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Application of the STEAM Approach in Physics Education in Indonesia: as an Initiative in Realizing the Sustainable Development Goals

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ABSTRACT

Objective: *The research aims to study the implementation of the STEAM approach in learning physics in Indonesia.* ***Method:*** *The method applied is a library study or literature review. This involves analyzing articles related to the STEAM approach in physics education in Indonesia, specifically those published between 2019 and 2023.* ***Results:*** *Findings reveal that the application of the STEAM approach in learning physics in Indonesia is relatively low during this period. Teachers encounter considerable challenges in effectively applying this approach. However, there are instances of successful research that demonstrate the effective use of the STEAM method to achieve desirable educational outcomes.* ***Novelty:*** *The research offers valuable new insights into the application of the STEAM approach in physics learning in Indonesia and connects these insights to the larger initiative of achieving the Sustainable Development Goals (SDGs). Future studies could investigate the relationship between the implementation of the STEAM approach in physics education and the progress towards achieving SDG goals through various educational initiatives. This exploration could help identify effective strategies for integrating STEAM principles into physics education and further contribute to sustainable development in the region.*

INTRODUCTION

Education is an essential aspect of a nation's progress. If humans receive education, they can develop themselves ultimately regarding their scientific potential. Through education, a nation can improve the standard of living of all citizens and build the dignity of the state and nation. Therefore, the government seeks to provide serious attention in an effort to overcome various problems in the field of education, starting from elementary, secondary, and higher education levels (Pristiwanti et al., 2022).

Current education has placed holistic and multidisciplinary learning as the primary focus (Wahyuni et al., 2023). This is through the development of the independent curriculum, which aims to produce graduates who have skills and competencies, which is one of the courses that plays an important role in developing students' abilities and understanding of the world around them (Satriawan, 2017). Education also has its role in responding to advances in science and technology and the increasingly rapid and complex flow of globalization in the 21st century (Maulidiansy et al., 2023).

The 21st century presents complex challenges that can be addressed through education. By providing effective education, we can prepare the younger generation to become graduates capable of competing with technology in today's world (Asrizal et al., 2018). Consequently, learning in the 21st century requires educators to possess creativity and innovation in their teaching methods (Khasanah et al., 2024). Through education, the next generation can develop new patterns of thinking, skills, values, and attitudes that will enable them to create positive change and work towards a sustainable world

(Sudarmin et al., 2021). Since 1992, UNESCO has promoted education for sustainable development. Therefore, in the current era of the Sustainable Development Goals (SDGs), immediate action is necessary to enhance the quality of education and ensure comprehensive learning opportunities for all children (Tanaka et al., 2019).

Various subjects have been implemented in schools to enhance the quality of education in Indonesia. One important subject is physics, which helps develop 21st-century skills necessary for achieving Sustainable Development Goals (SDGs). The primary aim of learning physics is for students to enhance their critical thinking skills, enabling them to solve everyday problems using the physics concepts they have learned (Rosdiana et al., 2022). However, a survey conducted by TIMSS (Trends in International Mathematics and Science Study) revealed concerning findings regarding students' problem-solving abilities, which were relatively low. This is evident from the significant number of students who struggle with mathematics problems (Hendri et al., 2023). The root of this issue lies in the fact that current physics instruction often focuses primarily on theoretical information and lacks practical application (Widarti, 2023). Meaningful physics learning should encourage students to discover and engage with concepts in a way that promotes deeper understanding and application.

The challenges encountered in physics education can be addressed by implementing the STEAM approach in the learning process. The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach combines these five disciplines to enhance critical thinking skills, problem-solving abilities, and creativity (Rahman et al., 2023). This approach has shown a positive impact on the creative thinking skills of high school students, particularly in their understanding of physics concepts (Rohman et al., 2021). Using the STEAM approach in physics education enables students to transition from a theoretical focus to a more practical and interactive learning experience that incorporates STEAM elements (Amiruddin et al., 2022). STEAM is an integrated learning framework that brings together the subjects of Science, Technology, Engineering, Arts, and Mathematics to foster students' thinking, communication, and critical thinking skills during their education (Fitriyah et al., 2021).

