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IMPLEMENTATION OF COTELBAPAI PHYSICS E-MODULE TO IMPROVE STUDENTS' SCIENTIFIC LITERACY AND PHYSICS IDENTITY

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Abstract :
This study examines the integration of local wisdom and artificial intelligence (AI) in physics learning media using *bakpia*, a traditional Indonesian food, as the learning context. The study aims to determine the effectiveness of the COTELBAPAI E-module and to analyze the profile distribution of students' scientific literacy and physics identity. A quasi-experimental method with an equivalent control group design was employed, involving 108 eleventh-grade students from SMAN 2 Banguntapan, divided into one experimental class and two control classes. Data were collected using test and questionnaire instruments. The results indicate that the COTELBAPAI E-module is highly effective in enhancing students' scientific literacy and physics identity. This is evidenced by a large effect size (3.017), with a 57.6% increase in students achieving very high scientific literacy, and an exceptionally large effect size (Cohen's d = 8.872), with a 76.7% increase in students categorized as having very strong physics identity. The novelty of this study lies in the integration of the Contextual Teaching and Learning (CTL) approach, artificial intelligence, and local wisdom within a single E-module, as well as the simultaneous evaluation of scientific literacy and physics identity. These findings provide empirical evidence that AI-assisted, context-based learning grounded in local culture can strengthen students' physics identity. However, the generalizability of the results is limited by the sample size and implementation duration.

Keywords: E-Module, Physics Identity, Scientific Literacy

INTRODUCTION

Physics, as a discipline that explains natural phenomena, continues to face challenges in its implementation as a school subject. These challenges include persistent misconceptions, limited use of learning media, ineffective instructional practices, and students' difficulty in recognizing the relevance of physics to everyday life, resulting in learning that lacks contextual meaning (Asmin & Rosdianti, 2021; Purba, 2021). One promising approach to addressing this issue is integrating local wisdom as a learning context and combining it with educational technology to make abstract concepts more tangible and meaningful for students.

The twenty-first century is characterized by rapid technological development, including artificial intelligence, which ideally should be integrated into classroom learning. However, the implementation of learning media in schools remains suboptimal, limiting students' active engagement in understanding physics concepts (Darma, et al., 2025). This condition highlights the need for innovative learning media that holistically accommodate cognitive, affective, and psychomotor domains, while also guiding students in the responsible and meaningful use of digital resources.

Classroom observations indicate that although learning practices have begun to adopt contextual approaches, they are rarely linked to local wisdom. In fact, local wisdom has strong potential to contextualize physics learning because it is closely related to students' lived experiences, allowing abstract concepts to become more concrete. While previous studies in Indonesia have examined physical concepts embedded in local traditions, culinary-based local wisdom remains one of the least explored contexts for physics learning media.

Learning media play a crucial role in supporting the achievement of instructional objectives, and meaningful interactivity can be realized through appropriate media design (Rahmawati & Rakhmawati, 2024). Nevertheless, existing studies have not fully addressed how learning media can support students in developing a sense of self-recognition in physics, or physics identity, alongside scientific literacy. This gap is particularly critical in Indonesia, where students' scientific literacy remains relatively low. In physics learning, scientific literacy develops when students are able to identify, interpret, and reason about physical phenomena in everyday contexts; however, insufficiently contextual learning media often prevent students from recognizing the relevance of physics concepts (Sari, et al., 2021).

Ideally, physics instruction should foster physics identity as an integrated construct, encompassing students' engagement, recognition within the learning community, and demonstrated competence. Research findings over the past five years and classroom observations consistently indicate that the lack of relevance between physics content and everyday experience is a major factor inhibiting the development of physics identity. This issue becomes particularly evident in challenging topics such as temperature and heat, where students frequently struggle to distinguish concepts and apply them meaningfully. Temperature and heat are foundational concepts underlying many physical phenomena and play a critical role in thermodynamics, scientific reasoning, energy literacy, and problem-solving skills (Muliyani, et al., 2023).

Hazari, et al (2010) define physics identity as a student's self-perception as a "physics person". This foundational work not only conceptualizes physics identity but also proposes a framework linking student identity–comprising personal identity, social identity, and identification with physics to key dimensions of physics identity namely recognition (being acknowledged by others), interest (a desire to engage with and understand physics), competence (the ability to comprehend physics content), and performance (the ability to carry out physics-related tasks). Physics identity reflects the process of self-identification and has been shown to enhance students' motivation to achieve higher performance in physics (Bøe, 2023). Furthermore, the relationship between physics identity, character development, and academic achievement suggests that students with a stronger physics identity tend to demonstrate more positive learning behaviours and achieve better academic outcomes (Anjelina, *et al.,* 2023).

