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The Effect of STEAM Approach in Physics Learning to Enhance 21st Century Skills: A Research-Based Analytical Study

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ABSTRACT

Objective: *The STEAM approach has an important role in improving 21st-century skills in students so that it can prepare them to face future demands. This study aims to analyze the effect of the STEAM approach in physics learning on improving 21st-century skills.* ***Method:*** *This study is literature research with a qualitative approach that uses national and international journals as data sources. Data were collected through Google Scholar and Scopus, and as many as 20 journal articles related to the STEAM approach in physics learning were published in 2020-2024. The data were analyzed using qualitative descriptive analysis through literature study.* ***Results:*** *Based on the research results, using the STEAM approach has a significant positive impact on various 21st-century skills, including creativity, concept understanding, critical thinking, argumentation skills, and problem-solving. Among these skills, creative thinking skills were the most measured. In addition, the STEAM approach is often integrated with learning models such as STEAM Learning and Project-Based Learning (PjBL). These findings confirm the effectiveness of the STEAM approach in developing comprehensive skills in students.* ***Novelty:*** *This research is expected to provide strategic insights for educators in designing innovative and practical learning, especially by utilizing the STEAM approach to support the needs of 21st-century education.*

INTRODUCTION

21st-century skills are the primary focus of education in the era of globalization and technological advances that continue to grow rapidly. 21st-century skills are needed to prepare students to compete in the global marketplace (Junyanti, 2024). Creativity, innovation, and the ability to adapt to change can be the key to facing challenges in an era of ever-evolving technological advances (Jaya et al., 2023). By having 21st-century skills, students are expected to be better prepared to face global market competition. These skills include thinking critically and creatively, communicating, collaborating, solving problems, and digital literacy (Ramadhan, 2023). Additionally, 21st-century skills include soft and dispositional skills such as cross-cultural skills, collaboration, critical thinking, and problem-solving (Ishartono et al., 2021).

In education, it is important to develop new forms of learning to overcome global challenges (Joynes et al., 2019). This can be done by paying attention to innovative approaches used in learning. The innovative approach must be used to improve and train 21st-century skills (Muliana et al., 2024). One approach that can be applied is the STEAM approach (Science, Technology, Engineering, Arts, and Mathematics).

The STEAM approach is a 21st-century learning method that integrates science, technology, engineering, math, and art into the learning process (Harahap et al., 2021). The STEAM approach integrates various disciplines of science and art; it is hoped that

the STEAM approach can stimulate student development optimally so that students not only stand out in the academic field but socially as well (Mu'minah & Suryaningsih, 2020) because the STEAM approach not only focuses on content, but also various skills such as collaboration, communication, problem-solving ability, and critical thinking skills (Tabiin, 2020). Based on this, it is known that the STEAM approach has an important role in improving 21st-century skills in students so that it can prepare students to face future demands (Al-Mutawah et al., 2022).

21st-century skills will provide a foundation for students to have soft skills and skills that can compete in a highly competitive global market (Kadri et al., 2021). Meanwhile, the STEAM approach that integrates various disciplines of science and art will produce an academically and socially skilled generation (Arodani et al., 2025). The STEAM approach involves a deep critical thinking process, creativity in exploring new ideas, and innovation to create relevant and applicable solutions, thus encouraging learners to integrate various disciplines in facing real-world challenges (Sutrisno & Syukur, 2023). Not only that, STEAM-based learning equips people with information management skills, continuous learning, innovation, global awareness, and strong character to meet the high market demand for science-based products and technological skills (Atmojo, 2020). Thus, integrating the STEAM approach into learning can be done to improve students' 21st-century skills so that students can develop their skills optimally and be ready to face competition in the future.

Physics is one of the subjects in school that is complex and abstract, so it is often a challenge to learn (Yunzal & Casinillo, 2020). In addition, physics is also a science that explains and analyzes various natural phenomena, which are usually done by experimentation, measurement, and mathematical presentation (Ady, 2022). This is often the reason students in schools have difficulty learning physics subjects. Therefore, it is important for an educator to create a fun, interactive, and innovative learning environment by utilizing existing resources and involving students directly in physics learning (Mahendra et al., 2023).