Briefly, the concept of STEAM in learning is 1) Science: the study of natural sciences (including the laws of nature related to physics, chemistry, and biology); 2) Technology: technology or devices used to support learning (consisting of the entire human and organizational system, knowledge, processes, and devices used to create and operate technological artifacts, as well as the artifacts themselves; 3) Engineering: techniques or engineering in solving problems (including knowledge of product design and creation; 4) Art: art and creativity; and 5) Mathematics: The language of shapes, numbers, and quantities including theoretical mathematics and applied mathematics (Bahrum et al., 2017). Overall, the STEAM approach promotes a comprehensive and engaging educational experience that equips students with essential skills for their future.

The STEAM approach offers students the opportunity to broaden their understanding of both scientific and humanitarian disciplines while simultaneously developing essential 21st-century skills. These skills include critical thinking, teamwork, communication, leadership, creativity, resilience, and others, which can flourish when learning is structured around the STEAM framework (Rahmawati et al., 2019). Therefore, it is anticipated that applying the STEAM approach to physics education can enhance students' 21st-century skills. Despite its growing popularity, the implementation of the STEAM approach in Indonesia remains limited. Only a handful of schools have adopted

STEAM learning practices (Maulidiansy et al., 2023). This limitation is particularly evident in the context of physics education, where the utilization of the STEAM approach is still insufficient. Given these challenges, this study aims to explore the development of research focused on applying the STEAM approach to physics learning in Indonesia.

RESEARCH METHOD

This study employs the literature review method. A literature review is a scientific approach that focuses on a specific topic, providing an overview of its development. This method allows researchers to identify and refine theories or methods, while also highlighting gaps between established theories and their practical relevance or application in research findings (Rowley, 2004; Bettany-Saltikov, 2012).

The literature review includes articles published from 2019 to 2023 that are fully accessible via Google Scholar. The reviewed articles meet specific criteria: they must involve research conducted in Indonesia, implement the STEAM approach, apply it to physics education, and be indexed by Sinta. The literature search focuses on the following keywords: 1) STEAM learning, 2) STEAM in Indonesia, and 3) Physics learning using the STEAM approach. This research follows five stages of the literature review process, which are:

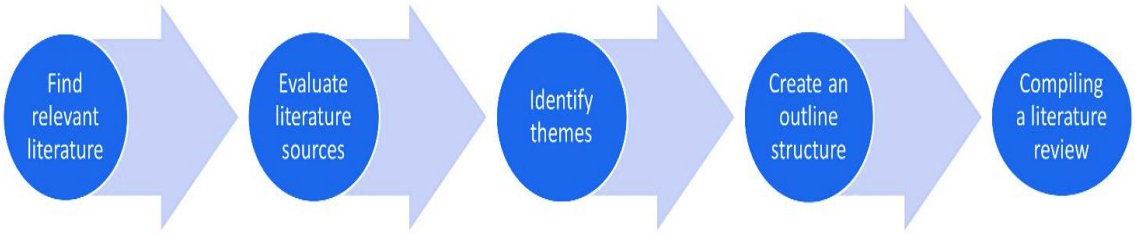

FIGURE 1. Stages of literature review

Figure 1 shows the first stage, I conducted a search for relevant literature using Google Scholar. In the second stage, I evaluated the literature obtained to ensure it met the criteria established for this research. The third stage involves identifying themes within the selected literature. The fourth stage outlines the structure of the literature related to the findings from the first three stages. Finally, in the fifth stage, a comprehensive review and compilation of the literature is completed.

RESULTS AND DISCUSSION

Results

A systematic review of scientific articles indicates that there have been very few studies over the last five years that utilize the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach in physics education in Indonesia. This aligns with previous research that has shown satisfactory results when applying the STEAM approach to physics learning in the country. Notably, studies have demonstrated improvements in students' critical thinking skills and conceptual understanding (Fitria et al., 2023; Budiyono et al., 2020).