In response to these challenges, the COTELBAPAI E-module was developed as a technology-assisted learning medium integrating local culinary wisdom Bakpia within the topic of temperature and heat (Fatmah, 2025). This E-module incorporates artificial intelligence as a reflective and conceptual reinforcement tool rather than a source of instant answers, and has been validated in terms of content quality, visual design, and material alignment. However, media feasibility does not necessarily guarantee instructional effectiveness; therefore, empirical testing is required to examine its impact on students' scientific literacy and physics identity in real classroom settings.

COTELBAPAI is an acronym for a learning media product "E-modul Suhu & Kalor Bebantuan AI Model Contextual Teaching and Learning Terintegrasi Bakpia untuk SMA/MA" that created in 2025 by Fatmah (Fatmah, 2025). "COTEL" refers to the Contextual Teaching and Learning model, BAP to bakpia as contextual local content containing heat and temperature concepts, and "AI" to Artificial Intelligence which supports learning in inquiry and modeling phases of contextual teaching and learning model.

Accordingly, this study aims to investigate the effectiveness and profile mapping of the COTELBAPAI E-module through a contextual teaching and learning framework. By integrating AI-supported reflection, local wisdom, and contextual learning strategies, this research offers a novel contribution to physics education by demonstrating how culturally grounded, technology-enhanced E-modules can simultaneously strengthen scientific literacy and physics identity, while reinforcing the relevance of physics to students' everyday experiences.

RESEARCH METHOD

Research Design

This study employed an experimental research method using a quasi-experimental design. This approach was selected because the subject groups were not randomly assigned but consisted of pre-existing groups, such as intact classroom settings within a school (Sugiyono, 2018). The research design applied was the equivalent control group design. Group equivalence was established based on the conditions that all groups were drawn from the same school, taught by the same teacher using the same instructional approach, and followed the same curriculum and learning materials.

The research was conducted at SMA Negeri 2 Banguntapan, located on Jl. Imogiri Timur, Glondong Hamlet, Wirokerten Village, Banguntapan Subdistrict, Bantul Regency, Special Region of Yogyakarta, Indonesia. The study took place during the even semester of the 2024/2025 academic year, from January to June 2025, and was implemented in several stages.

The first stage involved the exploration of local wisdom, instrument preparation, and thesis proposal writing, conducted from February 4, 2024, to March 18, 2025. The second stage consisted of data collection activities, including classroom observations and pretesting, carried out from January 6, 2025, to April 30, 2025. The third stage focused on report writing and documentation, which was conducted from May 1, 2025, to January 23, 2026.

Research Target/Subject

The school sample was selected using purposive sampling because the E-module integrates Bakpia as local wisdom originating from the Special Region of Yogyakarta specially 19 schools in Bantul regency, making geographical and cultural alignment essential. Purposive sampling refers to a non-probability sampling technique in which participants are deliberately selected based on predefined criteria that align with the objectives of the study, enabling researchers to obtain information-rich cases relevant to the research context (Privitera & Ahgrim-Delzell, 2018:462). SMA Negeri 2 Banguntapan was therefore chosen as it is located in Yogyakarta and has an institutional orientation toward developing local cultural values relevant to the E-module context.

At the class level, cluster random sampling was applied by randomly selecting classes from the available grade XI groups to form the experimental and contrast classes that consist 108 students (36 students for each class). This technique was used to ensure more objective data by equalizing initial academic conditions across classes and allowing observed differences to be attributed to the instructional treatment rather than pre-existing ability differences.

Research Procedure

The quasi-experimental research procedure using an equivalent control group design begins with the selection of two or more subject groups that have been previously formed, such as school classes, without random assignment of individual participants. This study employed one experimental class and two contrasts classes, aligned with the equivalent control group design framework proposed by Istiyono, et al. (2024, pp. 268-270) and Khairiyah, et al. (2025). These groups are chosen by considering the equivalence of initial characteristics, for example being from the same school, taught by the same teacher, using the same curriculum and learning materials, so that differences in outcomes can be attributed to the treatment provided.

Table 1. Classes and treatment on this study

Classes	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Contrast 1	O_1	X_2	O_2
Contrast 2	O_1	X_2	O_2

The notation used in this study were O_1 denotes the pretest administered to the experimental group prior to the implementation of the treatment. X_1 represent the treatement assigned to the experimental group which involves for implementation of COTELBAPAI E-module. X_2 indicates the treatment implemented in the contrast classes which employs a direct teaching model supported by the same conventional physics textbook for grade XI. O_2 refers to the posttest conducted after the treatment has been applied across all groups.

