

DESCRIPTIVE IMPLEMENTATION OF INTEGRATED STEM PHYSICS LEARNING IN INDONESIA AND PHILIPPINES

Ananda Resya Putri¹, Wipsar Sunu Brams Dwandaru¹, Viyanti², Anggreini², and Hazel Ann M. Cayabyab³

¹ Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

² Universitas Lampung, Lampung, Indonesia

³ Bicol University College of Education, Albay, Philippines

Corresponding author email: anandaresya.2025@student.uny.ac.id

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Abstract :

This study aims to describe and compare the implementation of integrated STEM physics learning in Indonesia and the Philippines. The study uses a qualitative descriptive research design, with non-test instruments in the form of questionnaires, interviews, and document analysis. The research subjects consisted of 11th grade students at SMAN 16 Bandar Lampung and 12th grade students in the STEM program at BUCEILS-SHS Philippines. Data validity was tested through source triangulation, while data analysis was conducted using Creswell's qualitative analysis stages. The questionnaire results showed that the implementation of integrated STEM physics learning in the Philippines obtained a percentage of 82% in the excellent category, while in Indonesia it was 75% in the good category. These findings were supported by the results of teacher interviews and learning tool analysis, which showed the integration of science, technology, engineering, and mathematics aspects through contextual learning and problem solving activities. The novelty of this study lies in its empirical comparative evidence that demonstrates how differences in national curriculum structures directly influence the depth, consistency, and effectiveness of integrated STEM physics learning implementation across countries. While previous studies have examined integrated STEM physics learning within single national contexts, field-based cross-country comparative evidence remains limited. This study addresses this gap by providing empirical data comparing STEM implementation indicators in Indonesia and the Philippines. The implications of the study indicate the need for curriculum policy support and strengthening of teacher competencies to optimize the implementation of STEM in physics learning.

Keywords: Indonesia, Philippines, Physics learning, STEM Integrated.

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INTRODUCTION

The STEM approach has now been widely implemented by various countries, including Indonesia, through collaboration with the United States Agency for International Development (USAID) (Nugroho et al., 2019). STEM-based learning methods have also been adopted by several other countries, such as Taiwan, Malaysia, Finland, Australia, Vietnam, China, and the Philippines. The STEM approach has become an important part of education reform, supported by the Philippine government through education guidelines that promote the integration of science, technology, engineering, and mathematics in the school curriculum. The Philippine government has also launched STEM education programs to strengthen the implementation of this approach in the education system.

Previous research shows that the STEM approach can develop in relation to the environment, creating learning that reflects the real-world experiences of students in their daily lives (Subramaniam et al., 2012). STEM learning activities can be hands-on or minds-on (Parmin & Sajidan, 2019). The STEM approach also actively involves students through practical activities, so that they not only acquire subject matter, but are also directly involved in practical learning (Sagala et al., 2019).

Physics lessons are very suitable for application with the STEM approach because they are in line with the characteristics of science lessons (Puspitasari et al., 2020) and form the basis for technological development (Bashooir & Supahar, 2018). The relationship between STEM and physics learning is highly significant in the context of education because physics encompasses all elements of STEM. Physics is key to understanding the scientific principles underlying physical phenomena, and STEM helps students understand the necessary scientific fundamentals. Physics and STEM learning encourage students to engage in scientific research, including formulating questions, planning experiments, collecting data, and interpreting results. This confirms the importance of integrating STEM into physics learning to provide a holistic experience and prepare students with relevant skills in science and technology.

A preliminary study at Bicol University College of Education Integrated Laboratory School-Senior High School in the Philippines found differences in the curriculum used compared to Indonesia. At the senior high school level, they only have two years, namely grades 11 and 12. Each level is divided into two programs, HUMSS (Humanities and Social Sciences) and STEM (Science, Technology, Engineering, and Mathematics). The HUMSS program is designed for students with an interest in social sciences, humanities, arts, and humanistic. Meanwhile, the STEM program is intended for students who are interested in subjects such as physics, chemistry, biology, advanced mathematics, and information technology. Physics is only taught to 12th grade students. The use of the K-12 senior high school program curriculum is the basis for developing the curriculum structure.

