statistics derived from teacher and student responses during classroom implementation, providing insights into the usability and acceptance of the e-module in real learning contexts. Effectiveness was evaluated by comparing students' pre-test and post-test results through paired t-tests and N-gain analysis, allowing measurement of both statistical significance and the magnitude of learning improvement. In addition, qualitative data obtained from classroom observations and student questionnaires were analyzed and triangulated with the quantitative findings to strengthen the overall interpretation and ensure the reliability of conclusions.Through these procedures, the credibility and replicability of the study are ensured, and the effectiveness of the developed PBL-based e-module integrating *pencak silat* ethnoscience can be empirically evaluated.

3. RESULTS AND DISCUSSION

This section presents the results of the study accompanied by a comprehensive discussion. The data shown are processed and analyzed data derived from expert validation, limited and medium-scale trials, and large-scale effectiveness tests. The presentation is supported by tables and figures to facilitate understanding. The discussion links the obtained results with the theoretical framework, basic concepts, and findings of previous studies.

3.1. Design Phase

The design phase involved compiling an initial e-module draft based on a comprehensive needs analysis. The module was structured to meet both teachers' and students' needs in supporting science learning objectives through a Problem-Based Learning (PBL) model integrated with pencak silat ethnoscience. The design process considered content structure, learning strategies, supporting media, technology, and assessment instruments. Learning objectives were formulated in accordance with Merdeka Curriculum targets aimed at enhancing students' science process skills while fostering critical, collaborative, and creative problem-solving competencies. Key learning outcomes included students' abilities to:

The data analysis in this study employed both quantitative and qualitative approaches to provide a comprehensive evaluation of the developed e-module. Product validity was determined by calculating the mean scores from expert validators, which assessed the content accuracy, media design, and overall learning feasibility. Practicality was analyzed using descriptive statistics derived from teacher and student responses during classroom implementation, offering evidence of the usability, clarity, and acceptance of the e-module in real learning settings. Effectiveness was measured by administering pre-tests and post-tests, with the results analyzed using paired t-tests to determine statistical significance and N-gain analysis to measure the magnitude of learning improvement. Furthermore, qualitative data obtained from classroom observations and student

response questionnaires were examined and triangulated with the quantitative findings to enrich the interpretation, provide contextual insights, and enhance the credibility of the research conclusions.The module content structure consisted of an introduction, concept map, material presentation sections (text, images, animations, videos), PBL problem scenarios, pencak silat ethnoscience activities, HOTS-based exercises, formative-summative assessments, and reflective activities in Table 1.

Table 1. Learning Strategy Structure:

PBL Syntax	Activity
Problem Identification	Students identify respiratory problems from contextual cases.
Information Gathering	Collect facts and scientific concepts related to respiration.
Experimental Planning	Plan problem-solving strategies, including pencak silat breathing practice.
Implementation	Carry out activities and pencak silat observations.
Data Analysis	Analyze findings and relate to respiratory system concepts.
Presentation	Present conclusions and solutions in class discussions.

3.2. Development Phase

The development phase involved realizing the initial design into a functional e-module integrated with pencak silat ethnoscience and the Problem-Based Learning (PBL) model. All materials, interactive media, and PBL scenarios were developed in accordance with the designed structure. Features included annotated materials, contextualized PBL problems, pencak silat breathing technique guides, animations, and interactive exercises. The e-module was built using Canva, PowerPoint, iSpring Suite, and Web2Apk to produce an interactive, Android-compatible module in Table 2.

Table 2. Aiken's V Index for Expert Validation

Aspect	Aiken's V Index
Content	0.87
Media	0.84
Learning	0.88
Language	0.91

Table 2 limited trials were conducted involving 2 teachers and 6 students, while medium-scale trials involved 3 teachers and 24 students across three schools. The feasibility assessments yielded average teacher feasibility scores of 88.13%–89.17% and student feasibility responses of 87.04%–89.00%, classified as 'Good' in Figure 1.