The STEAM approach can provide hands-on experience and opportunities for students to explore abstract physics concepts (Ozkan & Unsal, 2021). A strong and deep understanding can be a foundation for students to learn other science subjects. The STEAM approach is one of the student-centered learning approaches that can encourage students' deeper conceptual understanding (Amelia & Marini, 2022). Thus, the STEAM approach can be a solution to overcome students' learning difficulties in understanding complex and abstract physics material.

Implementing the STEAM approach in learning is still very little (Ishartono et al., 2021). This can occur due to various factors, especially in the educator, namely the teacher. Teachers have difficulties integrating the STEAM approach into teaching. One is related to planning educational programs with different weights between science and humanities subjects in the curriculum. In addition, the STEAM approach integrates various disciplines and is complex, requiring skilled teachers to integrate science, arts, and humanities as a whole (Perales & Aróstegui, 2024).

The integration of the STEAM approach with learning has many positive impacts. The STEAM approach will involve students and teachers directly in learning to provide an authentic experience in the teaching and learning process (Atiaturrahmaniah et al., 2022). In addition, students can gain a deeper understanding of science and mathematical concepts, which can improve their cognitive and affective skills. Other skills carried out in the STEAM approach allow students to share knowledge and experiences and increase student creativity and innovation in learning (Belbase et al., 2022).

Much research has been done on the STEAM approach to understand its effect on learning. Research conducted by Mu'minah and Suryaningsih (2020) discusses the application of STEAM to the development of 21st-century skills in science learning. In addition, there is research conducted by Rahman to explore the influence of STEAM on physics learning (Rahman et al., 2023). The novelty of this research lies in analyzing the effect of the STEAM approach in physics learning to improve 21st-century skills, as well as identifying learning models that are usually integrated.

Based on this, the author aims to analyze the effect of the STEAM approach in physics learning to improve 21st-century skills because it is expected that by knowing the effect of applying the STEAM approach in student learning, it can be a solution to design effective and appropriate learning strategies to prepare students to face future challenges by having the skills needed.

RESEARCH METHOD

This study aims to analyze the effect of the STEAM approach in physics learning to improve 21st-century skills in students. 21st-century skills, such as creativity, critical thinking, and problem-solving, are at the center of education today to prepare students for global challenges. Integrating STEAM, which combines science, technology, engineering, art, and mathematics, is expected to stimulate the development of students' skills holistically.

This research is a literature review, so the method used is a literature study. Secondary data is used by using several journals and articles that can be accounted for nationally and internationally. The articles or journals used in this study are 20 journal articles from 2020-2024 obtained through Google Scholar and Scopus searches related to the STEAM approach to physics and 21st-century skills.

After collecting several journals, they will be analyzed using qualitative descriptive analysis through literature studies. The research uses a qualitative approach that produces descriptive data in the form of written sentences and reviews results from research articles. According to Miles and Huberman (1994), the stages of data analysis in qualitative research can generally be carried out, as shown in Figure 1 (Suliyanah et al., 2021).