Interviews were also conducted with physics teachers at BUCEILS-SHS, who reported that the school has implemented integrated STEM physics learning using the Socratic method. In the learning process, not all physics material can be integrated using the STEM approach due to limited time in physics lessons and a lack of supporting facilities. Teachers focus on conceptual understanding rather than just the ability to solve physics problems. Not only that, teachers emphasize the application of physics in real life.

Preliminary studies conducted too in Indonesia, particularly at SMAN 16 Bandar Lampung and SMA Global Madani Bandar Lampung, found that both schools use the Merdeka curriculum. Teachers at both schools have implemented integrated STEM physics learning using the learning models recommended in the Merdeka curriculum, such as PBL (Project-Based Learning) and PjBL (Problem-based Learning). However, not all physics material can use these two models. In the physics learning process, teachers mostly use teaching aids in the physics laboratory, online practicums such as using PhET Colorado, PPT-based presentations, and videos. The implementation of integrated STEM physics learning has shown better learning outcomes because students are more active during the learning process compared to the lecture method.

Despite the widespread implementation of STEM based learning, variations in curriculum frameworks and policies among nations have led to inconsistent levels of STEM incorporation into physics instruction. In Indonesia, STEM lacks formal recognition as a dedicated curricular path, resulting in incomplete and teacher-driven adoption. Conversely, the Philippines has established an official STEM track in secondary education. Nevertheless, there is a scarcity of empirical comparative

research investigating how these structural disparities influence the execution of integrated STEM approaches in physics teaching.

The novelty of this study lies in its presentation of an empirical description of the implementation of integrated STEM physics learning in two different educational contexts, namely Indonesia and the Philippines. The differences in the implementation of integrated STEM physics learning in Indonesia and the Philippines indicate a gap in the education systems of the two countries. In Indonesia, STEM integration has not been explicitly accommodated in the national curriculum, so its application is still partial and highly dependent on the creativity of teachers and school policies. Meanwhile, in the Philippines, there is a special STEM track curriculum at the secondary level that directly places science, technology, engineering, and mathematics as a single unit in the learning process.

Although STEM-based learning has been widely implemented and studied in various countries, most research has focused on single-country contexts. Field-based comparative studies examining the implementation of integrated STEM physics learning across two countries with different curriculum systems remain limited. Differences in curriculum structures, such as the implicit integration of STEM in Indonesia and the existence of a formal STEM track in the Philippines, may influence the depth and consistency of science, technology, engineering, and mathematics integration in physics learning. Therefore, empirical comparative research is needed to provide measurable evidence of STEM indicator implementation in both contexts. This difference indicates a gap that needs to be analyzed to identify challenges and opportunities in improving the quality of physics learning in Indonesia to be in line with best practices in the Philippines and at the global level. Therefore, researchers are interested in conducting descriptive research on the implementation of integrated STEM physics learning in the Philippines and Indonesia.

RESEARCH METHOD

Research Design

This study uses a qualitative descriptive research design to describe the implementation of integrated STEM physics learning in the Philippines and Indonesia. The qualitative descriptive research method describes the implementation of integrated STEM physics learning in the Philippines and Indonesia as reviewed in accordance with STEM indicators. Due to time constraints in conducting the research, the material studied in this research was limited to vector material. This limitation was imposed so that the research could be more focused and in-depth, and to enable researchers to obtain relevant and measurable data in accordance with the research objectives.

Research Target/Subject

The research participants consisted of 11th grade students at SMAN 16 Bandar Lampung in the 2023/2024 academic year, comprising two physics classes (XI-5 and XI-6), and 12th grade students of the STEM program at BUCEILS-SHS Philippines. The sampling technique used in this qualitative descriptive study was purposive sampling. The selected classes were chosen based on specific criteria, namely classes that had implemented integrated STEM physics learning and were considered relevant to the objectives of this study

Research Procedure

The research was conducted through the following stages. First, preliminary observations were carried out in both schools to identify the implementation of integrated STEM physics learning. Second, research instruments were prepared, including a questionnaire, interview guide, and document analysis sheet. Third, questionnaires were distributed to students, using google form in Philippines and printed forms in Indonesia. Fourth, Interviews were conducted with physics teachers in both schools to obtain in-depth information regarding the planning, implementation, challenges, and evaluation of integrated STEM physics learning. Fifth, relevant documents such as curriculum structures, lesson plans or teaching modules, teaching materials, learning media, and assessment instruments were collected and analyzed.