The learning process in both classes of four meetings. The first meeting was conducted to administer the pretest. The second meeting focused on the introduction of heat concepts. The third meeting covered temperature concepts and included a practicum activity. The fourth meeting was conducted to administer the posttest, aimed at measuring improvements in student's scientific literacy and physics identity.

In the experimental class, the COTELBAPAI E-module was implemented across two main topics: heat and temperature. The learning activities were structured based on the phase of the Contextual Teaching and Learning and were delivered through the class' WhatsApp group.

In the constructivism phase, students were encouraged to construct their prior knowledge of heat and temperature by exploring bakpia as local wisdom, specifically the history and production process of bakpia. In the inquiry phase, students were guided to explore and articulate their understanding using AI tools to support information searching and problem-solving. In the questioning phase, students were given the opportunity to formulate questions individually and write them down ensuring equal participation among all students. In the learning community phase, students worked collaboratively in groups of four to solve physics problems and conduct practicum activities. In the modeling phase, students demonstrated their understanding by submitting assignments online or presenting their findings in class. In the reflection phase, students received reinforcement and clarification of concepts related to heat and temperature.

In the control class, the learning process was conducted using the standard physics textbook provided by the school, which is aligned with the national curriculum. The instruction did not involve AI-based media and was not integrated with local wisdom.

After the completion of the treatment, all groups are given a post-test using the same instruments as in the pre-test. The pre-test and post-test data are then analyzed to examine differences in learning gains between groups. The comparison of score changes between the experimental and control groups is used to evaluate the effectiveness of the treatment, allowing conclusions to reflect the impact of the intervention within authentic classroom settings despite the absence of full randomization.

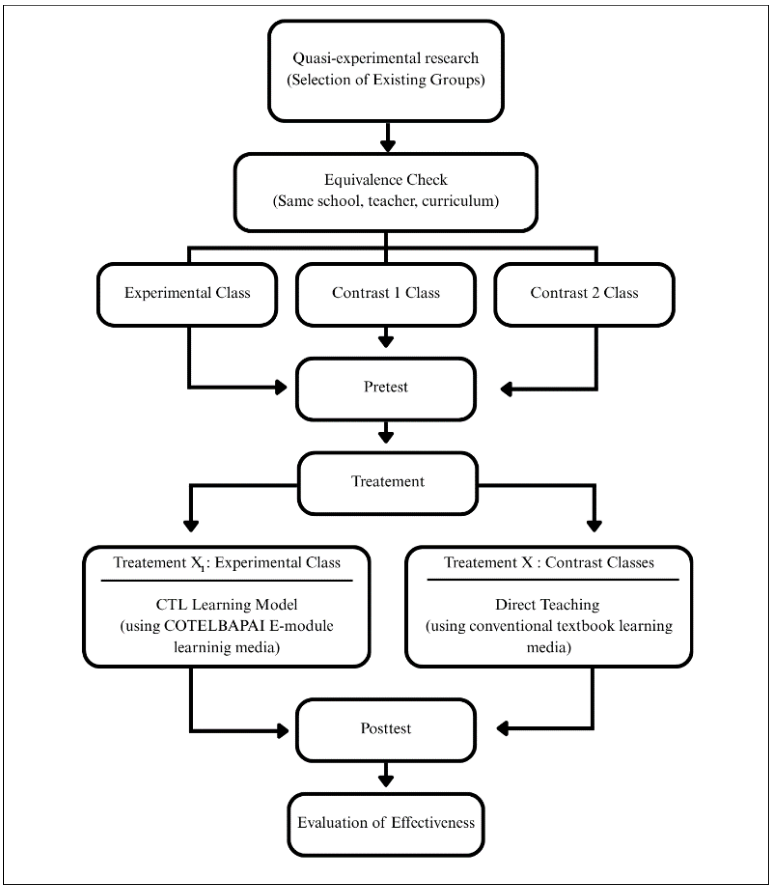

Figure 1. Schematic diagram of research procedure

Instruments, and Data Collection Techniques

Instruments for measure dependent variables were categorized into two main groups, learning material instruments and research instruments. The learning material instruments comprised the teaching module or lesson plans, COTELBAPAI E-module, and physics textbook. The research instrument tools included a student response questionnaire toward the COTELBAPAI E-module and an observation sheet assessing the implementation fidelity of the teaching module. Furthermore, research or data collection instruments are divided into learning data collection tools and variable-specific measurement instruments, as outlined in Table 2.