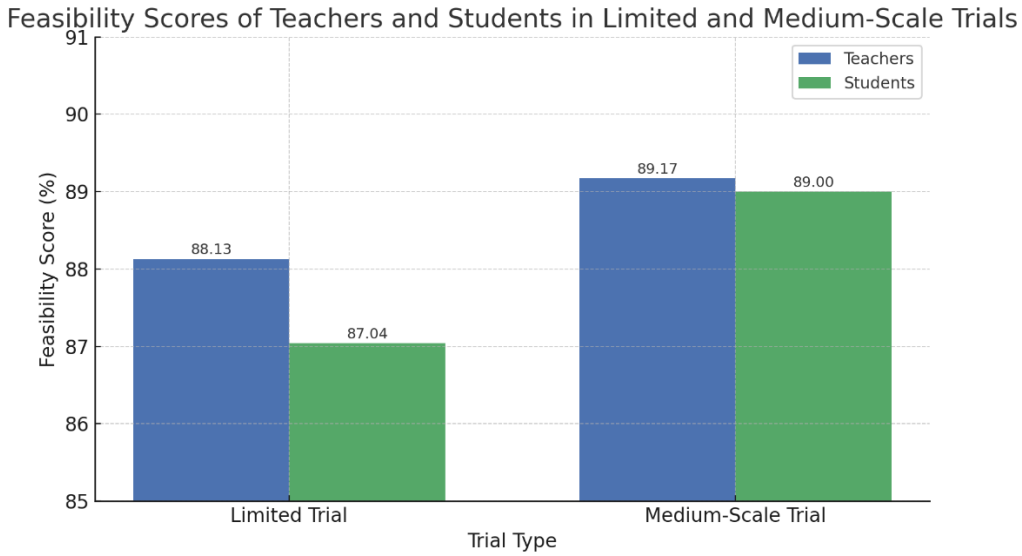

Figure 1. Illustrates The Comparison of Teacher and Student Feasibility Scores Between the Limited and Medium-Scale Trials

3.3 Implementation Phase

The implementation phase aimed to assess the practicality and usability of the e-module in real classroom settings for Grade VIII students. Following expert validation and revisions, limited and medium-scale trials were conducted. The limited trial involved 2 teachers and 6 students from one school, focusing on material appropriateness, curriculum alignment, model integration, media feasibility, readability, attractiveness, and clarity. The average teacher evaluation score was 88.13%, while student responses averaged 87.04%. The medium-scale trial involved 3 schools, each with 1 teacher and 8 students. Feasibility ratings improved slightly, with teachers averaging 89.17% and students 89.00%, indicating the e-module's practicality and readability in diverse classroom contexts in Table 3.

Table 3. Test Instrument Analysis Results:

Validity (r > 0.396)	**All items valid**
Reliability (Cronbach's Alpha)	0.766 (High)
Item Difficulty	Moderate to Difficult
Discrimination Index	Good (0.40–0.55)

3.4 Evaluation Phase

The evaluation phase involved a large-scale trial in three schools to assess the e-module's effectiveness in improving science process skills and learning outcomes. Experimental and control groups were established at each site. Pretests were administered prior to treatment. Data analysis showed no significant difference in initial abilities ($p > 0.05$), confirming group equivalence. Post-learning, posttests were conducted. Levene's test ($p > 0.05$) confirmed data homogeneity, while Shapiro-Wilk tests confirmed normality. Independent sample t-tests (one-tailed) showed significant differences in posttest scores favoring the experimental groups in all schools ($p < 0.05$).

This demonstrates the module's ability to enhance students' science process skills over conventional methods in Figure 2.