Instruments, and Data Collection Techniques

The data collection instruments used in qualitative research according to Creswell (2013) are interview, questionnaires, and document analysis. Non-test instruments in the form of questionnaires were distributed to students to determine the percentage of STEM indicators in physics learning that had been implemented in the Philippines and Indonesia. The questionnaires distributed were in the form of a Likert scale with a minimum score of 1 and a maximum score of 4 (Sugiyono, 2011) According to Sugiyono (2016), interviews are a data collection technique used when researchers want to conduct preliminary studies to identify issues that need to be researched, as well as when researchers want to obtain more in-depth information from respondents. Interviews were conducted by researchers with teachers at SMA 16 Bandar Lampung and BUCEILS-SHS. According to Morgan (2022), documentation is a data collection technique that involves compiling and analyzing documents, including written, image, and electronic documents. The documentation used in this study consisted of the learning tools used by teachers during the learning process, teaching materials, learning media, and assessment instruments.

Each statement in the questionnaire represents variables from integrated STEM physics learning in Indonesia and the Philippines. There are four aspects observed with a total of 19 statements. The following is the content of the questionnaire distributed in Table 1.

Table 1. Questionnaire grid for student STEM indicators

No.	Aspects analyzed	Description of aspects	Statement points
1.	Implementation of STEM-integrated physics learning	Implementation of STEM-integrated physics learning in schools	1
2.	STEM indicators in physics learning	Aspects of technology used by teachers in physics	2,3,4,5,6
		Aspects of science used by teachers in physics	7,8,9,10
		Aspects of engineering used by teachers in physics	11,12,13,14,15
		Aspects of mathematics used by teachers in physics	16,17
3.	Student engagement	The state of students during learning	18
4.	Difficulties in learning	Obstacles in learning	19

Because the questionnaire sheet on the implementation of integrated STEM physics learning uses a Likert scale consisting of 4 categories, each category has a specific interval that indicates the level of achievement of learning implementation. The intervals for each category can be seen in Table 2. The description of the categories of integrated STEM physics learning implementation is as follows according to Sugiyono (2017).

Table 2. Questionnaire percentage

Percentage	Criteria
80,1% - 100%	Very good
60,1% - 80%	Good
40,1% - 60%	Enough
20,1% - 40%	Poor
0% - 20%	Very poor

The collected data was tested for validity using triangulation. The triangulation technique is a technique for collecting existing data and sources (Sugiyono, 2017). Triangulation with sources means comparing and double-checking the degree of reliability of information obtained through different times and tools in qualitative research (Ediyanto et al., 2025). The following is the data triangulation cycle according to Denzin (2017) can be seen in the Figure 1.

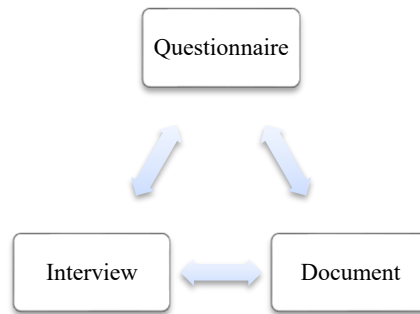


Figure 1. Data triangulation

Data Analysis Technique

After testing the credibility of the data using triangulation, the data is then analyzed. Data analysis is the process of organizing data, arranging it into patterns, categories, and basic units of description (Moleong & Surjaman, 2014). Data analysis is carried out to verify the accuracy of the data obtained. The researcher used Creswell (2013) data analysis technique, which explains that data analysis techniques in qualitative research go through several stages, as shown in Figure 2.