Table 2. Instruments used on each dependent variables

Variables	Indicator	Research Instruments
Scientific Literacy	Identifying physical phenomena occurring in daily life	Pretest and posttest (thermal expansion concept)
	Formulating hypotheses that are relevant to physical phenomena observed in daily contexts	Pretest and posttest (thermometer-related concepts)
	Analyzing physical problems scientifically through the application of appropriate physics concepts.	Pretest and posttest (phase changes)
	Drawing conclusions and making predictions based on empirical data.	Pretest and posttest (heat transfer)
Physics Identity	Interest	Interest questionnaire
	Recognition	Internal and external recognition questionnaires
	Performance	Performance assessment sheet

Variables	Indicator	Research Instruments
	Competence	Pretest and posttest (heat and temperature concept)

Data collection techniques were divided into test and non-test methods. Test-based data collection included pre-test and post-test assessments, a learning interest questionnaire, a recognition questionnaire, and a student response questionnaire. Non-test data collection techniques consisted of interviews, classroom observations, class assignment and determination, implementation of the learning process, and documentation.

Data Analysis Technique

The data analysis techniques in this study were aligned with the research objectives, as summarized in Table 3.

Table 3. Data analysis techniques

Research Objectives	Data Analysis Techniques	
	Effectivity	Mapping
To determine the effectiveness and profile mapping of the use of the COTELBAPAI E-mdule on scientific literacy To determine the effectiveness and profile mapping of the use of the COTELBAPAI E-mdule on physics identity	Prerequisite tests (normality and homogenity), non-parametric inferential statistics (Wilcoxon Signed Rank Test, Cohen's D)	Descriptive statistics (mean, mode, frequency distribution)

Prerequisite testing consisted of normality and homogeneity tests. The normality test was conducted to determine whether the collected data originated from a normally distributed population. Because the number of research subjects exceeded fifty, the Kolmogorov–Smirnov test was applied, with the significance criterion indicating normal distribution when the significance value exceeded the threshold and non-normal distribution when it fell below the threshold (Isnaini, et al., 2025).

The homogeneity test was used to examine whether the variances among data groups were equal. When the data were not normally distributed, variance homogeneity was assessed using Levene's Test, with a significance value greater than 0.05 indicating homogeneous variance and a value below 0.05 indicating non-homogeneous variance (Fahrizal, et al., 2024).

If the data did not meet the prerequisite assumptions, non-parametric inferential statistics were employed to draw conclusions from the data. In this context, the selection of samples for inferential statistical analysis is not contingent upon a specific sampling technique, rather, it's primarily determined by the underlying data characteristics and the research design framework (Stevens, 2009). One such analysis was the Wilcoxon Signed Rank Test, which was applied to paired data, such as pre-test and post-test scores, to determine whether the use of the COTELBAPAI E-module resulted in significant differences in students' scientific literacy and physics identity.

Table 4. Interpretation of the Wilcoxon Signed Rank Test (WSRT)

Asymp Sig. (2-tailed	Description
< 0.05	There is a significant difference in the use of the COTELBAPAI E-module in improving scientific literacy and physics identity
> 0.05	There is no significant difference in the use of the COTELBAPAI E-module in improving scientific literacy and physics identity

Effect size was calculated using Cohen's D to determine the magnitude of the instructional impact, with interpretation criteria presented in Table 5.

Table 5. Interpretation of Cohen's D

Cohens's d (d)	Interpretation
0.01 – 0.2	Very small effect
0.2 – 0.5	Small effect
0.5 – 0.8	Medium effect

Cohens's d (d)	Interpretation
0.8 – 1.2	Large effect
1.2 – 2	Very large effect
>2	Extremely large effect

(Cohen, 1998; Sawilowsky, 2009; Khoironi et al., 2023)

In addition, results mapping was conducted through descriptive statistical analysis, including mean values to compare pre-test and post-test results, mode to identify the most frequent scores, and frequency distribution to describe shifts in student performance profiles.

RESULTS AND DISCUSSION

The implementation of learning using the COTELBAPAI E-module (AI-assisted Temperature and Heat E-Module based on the Contextual Teaching and Learning model integrated with Bakpia local wisdom for senior high school) which shown in Figure 1 in the experimental class was conducted over four meetings. Each week, two meetings were held with time allocations of 40 minutes × 2 class periods and 40 minutes × 3 class periods. The introductory session contained an explanation of the temperature and heat learning plan for the upcoming meetings through an AI-assisted E-module integrated with Bakpia local wisdom using the CTL model.