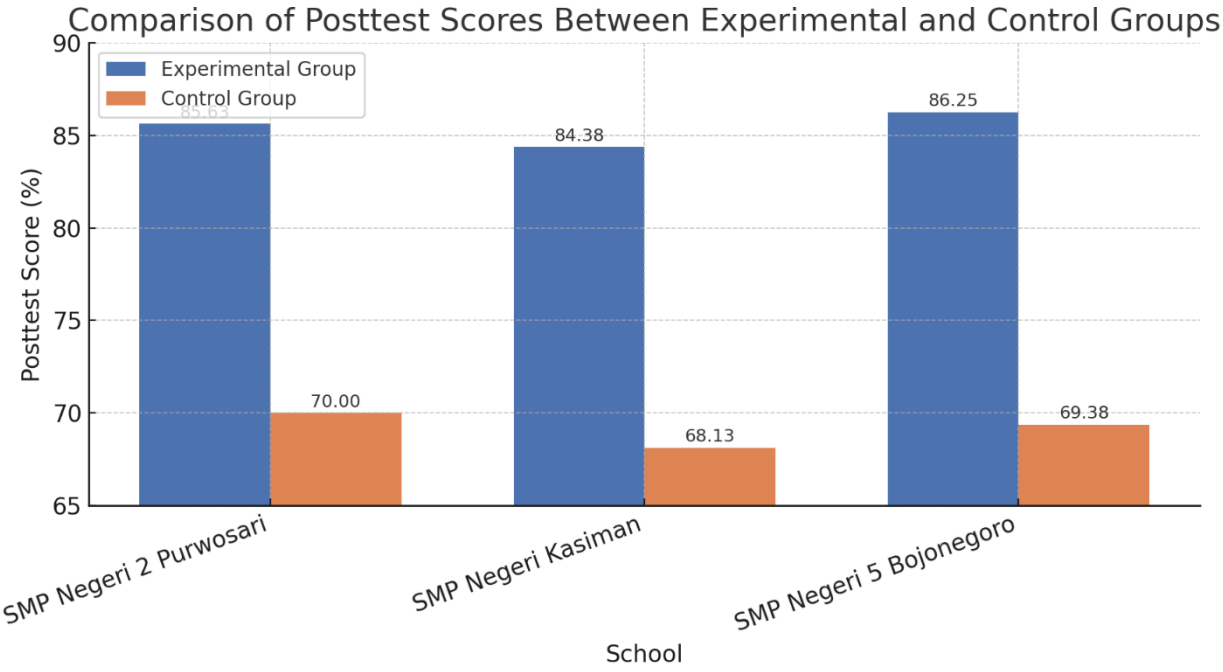

Figure 2. Comparison of Posttest Scores Between Experimental and Control Groups

4. DISCUSSION

The results of this study indicate that a PBL-based e-module integrated with pencak silat ethnoscience produced measurable improvements in students' science process skills and learning outcomes on the human respiratory system. These findings can be understood through several interrelated mechanisms. First, embedding pencak silat breathing practices and culturally familiar problem scenarios increased the contextual relevance of the material, which likely enhanced students' motivation, attention, and willingness to engage with tasks. This is consistent with the principles of culturally relevant pedagogy, which emphasize that learning becomes deeper and more meaningful when it is connected to learners' identities and daily experiences (Gay, 2018). Second, the use of a Problem-Based Learning framework encouraged active inquiry, collaborative problem solving, and extended cognitive elaboration — processes associated with deeper understanding and transfer. Previous research has shown that PBL improves skills, problem-solving abilities, and long-term retention compared to conventional approaches, especially when tasks are authentic and scaffolded effectively (Hmelo-Silver, 2004) (Strobel & van Barneveld, 2009).

Third, from an experiential-learning perspective, the module's design (concrete problem scenarios → reflection → conceptualization → application) allowed students to cycle between doing and thinking, which supports construction and internalization of scientific concepts. Experiential-learning theory highlights that such cycles strengthen the ability to translate observations into hypotheses and experimental designs (Kolb, 2015). Fourth, the integration of bodily practice (breathing techniques) with conceptual explanation is supported by embodied-

cognition theory, which argues that sensorimotor experiences ground abstract concepts. Breathing practice provided a multimodal anchor, enabling students to directly connect lived experience with physiological mechanisms. Studies have shown that controlled breathing improves physiological regulation and attentional control, thereby supporting cognitive processing and learning readiness (Zaccaro et al., 2018). Fifth, the digital e-module format itself amplified these pedagogical affordances: interactive multimedia, immediate feedback, and multimodal representations reduced cognitive load and facilitated dual coding of information. According to the cognitive theory of multimedia learning, well-designed multimedia fosters meaningful learning by aligning visual and verbal channels (Mayer, 2021)

Despite these promising outcomes, some limitations must be acknowledged. The magnitude of gains varied across classes and test items, suggesting that teacher facilitation, time allocation, and students' prior knowledge influenced effectiveness. Pre- and post-tests captured immediate outcomes but did not measure long-term retention or transfer. Social-desirability bias in questionnaires and observer effects may also have influenced results. Moreover, while pencak silat was a culturally appropriate anchor for this context, generalizing the approach to other regions requires careful adaptation and validation (Ladson-Billings, 2009). Practically, this study supports integrating local cultural practices into science instruction when combined with student-centered pedagogies and multimedia resources. Theoretically, the findings suggest a synergy among culturally responsive pedagogy, experiential learning, embodied cognition, and multimedia instructional design. Future research should explore long-term effects, test the model with larger and more diverse samples, and investigate its adaptability to other cultural practices and science topics (Savery, 2015) (Hmelo-Silver, 2017). In summary, the integration of pencak silat ethnoscience within a PBL-based e-module represents an effective approach for teaching the respiratory system. The combination of cultural relevance, active problem solving, embodied experience, and multimedia support provides a coherent explanation for the observed improvements, while also offering important insights for future development of culturally contextualized science education.