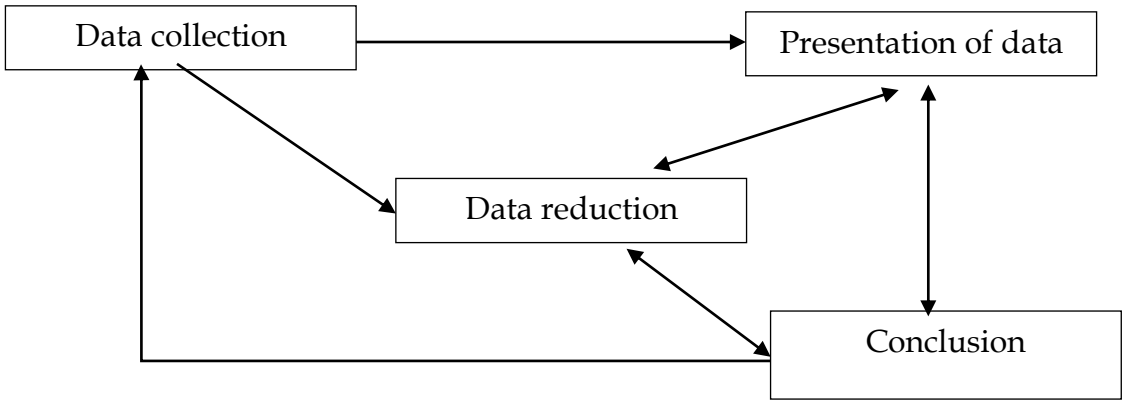

Figure 1. The flow of data analysis

Based on Figure 1, this study carried out the data analysis stage in four stages. The first stage is collecting data. In this study, the data collection process was carried out by searching for journals on Google Scholar and Scopus to get information about the STEAM approach to physics and its effect on 21st-century skills. The second stage is data reduction. At this stage, the author summarizes, selects the main things, and focuses on important things so that the data obtained has a clear picture and makes it easier for researchers to collect further data. The third stage is data presentation, where in this study, the data will be presented with narrative text in the form of a brief description of the data found and article review tables. The fourth stage is conclusion and verification, which is to conclude the review results and explain new findings that have never existed.

RESULTS AND DISCUSSION

Results

STEAM is one of the results of developing the STEM approach, namely by adding the Art aspect to the STEAM approach. However, the addition of art components is not only for drawing or coloring but also to form creativity and creative thinking patterns in students' learning skills in the 21st century (Lee, 2020). STEAM learning is a contextual learning approach that allows learners to understand the events around them. In STEAM learning, students are encouraged to be able to solve problems encountered in everyday life through the stages of scientific methods (Purwanti et al., 2021). The following table reviews the results of several research journals related to the relationship between the STEAM approach and 21st-century skills in Physics learning, as shown in Table 1.

Table 1. Review result of STEAM approach and 21st century skills in physics learning from 2020-2024.

No	Description			Influence on 21st Century Skills	Model or Approach Used
1	Author	:	Anis Fitriyah and Shefa Dwijayanti R	Creative	Project
	Year	:	2021	Thinking	Based

No	Description			Influence on 21st Century Skills	Model or Approach Used
	Title	:	Pengaruh Pembelajaran STEAM Berbasis Pjbl (Project-Based Learning) Terhadap Keterampilan Berpikir Kreatif Dan Berpikir Kritis		Learning
	Research Results	:	STEAM has a significant impact on students' creative thinking skills		
2	Author	:	Rauzatul Jannah, M Taufiq, and Rahma Rahma	Concept Understanding	STEAM
	Year	:	2022		
	Title	:	Pengaruh Penerapan Pendekatan STEAM Pada Materi Fluida Statis Terhadap Pemahaman Konsep Siswa Kelas XI SMA Negeri 1 Jangka		
	Research Results	:	STEAM learning has an influence on students' Concept Understanding		
3	Author	:	Abd. Rohman, Ishafit, and Hotimatul Husna	Creative Thinking	Project Based Learning
	Year	:	2021		
	Title	:	Pengaruh Penerapan Model Project Based Learning Terintegrasi STEAM Terhadap Berpikir Kreatif ditinjau dari Pemahaman Konsep Fisika Siswa SMA Pada Materi Dinamika Rotasi		
	Research Results	:	STEAM has a significant influence on students' Creative Thinking skills		
4	Author	:	Agus Budiyono, Hotimatul, and Husna Arin Wilandi	Creative Thinking	Problem Based Learning
	Year	:	2020		
	Title	:	Pengaruh Penerapan Model PBL Terintegrasi STEAM Terhadap Kemampuan Berpikir Kreatif ditinjau dari Pemahaman Konsep Siswa		
	Research Results	:	STEAM has a significant effect on students' Creative Thinking ability.		
5	Author	:	Ayu Andriani	Argumentation Skills	Inquiry
	Year	:	2020		
	Title	:	Bandul si Alarm Gempa Produk Implementasi STEAM dalam Pembelajaran Fisika Berbasis Inquiry Pada kelas XI MIA 4 di SMAN 4 Kejuruan Muda Tp 2019/2020		
	Research Results	:	STEAM implementation can mastery of concepts and argumentation skills		
6	Author	:	Sri Lestari	Critical Thinking	STEAM
	Year	:	2021		
	Title	:	Spectra-Plus Assisted STEAM Approach 21st Century Skills Orientation in Learning Physics		
	Research Results	:	STEAM assisted by spectra-plus can improve scientific critical thinking skills		
7	Author	:	Anis Fitriyah and Shefa Dwijayanti R	Critical Thinking	Project Based Learning
	Year	:	2021		
	Title	:	Pengaruh Pembelajaran STEAM Berbasis Pjbl (Project-Based Learning) Terhadap Keterampilan Berpikir Kreatif Dan Berpikir Kritis		
	Research	:	STEAM has a significant impact on students'		