Figure 2. Sample of COTELBAPAI E-module (Fatmah, 2025)

The E-module was introduced as a learning medium with self-learning characteristics that can support students' independent learning through its features and design. AI, as a rapidly developing technology, was already familiar to and used by several students at SMAN 2 Banguntapan to help solve various problems, both in physics and other subjects. However, the use of AI had not yet been directed toward the application of contextual knowledge, such as linking physics concepts with local wisdom, and therefore required guidance. Bakpia local wisdom was incorporated as a contextual representation of the temperature and heat material to be taught. The introduction of Bakpia to students was conducted easily, as all students were familiar with it and came from the same region where Bakpia is recognized as local wisdom, namely the Special Region of Yogyakarta.

The CTL model was explained using simpler language than that presented in Table 2, including activities such as observing, experimenting, questioning, group learning, practicing, communicating, and assessment. To improve time efficiency, the teacher asked class representatives to determine group divisions before implementing the CTL learning community phase. Group formation was conducted once throughout the learning process. Since all students in the experimental class owned smartphones and the classroom had good signal coverage, the teacher introduced the E-module by distributing it through the class group. The teacher then instructed students to complete a series of pretests measuring initial science literacy and physics identity. Subsequently, learning activities were carried out according to the CTL syntax in each meeting. Finally, at the end of the learning process, posttests were administered to measure science literacy and physics identity.

Table 6. Results of prerequisite tests

Ability measured	Prerequisite tests	
	Normality test	Homogenity test
Scientific literacy	<0.001	<0.001
Physics identity	0.002	0.271

For scientific literacy, the results of the Wilcoxon Signed Rank Test compared across the contrast classes yielded consistent outcomes, indicating a difference in scientific literacy before and after the learning intervention regardless of the type of learning media used. The results of the Wilcoxon Signed Rank Test for scientific literacy are presented in Table 7.

Table 7. Results of the wilcoxon signed rank test for scientific literacy

Classes	Asymp Sig. (2-tailed)
Experimental	< 0.001
Contrast 1	< 0.001
Contrast 2	< 0.001

Differences in scientific literacy were further examined by measuring the magnitude of the instructional effect using Cohen's D analysis. Table 7 presents a comparison of Cohen's D coefficients for each class and shows that the largest improvement in scientific literacy occurred in the experimental class, categorized as an extremely large effect.

Table 8. Cohen's d coefficients for scientific literacy in each classes

Classes	Cohens's d coefficient
Experimental	3.017
Contrast 1	1.902
Contrast 2	1.531

Profile mapping of scientific literacy was conducted in three classes with the following results.