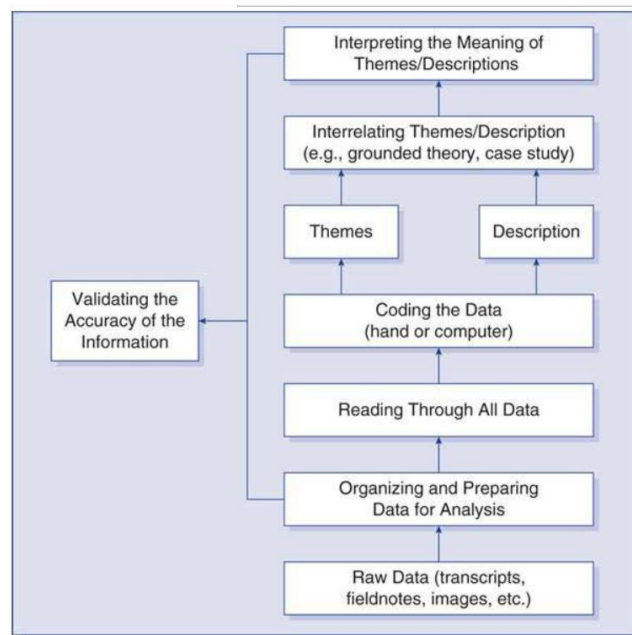


Figure 2. Data analysis techniques

RESULTS AND DISCUSSION

This study uses a qualitative approach to describe the implementation of integrated STEM physics learning in the Philippines and Indonesia. The instruments used in this study were non-test instruments in the form of questionnaires, interviews, and document analysis with the following results.

The questionnaire was distributed to 39 students at BUCEILS-SHS Philippines and 36 students at SMAN 16 Bandar Lampung. The questionnaire was distributed via G-Form, and responses were successfully obtained from 39 BUCEILS-SHS students. Meanwhile, for students at SMAN 16 Bandar Lampung, the questionnaire was distributed directly and responded to by 36 students. The following presents the results of the calculation or recapitulation of the questionnaire scores carried out at BUCEILS-SHS SMAN 16 Bandar Lampung in Figure 3.

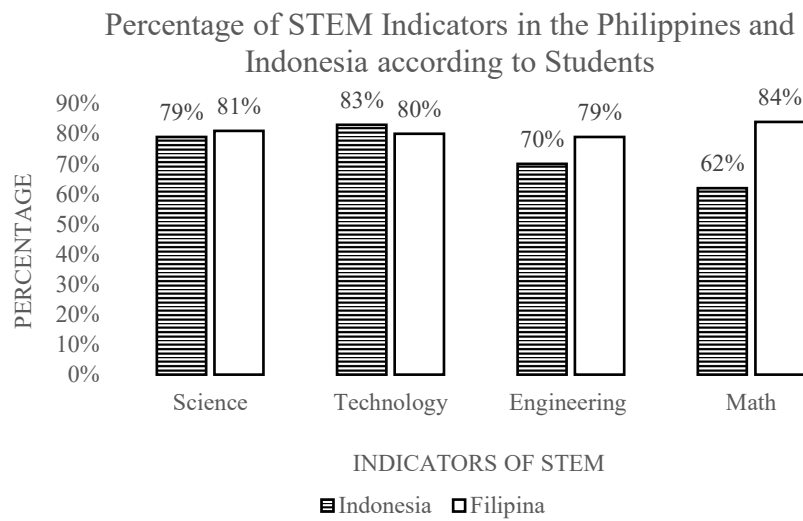


Figure 3. Percentage of STEM indicators in the Philippines and Indonesia

Interviews were only conducted with physics teachers in the Philippines and Indonesia. This was because the researchers wanted to obtain more in-depth information through the teachers' perspectives on STEM-integrated physics learning that had been taught by teachers to students at school. The interviews consisted of 15 questions containing the teachers' views on the implementation of STEM-integrated physics learning in the Philippines and Indonesia.

Interviews with physics teachers at BUCEILS-SHS Philippines showed that teachers already had experience in applying physics learning with an integrated STEM approach through various methods, such as interdisciplinary, collaborative, inquiry-based approaches, the use of technology, and linking physics material to real-life applications. Teachers interpret the integrated STEM approach as the use of various physics teaching techniques, including problem-based and inquiry-based learning, which integrate science, technology, engineering, and mathematics. The main objectives of STEM integration in physics learning are to provide a comprehensive and meaningful learning experience, prepare students for modern STEM careers, and improve critical thinking, analytical, and technological literacy skills.