No	Description			Influence on 21st Century Skills	Model or Approach Used
	Results		Critical Thinking skills		
8	Author	:	Safriana, Fajrul Wahdi G, and Khairina	Creative Thinking	Project Based Learning
	Year	:	2022		
	Title	:	Pengaruh Model Project Based Learning Berbasis STEAM Terhadap Kemampuan Berpikir Kreatif Siswa Pada Materi Alat- Alat Optik Di SMA		
	Research Results	:	STEAM berpengaruh terhadap kemampuan Creative Thinking siswa		
9	Author	:	Tasta Witdiya, Gito Supriadi, Atin Supriatin, and Jhelang Annovasho	Creative Thinking	STEAM
	Year	:	2023		
	Title	:	The Effect of STEAM Learning on Improving Each Indicator of Students' Creative Thinking in Physics Learning		
	Research Results	:	STEAM learning has an effect on students' Creative Thinking ability.		
10	Author	:	Muhammad Syukri, Zhaifatul Ukhaira, Zainuddin, Fitria Herliana, Nurazidawati, and Mohamad Arsad	Critical Thinking	STEAM
	Year	:	2022		
	Title	:	The Influence Of STEAM-Based Learning Application on Students' Critical Thinking Ability		
	Research Results	:	STEAM has a significant influence on students' Critical Thinking ability.		
11	Author	:	Wasito Utomo, Wiwid Suryono, Jimmi, Tomi Apra S, and Ika Agustina	Critical Thinking	Hybrid Based Learning
	Year	:	2023		
	Title	:	The Effect of STEAM-Based Hybrid Based Learning Model on Students' Critical Thinking Skills		
	Research Results	:	STEAM has a higher effect on Critical Thinking ability.		
12	Author	:	Adriyawati, Erry Utomo, Yuli Rahmawati, and Alin Mardiah	Problem Solving	Project Based Learning
	Year	:	2020		
	Title	:	STEAM-Project Based Learning Integration to Improve Elementary School Students' Scientific Literacy on Alternative Energy Learning		
	Research Results	:	STEAM-PjBL integration encourages student curiosity and problem solving		
13	Author	:	Enggar Kusuma T, Nawang Sulistyani, and Dian Fitri Nur Aini	Problem Solving	Project Based Learning
	Year	:	2023		
	Title	:	Implementasi Pembelajaran STEAM Berbasis PjBL Terhadap Kemampuan Problem Solving pada Materi Energi Alternatif di SD		
	Research Results	:	STEAM learning model can improve students' ability to solve problems.		
14	Author	:	Ferawati Artauli H and Tetti Hasibuan	Creativity	Project Based Learning
	Year	:	2023		
	Title	:	Efektivitas Pembelajaran STEAM Berbasis PJBL Dalam Meningkatkan Kreativitas		