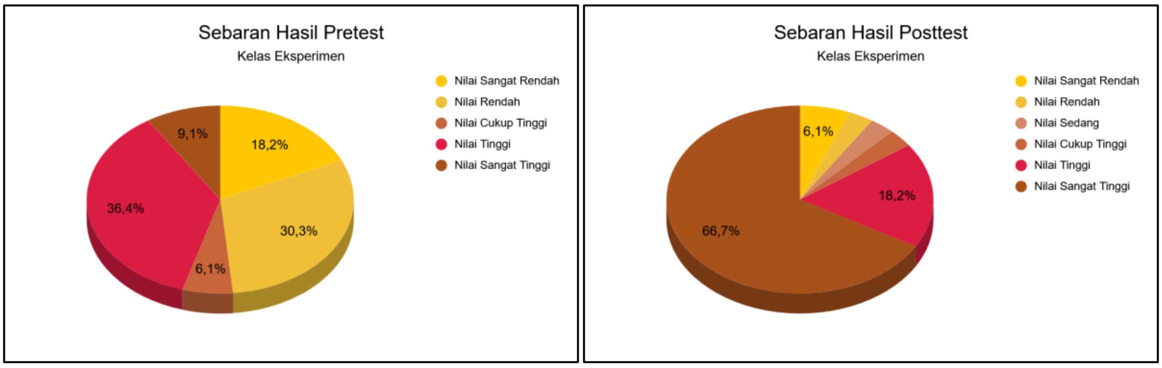

Figure 3. Mapping of science literacy scores in the experimental class

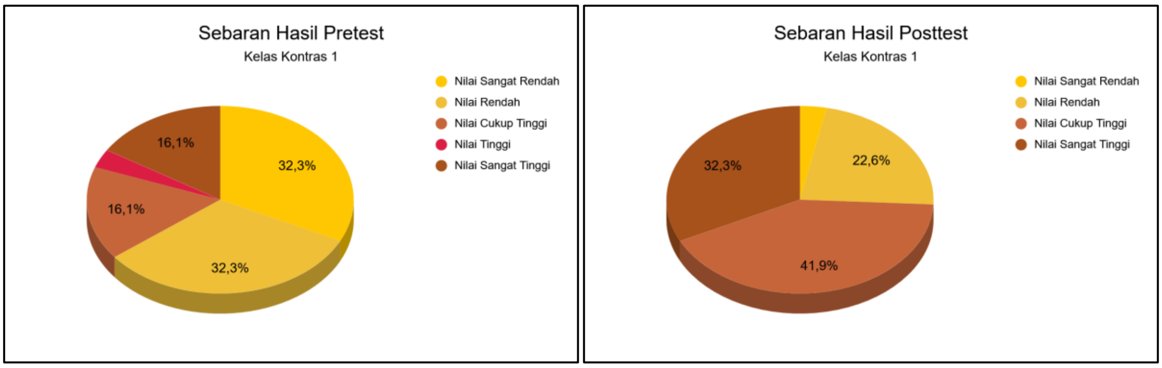

Figure 4. Mapping of science literacy scores in the contrast 1 class

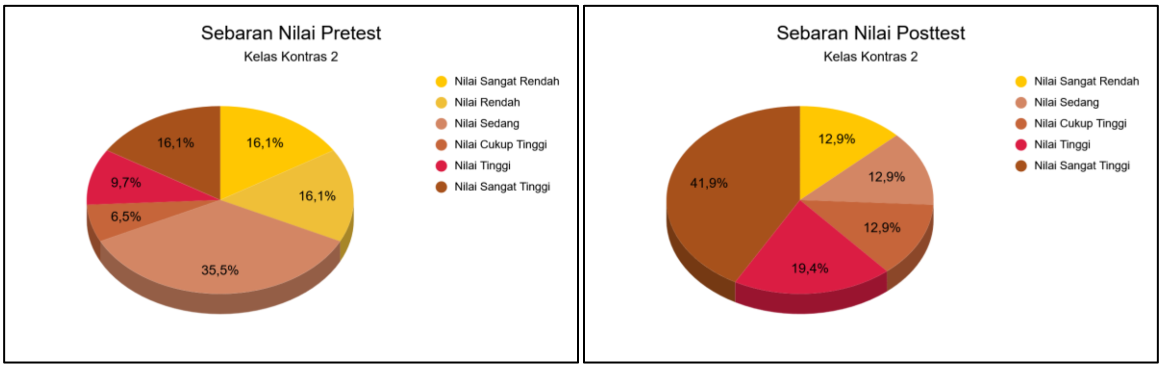

Figure 5. Mapping of science literacy scores in the contrast 2 class

The distribution of score categories differed across classes before and after the intervention. However, only in the experimental class did the very high score category become the most dominant after learning with the COTELBAPAI E-module

Regarding physics identity ability, the results of the Wilcoxon Signed Rank Test, compared with the contrast classes, indicate that only the experimental class showed a difference in physics identity ability before and after the learning intervention using the COTELBAPAI E-module.

The COTELBAPAI E-module has been proven effective in improving science literacy skills. The difference in students' science literacy scores in the experimental class before and after using the E-module indicates that the learning implementation aligns with established theoretical frameworks. In this context, the integration of local wisdom into the E-module successfully presents authentic scientific facts (Dolney, 2024). Overall evidence confirms that the implementation of an AI-assisted E-module within a CTL model integrated with Bakpia local wisdom is effective in enhancing science literacy among senior high school students.

The mapping results show that the application of the E-module consistently encourages a shift in students' science literacy toward higher levels through more meaningful and structured learning. According to constructivist learning theory, science literacy develops when learners actively reorganize prior knowledge through meaningful experiences and contextual problem-solving. This is supported by findings that integrating physics topics with students' daily experiences significantly enhances their ability to identify physical phenomena (Fitriadi et al., 2022). Contextual learning based on local wisdom, data visualization, and inquiry stages has been shown to improve hypothesis formulation skills, problem analysis, and data-based conclusion drawing and prediction (Yolanda, 2021; Widiawati et al., 2022). Therefore, both the outcome mapping and theoretical foundations indicate that the E-module plays an effective role in improving students' science literacy in a deeper and more evenly distributed manner.

Table 9. Results of the wilcoxon signed rank test for physics identity

Classes	Asymp Sig. (2-tailed)
Experimental	0.001
Contrast 1	0.187
Contrast 2	0.795

Differences in physics identity ability can be measured in terms of the magnitude of the learning intervention effect using Cohen's D analysis. Table 9 presents a comparison of Cohen's D coefficients for each class and shows that the largest effect on the improvement of physics identity occurred in the experimental class, categorized as a very large effect.

Table 10. Cohen's d coefficients for physics identity in each classes

Classes	Cohens's d coefficient
Experimental	8.872
Contrast 1	7.780
Contrast 2	3.611

The mapping of physics identity profiles was conducted in three classes with the following results.