In lesson planning, teachers emphasize clear learning objectives, the use of technological tools, and mathematical modelling with reference to the K–12 Physics curriculum established by the Philippine Department of Education. Teachers select real-world issues as the context for learning, but in practice, they have not fully implemented project-based or problem-based learning directly due to time constraints. Nevertheless, teachers utilize various media and learning resources, such as textbooks, PhET Colorado simulations, Desmos, GeoGebra, PowerPoint presentations, digital documents, and educational videos. Learning outcomes show an increase in students' conceptual understanding, critical thinking skills, problem solving, and research abilities. Teachers also face challenges in explaining the interrelationships between disciplines, limitations in physics laboratory facilities, and STEM integration evaluation that is considered suboptimal, particularly in the integration of technology and engineering aspects and time management to cover broad physics competencies. Learning assessment is conducted through written tests, student worksheets, and authentic assignments, such as video production and experiment design by students.

Meanwhile, interviews with physics teachers at SMAN 16 Bandar Lampung showed that teachers had implemented STEM-integrated physics learning by systematically connecting science, technology, engineering, and mathematics. This approach aims to improve students' STEM literacy and develop critical, creative, collaborative, and communicative thinking skills. In planning the learning process, teachers set learning objectives, compile teaching modules, and prepare supporting facilities and infrastructure. Although not all physics material can be integrated, the STEM approach is applied to certain material, such as vectors and fluids, through project-based and problem-based learning models.

The implementation of learning showed an increase in student learning outcomes across the board, accompanied by increased student activity and interactivity. The learning media used included PowerPoint presentations, the internet, posters, PhET Colorado simulations, and Google Maps. The main challenges faced were the need for careful planning and the relatively long time required to implement the project, which were overcome by strengthening basic physics concepts and providing assistance in designing innovations. The impact of integrated STEM physics learning can be seen in the improvement in student learning outcomes, motivation, interest in learning, and collaboration skills, with assessments carried out formatively and through performance assessments.

The results of the research based on document analysis show that physics learning at BUCEILS-SHS Philippines and SMAN 16 Bandar Lampung is supported by relatively complete learning tools, including curriculum, teaching modules or lesson plans, teaching materials, and assessment instruments. The document analysis aimed to identify the characteristics of physics learning and the form of STEM approach integration applied in each school. The documents analyzed reflect different national education policies, but both lead to the strengthening of science literacy and 21st-century competencies.

In terms of curriculum, BUCEILS-SHS Philippines implements the K-12 Curriculum under the Philippine Department of Education, with physics taught in Grade 12 of the STEM program and supplemented with learning competencies for each topic. Meanwhile, SMAN 16 Bandar Lampung uses the Merdeka Curriculum, which places physics as an elective subject in Phases E and F, with a focus on mastering essential concepts and strengthening the character of the Pancasila Student Profile. The teaching modules at BUCEILS-SHS are arranged in the form of lesson plans using the 7E learning model, while SMAN 16 Bandar Lampung uses Merdeka Curriculum teaching modules arranged based on Learning Objectives and Learning Outcomes. Both learning tools demonstrate STEM integration through contextual learning, the use of technology, and problem-solving activities.

In terms of teaching materials, BUCEILS-SHS uses the General Physics 1 textbook and e-modules compiled by teachers, while SMAN 16 Bandar Lampung uses official e-books from the Ministry of Education, Culture, Research, and Technology and LKPD developed by subject teachers. Vector material is one of the learning focuses in both schools. The assessment instruments at BUCEILS-SHS apply authentic assessment, which includes written works, performance tasks, and quarterly assessments, while SMAN 16 Bandar Lampung uses formative assessment, which includes attitude assessment, process skills, performance, and mid-term and end-of-semester tests. In general, both schools have developed an assessment system that assesses the learning process and outcomes as part of integrated STEM physics learning.

This discussion examines the implementation of integrated STEM physics learning in the Philippines and Indonesia based on student questionnaire data, teacher interviews, and analysis of learning tools. The discussion focuses on the achievement of STEM indicators and factors that influence differences in implementation in both countries.