No	Description			Influence on 21st Century Skills	Model or Approach Used
			Mahasiswa Teknik Sipil Mata Kuliah Mekanika Fluida Dan Hidrolika		
	Research Results	:	STEAM is feasible and recommended for use because it has increased student creativity		
15	Author	:	Sh. Ramankulov, A. Choruh, and S. Polatuly	Creativity	STEAM
	Year	:	2022		
	Title	:	STEAM Technology as A Tool for Developing Creativity of Students: On the Example of a School Physics Course		
	Research Results	:	STEAM can be used to develop students' creativity.		
16	Author	:	Gulbin Ozkan and Unsal Umdu Topsakal	Concept Understanding	STEAM
	Year	:	2020		
	Title	:	Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics		
	Research Results	:	STEAM influences students' conceptual understanding and reduces misconceptions.		
17	Author	:	Mohd Zaidi Bin Amiruddin, Dhela Rochmatul Magfiroh, Irma Savitri and Sitti Maizatul Iqma Binti Rahman	Creative Thinking, Critical, and	STEAM
	Year	:	2022	Concept	
	Title	:	Analysis of The Application of The STEAM Approach to Learning in Indonesia: Contributions to Physics Education	Understanding .	
	Research Results	:	The application of STEAM can improve creative thinking, critical thinking, and concept understanding skills.		
18	Author	:	Emma Suganda1, Sri Latifah, Irwanandi, Putri Mardiana Sari, Henita Rahmayanti, Ilmi Zajuli Ichsan, Md. Mehadi Rahman	Creative Thinking	STEAM
	Year	:	2021		
	Title	:	STEAM and Environment on students' creativethinking skills: A meta-analysis study		
	Research Results	:	STEAM learning can improve students' Creative Thinking skills		
19	Author	:	R E Anggraeni and Suratno	Critical Thinking	STEAM
	Year	:	2022		
	Title	:	The analysis of the development of the 5E-STEAM learning model to improve critical thinking skills in natural science lesson		
	Research Results	:	Integrating the STEAM approach can improve students' Critical Thinking skills		
20	Author	:	Agnesi Sekarsari Putri, Zuhand Kun Prasetyo, Lusila Andriani Purwastuti, Anti Kolonial Prodjosantoso, Himawan Putranta	Critical Thinking and Creative thinking	Blended Based Learning
	Year	:	2023		
	Title	:	Effectiveness of STEAM-based blended learning on students'critical and creative thinking skills		
	Research Results	:	STEAM-based integrated learning improves critical thinking and creative skills		

Table 1 shows that various studies have examined the effect of the STEAM approach on 21st-century skills in students, focusing on aspects such as creative thinking, critical thinking, concept understanding, argumentation skills, creativity, and problem-solving ability. The distribution of the research results is interpreted in Figure 2.

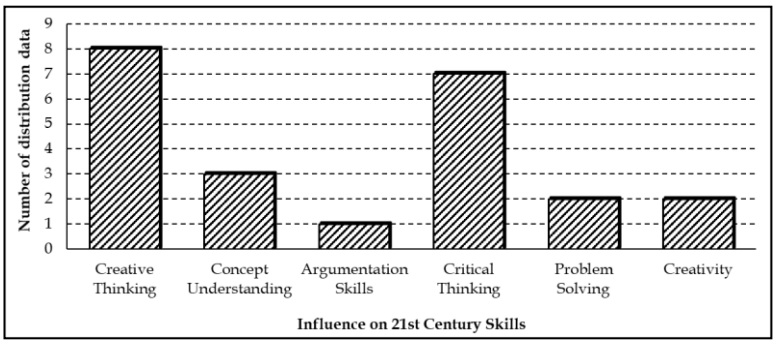

Figure 2. Distribution chart of the effect of STEAM approach on 21st century skills.

Figure 2 shows that the STEAM approach is most widely integrated to measure creative thinking skills, with 8 supporting documents. Furthermore, critical thinking skills are measured in 7 documents. Concept understanding is recorded in 3 documents, while problem-solving skills and creativity are measured in 2 documents each. Finally, there is 1 document that measures argumentation skills.In addition, based on table 1, it can be seen that the STEAM approach can be integrated in various learning models such as Project Based Learning (PjBL), STEAM learning, Problem Based Learning (PBL), Inquiry, Hybrid Based Learning and Blended Based Learning in physics education. The distribution of the research results is interpreted in Figure 3.