Profile mapping of scientific literacy was conducted in three classes with the following results.

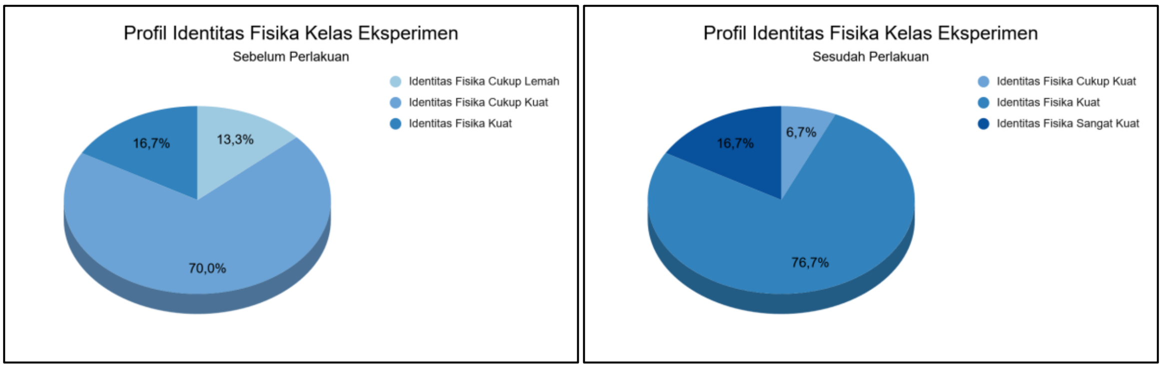

Figure 6. Mapping of physics identity scores in the experimental class

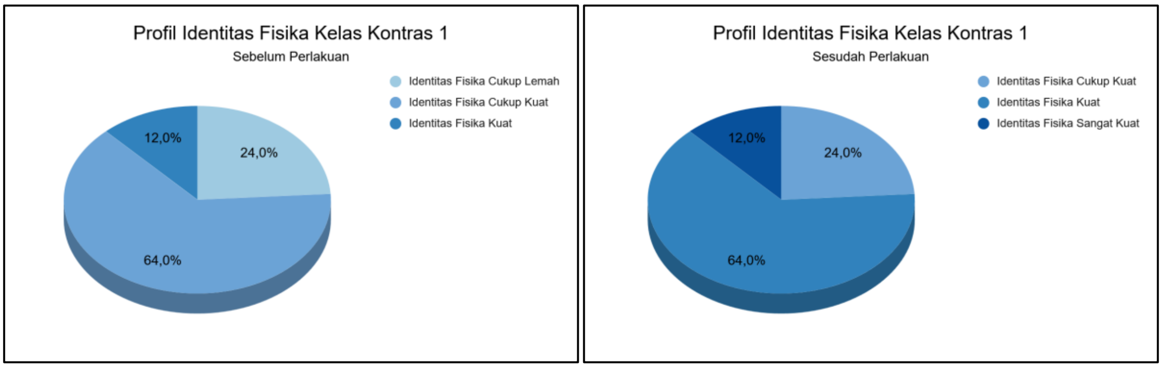

Figure 7. Mapping of physics identity scores in the contrast 1 class

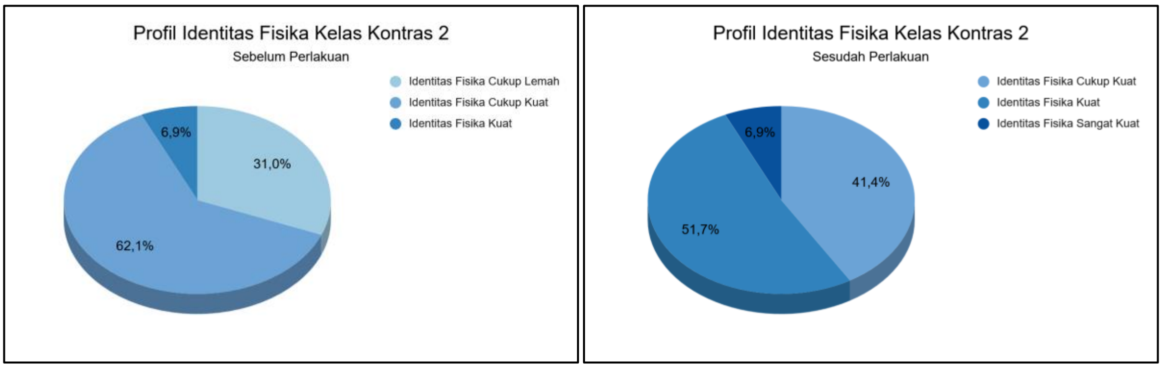

Figure 8. Mapping of physics identity scores in the contrast 2 class

The distribution of score categories differed across classes before and after the intervention. However, only in the experimental class did the very strong physics identity category appear after the learning intervention using the COTELBAPAI E-module.