The results of the study show that the implementation of integrated STEM physics learning in the Philippines is in the excellent category with a percentage of 82%. This achievement indicates that the elements of Science, Technology, Engineering, and Mathematics have been consistently integrated into physics learning. This high percentage is inseparable from the Philippine curriculum structure, which explicitly provides a STEM Track at the high school level. These results refer to research conducted by Manalo (2025), which highlights the effectiveness of integrating STEM pathways into the Philippine K-12 curriculum. The K-12 curriculum in the Philippines places physics as a specialized subject, so that learning is designed to be more in-depth and contextual. This allows teachers to relate physics concepts to real-world problems that require an understanding of STEM disciplines. The research conducted by (Tan et al., 2025) also emphasizes how teachers in Southeast Asia, including the Philippines, develop cross-disciplinary STEM curriculum objectives that strengthen the consistency of science, technology, engineering, and mathematics integration in learning. This finding indicates that the high implementation of integrated STEM physics learning in the Philippines not only aligns with previous research emphasizing the importance of structured curriculum support, but also provides empirical evidence that the existence of a STEM Track within the K-12 system contributes to more systematic and consistent integration of science, technology, engineering, and mathematics at the classroom level.

Based on interview results, physics teachers at BUCEILS-SHS have implemented STEM-integrated physics learning through conceptual and contextual approaches. Building on previous research by A. Funa et al., (2024) on the Integrated STEM and Problem-Based Learning (*I-STEM-PBL-ESD*) framework, this study emphasizes the importance of conceptual and contextual understanding in STEM education for sustainable learning. Teachers emphasize conceptual understanding over simply solving mathematical problems, and relate physics material to everyday phenomena. The use of learning technologies such as PhET Colorado, e-modules, learning videos, and digital presentations reinforces the Technology aspect of STEM learning. The use of digital media such as PhET, e-modules, and learning videos is also reinforced by Govender (2025) study, which confirms that digital literacy and the use of interactive technological tools greatly support the development of students' STEM skills. The results indicate that the integration of conceptual understanding, real-life contextualization, and the use of digital technology in integrated STEM physics learning reflects a form of coherence that is not merely technical, but also pedagogical and structural, thereby contributing to more meaningful and applicable learning aligned with 21st-century competencies.

In addition, the Engineering aspect is evident from the students' involvement in problem-solving and simple solution design activities, although these are not yet fully project-based due to time constraints. Mathematics aspect continues to be used as a tool for analyzing physics concepts, rather than as the main objective of learning. These findings are in line with previous research stating that STEM learning is effective when mathematics is used as a tool to explain scientific phenomena, rather than as the main focus of learning. Student involvement in problem solving and simple engineering activities that are not yet fully project-based is in line with the problem-based learning model in STEM education studied by A. Funa (2024). This model emphasizes problem-based learning activities as a means of naturally applying the aspects of Engineering and Mathematics. In addition, Sahito & Wassan (2024) also show that the effectiveness of STEM learning increases when mathematics is used as a tool to explain scientific phenomena, rather than as the main objective of learning. Thus, students' involvement in problem-solving and simple solution design, although not yet fully project-based, indicates that the integration of Engineering and Mathematics in physics learning functions more as a means of strengthening conceptual understanding and analytical thinking skills rather than merely achieving procedural outcomes.

Overall, the implementation of integrated STEM physics learning in the Philippines demonstrates a consistent and structured integration of Science, Technology, Engineering, and Mathematics, supported by the existence of a STEM Track within the K–12 system and reinforced through conceptual, contextual, and technology-supported instructional practices. This integration is reflected not only at the curriculum policy level but also in teachers' pedagogical strategies that emphasize conceptual understanding, real-life relevance, and the use of engineering and mathematics as tools to strengthen analytical thinking and problem-solving skills.