4.1 Validity of the E-Module

Based on the validation results from content, media, learning, and language experts, the developed e-module was declared to have a very high level of validity, with Aiken's V index values ranging from 0.84 to 0.91. These values indicate that all components of the module met the content, didactic, and technical feasibility criteria. This finding aligns with the study (Putra et al., 2022) ,which stated that digital learning media integrating local wisdom tend to achieve high validity scores because they effectively relate scientific concepts to students' cultural contexts.

4.2 Feasibility of the E-Module Based on Limited and Medium-Scale Trials

In the limited trial involving 2 teachers and 6 students, and the medium-scale trial involving 3 teachers and 24 students across three schools, high feasibility scores were obtained from both teachers and students. The average feasibility score from teachers ranged from 88.13% to 89.17%, while students' scores ranged from 87.04% to 89.00%. This demonstrates that the e-module is easy to use, attractive, and suitable for classroom learning needs. These findings are consistent

with the study (Rahmadani et al., 2024), which stated that contextual, digital-based learning media can improve student engagement and motivation in learning activities.

4.3 Effectiveness of the E-Module Based on Large-Scale Trials

In the large-scale effectiveness testing phase conducted in three schools, the pretest results showed no significant difference in initial abilities between the experimental and control groups ($p > 0.05$). However, after implementing the e-module in the experimental groups' learning process, the posttest results showed significant differences ($p < 0.05$) compared to the control groups who received conventional instruction. These findings confirm that the developed e-module effectively improves students' science process skills. This result is in line with studies (Aguilar, C. A., & Donovan, 2022) and (Syahrial et al., 2024), which state that problem-based learning combined with local cultural contexts can enhance scientific literacy, critical thinking, and science process skills among students.

4.4 Relevance of the Findings to Theory and Previous Studies

The improvements in students' cognitive learning outcomes and science process skills align with the theory proposed by Hmelo-Silver (2004), which states that the Problem-Based Learning model is effective in encouraging students to think critically, solve authentic problems, and conduct independent or collaborative scientific investigations. Furthermore, the application of *pencak silat* breathing techniques within the context of science learning provided both physical and mental stimulation that supported students' understanding of the physiological concepts of the human respiratory system in a real and relatable manner. This finding is also consistent with the study (Syahrial et al., 2024), which reported that integrating local cultural practices into science learning not only improves scientific literacy but also nurtures students' appreciation for their cultural heritage in Table 4.

Table 4. Percentage of Posttest Score Increases for Experimental and Control Groups

School	Experimental Posttest (%)	Control Posttest (%)
SMP Negeri 2 Purwosari	85.63	70.00
SMP Negeri Kasiman	84.38	68.13
SMP Negeri 5 Bojonegoro	86.25	69.38

Table 4 from the table, it is evident that the posttest scores of the experimental groups were consistently higher by approximately 15–17% compared to the control groups in all schools. This indicates a significant effectiveness of using the PBL-based e-module integrated with pencak silat ethnoscience.