The present research is positioned within a body of prior research on Contextual Teaching and Learning (CTL), which consistently highlights its effectiveness in linking learning to real-life experiences. Such applications have predominantly been conducted at the undergraduate level rather than in senior high school context (Fadhilah, et al., 2021). AI integration studies lack explicit instructional models guiding structured learning stages (Andriyeni & Zakir, 2023). Thus, AI incorporation within pedagogical syntax remains insufficiently articulated. Moreover, integration between AI and local wisdom remains unexplored. Wilujeng (2021) finding stated that local wisdom integration previously focused on textbook without effectiveness evaluation. Similarly, E-modules lacked integration of AI and local wisdom (Maghfiroh, et al., 2023). Research on physics identity that Purwaningsih, et al., (2020) did remains limited among school students. Existing studies emphasize teachers rather than students in physics identity analysis. Putri, et al. (2025) also find that science literacy lacks contextual measurement using the local wisdom framework. Comparative effectiveness studies within identical environments remain necessary. Therefore, based on the findings, this study contributes by providing empirical evidence that COTELBAPAI E-module effectively improves students' scientific literacy and physics identity. It also demonstrates that integrating CTL, AI, and local wisdom within a single instructional framework can enhance contextual understanding and student engagement in physics learning

The findings also show that the implementation of the COTELBAPAI E-module in the experimental class resulted in more meaningful development of students' physics identity compared to contrast class one and contrast class two. The provision of contextual knowledge such as local culture and the use of active, participatory learning models play an important role in enhancing physics identity (Helnova, 2021; Sasmi et al., 2025). The growth of learning interest, recognition of engagement during physics learning, performance, and increased competence is expected to contribute to the formation of students' physics identity.

The mapping results indicate that the implementation of an AI-assisted E-module integrated with Bakpia local wisdom is theoretically capable of strengthening students' physics identity through changes in engagement and self-positioning within physics learning. Profile shifts observed in the experimental class show that contextual E-module–based CTL learning promotes more meaningful engagement by integrating local culture, problem-solving activities, interactive electronic media, laboratory-based learning, and alignment with twenty-first century competencies (Ifanka, 2024; Hardani et al., 2025). The strengthening of physics identity is also shaped through structured social interactions embedded in the E-module and CTL phases such as inquiry and learning community, which reinforce students' recognition as members of the physics learning community (Wu & Yu, 2025; Hite et al., 2024). Student involvement in experimental and presentation activities becomes more evident in the experimental class, supported by contextual learning, educational technology, and AI integration that provides continuous feedback (Ibrahim et al., 2022; Morris et al., 2021). Overall, the mapping of physics identity confirms that AI-assisted E-modules grounded in CTL and local wisdom are effective in developing students' identities as active participants in physics learning.

The findings of this study imply that physics learning media integrating local wisdom and artificial intelligence have the potential to enhance students' scientific literacy and physics identity. This study also provides practical, theoretical, and technological implication for physics learning. Practically, AI-assisted E-modules with local wisdom enhance engagement and strengthen students' physics identity through contextual learning. Theoretically, this study contributes by integrating CTL, local culture, and artificial intelligence into physics identity development. Technologically, AI-based feedback supports continuous participation and aligns with 21st century competencies. However, limited sample, self-reported data, and short implementation duration may affect generalizability and long-term impact.

CONCLUSION

Implementation of COTELBAPAI E-module has been empirically demonstrated to be highly effective in enhancing students' scientific literacy and physics identity as evidenced by both effectiveness testing and profile mapping analysis. COTELBAPAI E-module exhibits a substantial effect size of 3,017 in improving scientific literacy, alongside a marked increase of 57,6% in the proportion of students categorized within the very high achievement level based on profile mapping results. Furthermore, the COTELBAPAI E-module shows exceptional effectiveness in strengthening students' physics identity, as indicated by Cohens' D coefficient of 8,872 which falls within "very large" effect size category and supported by a significant of 76.7% in the proportion of students classified as having a very strong physics identity. For future research, development of AI-assisted E-module integrating bakpia local wisdom should expand on various physics topics, the E-module display ad presentation should be delivered with high efficiency, implementation of COTELBAPAI E-module should occurs across the Yogyakarta region to assess effectiveness, extended instructional time enables deeper E-module implementation and learning.

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