The implementation of integrated STEM physics learning in Indonesia is categorized as good, with a percentage of 75%. This result shows that STEM learning has been implemented, but not optimally across all indicators. In the Indonesian context, the application of STEM is greatly influenced by teacher creativity because the national curriculum does not explicitly include STEM as the main approach to physics learning. Based on document analysis and interviews, teachers at SMAN 16 Bandar Lampung implement integrated STEM learning through the Project-Based Learning (PjBL) and Problem-Based Learning (PBL) models in accordance with the Merdeka Curriculum guidelines. Research conducted by Solihin et al., (2021) emphasizes the importance of teacher innovation in adapting the STEM approach without major structural changes to the curriculum. Research conducted by Irma Waty Simanjuntak & Purwaningsih (2024) confirms that the implementation of STEM-based Problem-Based Learning is effective in building problem-solving skills and contextual understanding of physics concepts. The implementation of integrated STEM physics learning in Indonesia shows that although it is not explicitly supported by the curriculum structure, STEM integration can still be carried out through teachers' pedagogical innovation and initiative; however, its consistency largely depends on the capacity and creativity of individual educators.

The Science aspect is seen in observation, experimentation, and understanding of physics concepts. The Technology aspect is realized through the use of learning media such as PhET

Colorado, the internet, PPT, and learning videos. The Engineering aspect emerges through the design of solutions or simple projects, while the mathematics aspect is used to analyze and solve physics problems. In line with the research by Laila & Anggaryani (2021), the use of STEM-integrated Virtual Laboratories (PhET) in physics lessons has a significant effect on students' problem-solving skills. Previous research by Mulyani (2019) states that STEM has been widely applied in learning. STEM-integrated physics learning helps students to use technology. The use of digital media such as PhET, the internet, and learning videos as representations of the Technology aspect in STEM is also supported by Samsudin & Liliawati (2022), who found that interactive technology increases student participation and understanding in physics learning. The integration of Science, Technology, Engineering, and Mathematics aspects in physics learning in Indonesia demonstrates that STEM integration is not merely reflected in the use of digital media or simple project activities, but also in the interaction among these aspects that simultaneously fosters conceptual understanding, analytical thinking skills, and students' technological literacy, thereby creating a more holistic and contextual learning experience.

However, teachers experience several obstacles in implementing STEM, including limited learning time, varying mathematical abilities of students, and the need for more careful lesson planning. These obstacles prevent the maximum integration of all physics material using the STEM approach. The obstacles faced by teachers, such as time constraints, variations in students' mathematical abilities, and the need for careful planning, are in line with the findings of Nurmaliah et al., (2021), who reported that the success of PjBL-STEM implementation is highly dependent on teacher readiness and sufficient learning time support. Similar constraints were also identified by Indrasti & Paidi (2025), who emphasized the need for teacher training and systematic planning so that STEM integration can cover all physics topics more comprehensively. These challenges indicate that STEM implementation in Indonesia is still at an adaptive stage, where integration largely depends on classroom conditions and individual teacher capacity, thereby potentially leading to disparities in the quality of implementation across topics and classes.

The implementation of integrated STEM physics learning in Indonesia indicates that integration has been carried out in the good category through the use of PjBL and PBL approaches as well as digital technology utilization; however, its implementation remains contextual and highly dependent on teachers' initiative and readiness, so the consistency and depth of integration across the Science, Technology, Engineering, and Mathematics aspects are not yet evenly distributed and are still influenced by time constraints, lesson planning demands, and variations in students' abilities.

The difference in the results of integrated STEM physics learning implementation between the Philippines and Indonesia is influenced by differences in curriculum policies and education systems in each country. The Philippines has a specific STEM curriculum that structurally supports the integration of science, technology, engineering, and mathematics into a single learning unit. Meanwhile, in Indonesia, STEM is still implicit and depends on teacher initiatives and school policies. In a study by A. Funa (2024) it is explained that the Philippine curriculum allows for the systematic application of problem-based and integrated STEM learning. In contrast, in Indonesia, the STEM approach is still implicit and highly dependent on teacher initiatives and school policies. This is confirmed by Muchtar* & Ding (2024), who found that most physics teachers in Indonesia understand the concept of STEM, but its implementation is not yet uniform due to the lack of explicit guidance in the national curriculum. The differences in STEM implementation outcomes between the Philippines and Indonesia indicate that the presence of an explicitly structured STEM curriculum plays a crucial role in ensuring consistency and uniformity of classroom practices, whereas an implicit approach tends to result in more variable implementation that largely depends on individual teacher capacity.