The STEAM approach consists of several stages, starting with the presentation of materials, followed by a discussion of potential solutions to problems. After these discussions, students have the opportunity to design their own STEAM projects for

learning (Efwinda et al., 2021). A key aspect of learning through the STEAM approach is the ability for students to develop their own ideas while also understanding the perspectives of others in various situations encountered during their learning process (Ozkan, 2021). Understanding concepts is crucial in both the learning process and in problem-solving, both academically and in daily life (Jannah, 2022). The STEAM approach effectively connects theory with real-life applications, enhancing students' conceptual understanding and their ability to tackle existing problems. Furthermore, STEAM can be integrated with Education for Sustainable Development (ESD), aligning physics education with essential 21st-century skills. Table 1 shows implementation of STEAM learning in physics learning in Indonesia.

Table 1. Implementation of STEAM learning in physics learning in Indonesia

Source	Findings
Lestari (2021)	This study aims to describe the development of 21st-century skills with STEAM-based PjBL learning assisted by Spectra-Plus on the subject matter of sound wave musical instrument prototypes. The results indicate that learning with the STEAM method can develop soft skills because students are given a comprehensive understanding of science through 21st-century skills.
Kartika et al. (2022)	This study analyzes the application of constructivist learning theory in STEAM-based physics learning. The results show that STEAM-based learning is implemented using constructivist principles.
Rosdiana et al. (2022)	This study aims to determine students' high-level thinking skills using the STEAM method on regular straight-motion material. The results obtained indicate that STEAM learning can improve students' high-level thinking skills on regular straight-motion material in class X IPA 5 SMA Negeri 2 Peseusang.
Jannah et al. (2022)	This study aims to determine the impact of the STEAM approach to static fluid material on the conceptual understanding of class XI students of SMA Negeri 1 Jangka. The research found that STEAM learning influenced students' conceptual understanding of static fluid material for class XI SMA Negeri 1 Jangka.
Widarti & Roshayanti (2021)	This study analyzes the potential of implementing STEAM (Science, Technology, Engineering, Arts, and Mathematics) oriented to ESD (Education for Sustainable Development) in fluid learning. The results obtained show that implementing ESD-oriented STEAM in learning also provides students with provisions and skills for facing life in the real world.
Ayu Andriani (2020)	This study, conducted in 2019, described the success of inquiry-based STEAM learning in the Laboratory in improving physics learning outcomes through concept mastery, argumentation skills, and fostering students' entrepreneurial character. Based on the analysis results, it can be concluded that the application of STEAM in inquiry-based physics learning has proven to be an appropriate, influential, and effective strategy in improving students' mastery of the concept of mechanical waves in simple pendulum oscillations.
Wahyuni et al. (2023)	This study aims to analyze physics teaching materials for grade X from two important perspectives: ESD and STEAM. The results indicate that the application of ESD and STEAM pillars in teaching materials is still low.
Budiyono et al. (2020)	This study aims to describe the effect of implementing an integrated PBL model with a STEAM approach on creative thinking skills in terms of students' conceptual understanding. Based on data and analysis of the results of research that has been conducted regarding the effect of the STEAM approach on students' critical thinking skills, namely: 1) There is a significant effect of the integrated PBL model with a STEAM approach on the creative thinking skills of high school students., 2) Students who have a high conceptual understanding have higher creative thinking skills than students who have a low conceptual understanding. 3) There is an interaction effect between the integrated PBL model with a STEAM