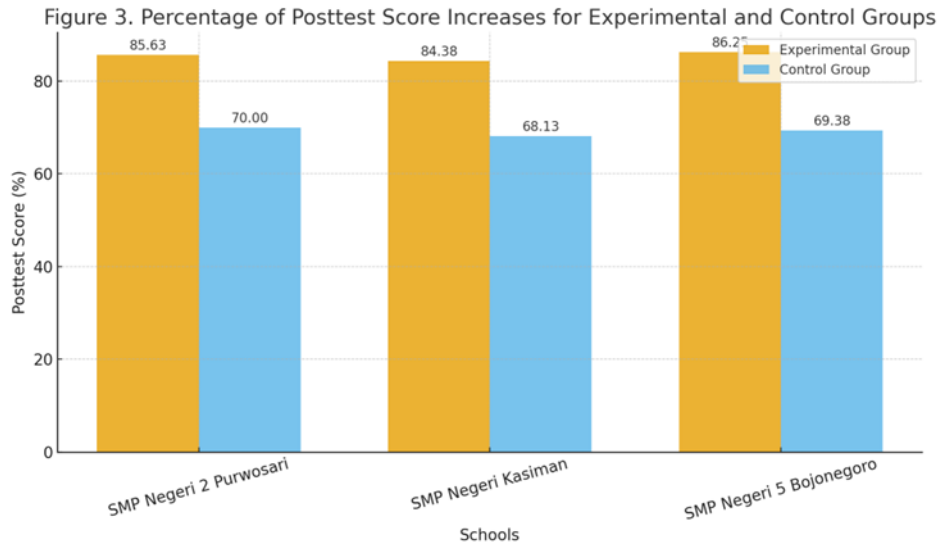

Figure 3. The Following is a Description of the Effectiveness Testing Results Presented in a Bar Chart Format

Figure 3 here is the bar chart with English labels and description, showing the posttest score percentages for experimental and control groups across the three schools.

4.5 Limitations and Challenges

Despite these positive results, several limitations must be acknowledged. First, variations in teacher quality and familiarity with PBL could have influenced the effectiveness of the e-module, as some teachers may have implemented the activities more effectively than others. Second, differences in students' cultural backgrounds and prior exposure to *pencak silat* may have affected their engagement and ability to connect with the ethnoscience elements. Third, the study was conducted in a limited number of schools within a single district, which may constrain the generalizability of the findings. Additionally, the study primarily measured outcomes in the short term, without evaluating the long-term retention of science process skills.

4.6 Implications and Future Directions

These findings have broader implications for science education. The integration of ethnoscience within PBL-based digital modules could be extended to other topics beyond the respiratory system, such as the circulatory system, motion, or energy, where local cultural practices can provide rich contextualization. Furthermore, the approach may be adapted to other cultural traditions across Indonesia, enabling more diverse and inclusive science learning experiences. For future research, longitudinal studies are recommended to assess the sustainability of learning gains, while larger-scale implementations across varied regions could strengthen the external validity of the findings. Finally, providing professional development for teachers on how to effectively implement PBL and ethnoscience-based learning media will be essential for scaling up this innovation.

5. CONCLUSION

Based on the results obtained from the stages of design, development, implementation, and evaluation, this study concludes that the science e-module developed using the Problem-Based Learning (PBL) model integrated with pencak silat ethnoscience demonstrated very high validity, as reflected in expert validation results with Aiken's V values ranging from 0.84 to 0.91 across content, media, learning, and language aspects, indicating that the product is highly appropriate for teaching the topic of the human respiratory system in junior high school science. In addition to validity, the e-module also showed high feasibility, as demonstrated by teacher assessments ranging from 88.13% to 89.17% and student responses between 87.04% and 89.00%, confirming that the e-module is not only user-friendly but also well-accepted and easily understood by both teachers and students in classroom contexts. The effectiveness of the developed product was further supported by empirical evidence, where paired t-tests revealed significant differences ($p < 0.05$) between experimental groups using the e-module and control groups applying conventional methods, with experimental groups consistently outperforming the control groups by approximately 15–17% in posttest scores across all three participating schools. These findings suggest that the integration of ethnoscience values from pencak silat breathing practices into a PBL framework provided students with a more meaningful, contextualized, and culturally relevant learning experience, allowing them to connect abstract biological concepts with real-life practices rooted in their local traditions, which in turn enhanced their science process skills, motivation, scientific literacy, and higher-order thinking abilities such as critical and collaborative problem-solving. Despite these promising outcomes, the study is not without limitations, as the trials were conducted in a limited number of schools, focused solely on the human respiratory system, and did not include long-term evaluation of knowledge retention or transfer, which restricts the generalizability of the findings. Therefore, future research should expand the implementation of this e-module across a wider range of topics, schools, and regions to further test its adaptability and sustainability, while also exploring its long-term impacts on students' learning, scientific attitudes, and cultural identity. From a practical perspective, the results of this study highlight the potential of integrating ethnoscience into digital learning media as an innovative strategy to contextualize science learning, strengthen student engagement, and support the goals of the Merdeka Curriculum, providing valuable implications for policymakers, educators, and curriculum developers to design culturally grounded, inquiry-based, and student-centered learning resources that bridge modern science with local wisdom.

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