Nevertheless, the results of the study show that STEM-integrated physics learning in both countries has had a positive impact on student engagement and activity in learning. Students have become more active, critical, and able to relate physics concepts to real life. These findings reinforce the view that the STEM approach is relevant for improving the quality of physics learning and 21st-century skills. Research by Cahya et al., (2025) found that STEM integration enhances the active and collaborative character of students in Indonesia and the Philippines, strengthening higher-order thinking skills and global citizenship values. A similar finding was reported by Francisca et al., (2021), who showed that the STEM-integrated learning approach significantly improved Indonesian

students' understanding of physics concepts and problem-solving skills. Furthermore, Tan et al., (2025) emphasized that the successful implementation of STEM in Southeast Asia also depends on teachers' ability to develop interdisciplinary curricula focused on 21st-century skills. Taken together, these results suggest that beyond structural curriculum differences, the integration of STEM in physics learning in both contexts contributes to the development of active engagement, critical thinking, and real-world problem-solving skills, thereby reinforcing its relevance as a pedagogical approach for fostering 21st-century competencies when supported by interdisciplinary instructional practices.

Thus, the results of this study imply that the implementation of STEM-integrated physics learning in Indonesia needs to be supported more systematically through curriculum policies, strengthening teacher competencies, and providing adequate learning facilities so that its implementation can be on par with countries that already have special STEM pathways, such as the Philippines. This recommendation is in line with literature review Nurwahyunani (2021) which emphasizes that the STEM approach can improve the quality of science learning if it is supported by national policies and structured teacher training programs. Meanwhile, Nurhairani et al., (2024) show that at the ASEAN level, STEM integration linked to the local cultural context has been proven to strengthen the relevance of learning and improve the success of cross-border education policy implementation. Strengthening STEM implementation in Indonesia requires more structured curriculum policies, enhanced teacher competencies, and adequate learning facilities to ensure that its integration can be carried out more systematically and sustainably.

This study has several limitations that should be considered when interpreting the results. First, the research focused only on vector material, which may limit the applicability of the findings to other physics topics that require different forms of interdisciplinary integration. In addition, the study involved only one senior high school in Indonesia and one in the Philippines; therefore, the findings may reflect specific institutional characteristics such as school culture, teacher readiness, and available facilities rather than fully representing national-level STEM implementation in both countries. The duration of the research was also relatively limited, which may not fully capture the long-term consistency and sustainability of STEM integration in classroom practice.

Furthermore, although multiple data sources were used, including questionnaires, interviews, and document analysis, much of the data relied on participants' perceptions and descriptive interpretation, which may introduce subjectivity. The geographical distance between the two research locations also limited direct classroom observation, potentially affecting the depth of contextual analysis. Future research is recommended to involve more schools, broader physics content, longer observation periods, and more intensive direct classroom engagement to obtain a more comprehensive understanding of integrated STEM physics learning implementation

CONCLUSION

Based on the results of the study, it can be concluded that integrated STEM physics learning in the Philippines and Indonesia has been implemented well. Student questionnaire results show that STEM implementation in the Philippines is in the excellent category with a percentage of 82%, while in Indonesia it is in the good category with a percentage of 75%. The difference in the level of implementation is influenced by differences in curriculum policy and education systems in each country. In the Philippines, the existence of a specific STEM curriculum pathway allows for a more structured and consistent integration of science, technology, engineering, and mathematics in physics learning. Meanwhile, in Indonesia, the application of STEM is still implicit in the curriculum, so its implementation is highly dependent on the creativity of teachers, the readiness of students, and the availability of supporting facilities and infrastructure.

Nevertheless, STEM-integrated physics learning in both countries has demonstrated positive impacts on student engagement, conceptual understanding, and the development of critical thinking and problem-solving skills. Therefore, strengthening STEM implementation in Indonesia requires more explicit curriculum policies, continuous and targeted teacher professional development, as well as adequate learning facilities and time allocation. With more systematic support, STEM implementation can be carried out more consistently, structured, and sustainably, rather than relying solely on individual teacher initiative.

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