Source	Findings
	approach and conceptual understanding of the creative thinking skills of high school students.
Rohman et al. (2021)	The objective of the study is to describe the influence of implementing the STEAM integrated project learning model towards thinking creatively reviewed from understanding draft high school students on the material dynamics rotation. Research results show a significant influence on the PjBL model, which integrated STEAM into skills and creative thinking in participants who were educated in XI science class in high school.
Nur et al. (2023)	Study This aims to integrate five disciplines of knowledge. Participants are educated to increase skills, think critically, solve problems, and be creative. Research results show an impact on creativity and results. Study participants are educated.
Wardani et al. (2023)	Objective study: To develop modules physics STEAM-based to increase critical students with material sound, test module eligibility physics STEAM-based for increased critical students with material sound, and test module eligibility physics STEAM-based for increased critical students. Based on the results, the analysis obtained that e-module development STEAM based to increase skills think critically on the subject discussion sound can be implemented in learning.
Safriana et al. (2022)	Study this aims to know the influence of the project-based learning model based on STEAM on the ability of creative students to think creatively about material tools and optics. Based on the results analysis, the project-based learning model based on STEAM influences creative students' ability to think creatively about material optical instruments, and students are also interested in studying using the project-based learning model based on STEAM.
Fitriyah & Ramadan (2021)	Objective study this is to test the influence of STEAM-based learning PjBL on thinking creatively and critically for students. Research has shown that STEAM-based learning PjBL can be used as an alternative learning method for empowering 21st-century skills.
Febriansari et al. (2022)	Study this aims to reconstruct the STEAM learning model with a combination approach to design thinking on materials learning energy renewable. Research results show that the STEAM learning model is very relevant to the 21st-century skills needed, and the approach to design thinking strengthens the learning model more contextually to give understanding in a way practical through settlement problems daily.
Widarti et al. (2023)	Objective study: This is to obtain device learning integrated with ESD-oriented STEAM on the material valid fluid. Research results show that device learning physics ESD-oriented STEAM-based has very valid results.

Discussion

Table 1 presents the review results regarding the application of the STEAM approach in learning physics in Indonesia. The findings indicate that the implementation of STEAM learning in physics education remains very limited (Andriani, 2020; Kartika, 2022). This observation is supported by the search results of publications in journals over the past five years, which show a scarcity of related studies. This situation is consistent with research conducted (Amiruddin et al., 2022). The STEAM approach is characterized by student-centered learning that is project-based, collaborative, design-focused, and cooperative, promoting a comprehensive educational experience (Cook, 2018; Esriyanto, 2020; Nuragnia, 2021). Additionally, this approach can be integrated with various learning models, encouraging innovation and collaboration with other methodologies.

The STEAM approach employs a participant-centered model designed to develop students' abilities to educate themselves, solve problems, collaborate, and manage projects (Margot & Kettler, 2019). The advancement of STEAM education represents an

effective strategy for enhancing the quality of education. However, the utilization of the STEAM approach in Indonesia, particularly in physics education, remains quite limited. Despite this, there has been a significant amount of research in Indonesia exploring the use of the STEAM approach in learning physics (Lestari, 2021; Widarti, 2021). Initiatives to implement STEAM can foster higher-order thinking skills, facilitate collaboration with Education for Sustainable Development (ESD), and promote the creation of STEAM-based educational materials.

Each Sustainable Development Goals (SDGs) emphasizes the importance of education in empowering individuals with the knowledge, abilities, skills, and values necessary for personal development and societal contribution (Sudarmin et al., 2021). In this context, STEAM education plays a crucial role in preparing future generations to tackle the challenges faced by society. Therefore, it is anticipated that there will be an increase in studies and educational initiatives utilizing the STEAM approach in Indonesia, particularly in the field of physics.

CONCLUSION

Fundamental Finding: The analysis of the literature reveals that from 2019 to 2023, the utilization of the STEAM approach in learning physics in Indonesia remains low. **Implication:** Teachers are still encountering difficulties in implementing the STEAM project approach effectively. However, successful research indicates that the STEAM approach can help achieve the desired learning outcomes. It is hoped that the STEAM approach will be increasingly applied in physics education to address the challenges of 21st-century education. By implementing this approach, there is a potential to enhance the quality of education in Indonesia, particularly in physics, thereby contributing to the realization of the Sustainable Development Goals (SDGs) through education. **Limitation:** This research focuses solely on studies related to learning physics using the STEAM approach from 2019 to 2023. **Future Research:** Future studies could explore the relationship between the implementation of the STEAM approach in physics education and the achievement of SDGs through educational initiatives.

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