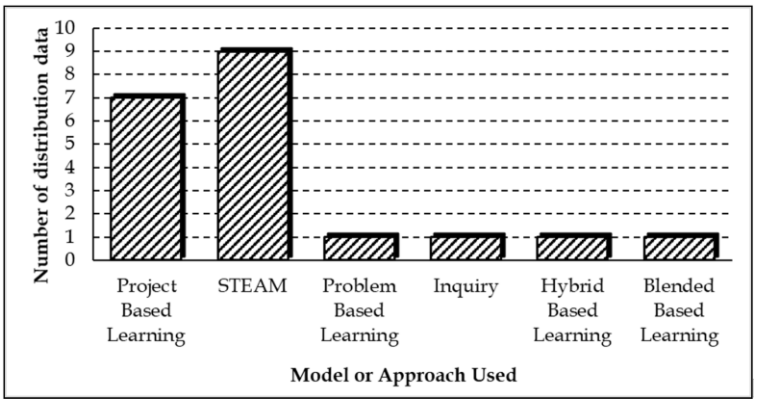

Figure 3. Distribution chart of learning models integrated with STEAM approach.

Figure 3 shows that the STEAM approach is mostly integrated with the STEAM learning model, which is recorded in 9 research documents. This approach is also often integrated with the Project-Based Learning (PjBL) model, which is supported by seven documents. Meanwhile, the Problem-Based Learning (PBL), Inquiry, Hybrid-Based Learning, and Blended-Based Learning models were each integrated in 1 research

document. Based on Figures 2 and 3, each study shows that the STEAM approach consistently provides positive effects in improving the targeted skills. For example, the implementation of STEAM was shown to significantly improve students' creative thinking, critical thinking, and concept understanding skills, especially when integrated with various learning models. The data also revealed that creative thinking skills were the most researched aspect using the STEAM approach, with the STEAM Learning model being the most dominant. These findings confirm the effectiveness of the STEAM approach in developing well-rounded skills in students, preparing them to face challenges in the era of globalization and the dynamics of an increasingly complex changing world.

Discussion

The result shows that using STEAM significantly influences students' 21st-century skills. In addition, integrating STEAM into learning can positively affect student development. The STEAM approach can also be integrated with various learning models, primarily through the STEAM Learning and Project-Based Learning (PjBL) approach. The STEAM approach significantly influences student creativity because it involves innovative and creative thinking processes. As a learning tool, STEAM helps students develop science and technology-based ideas and ideas through an integrated process of critical thinking, exploration, and problem-solving from five main disciplines (Rahma, 2024). Integrating this approach into innovative learning can produce creative and critical ideas and solutions that make it easier for students to solve various problems (Fitriyah & Ramadani, 2021). In addition, the STEAM-based learning process encourages the development of students' creative thinking skills by producing relevant and applicable results (Amiruddin et al., 2022). Specifically, the STEAM approach's art stage, which involves students designing and creating products based on problem-solving, can effectively hone their creativity (Budiyono et al., 2020).

At the tertiary level, STEAM improves students' creative thinking skills by providing more opportunities for exploration through discussions, presentations, questions and answers, and experiments in projects assigned by lecturers (Hasibuan, 2023). Furthermore, STEAM also enables skill development, practical application of knowledge, and implementation of creative ideas in educational institutions and professional activities of school graduates (Ramankulov et al., 2022). This indicates that integrating STEAM elements in learning can stimulate students' Creativity in solving problems and generating new ideas. STEAM involves art elements encouraging students to find innovative solutions and creative thinking. Art also encourages students' imagination and broader thinking and creates original and innovative solutions (Cahyani et al., 2023).

STEAM learning also has a positive influence on students' concept understanding. The results of research conducted (Ozkan & Umdu, 2021) show that the STEAM approach positively affects students' conceptual understanding and can reduce or change the number of misconceptions related to force and energy. This research is in

line with that conducted (Amiruddin et al., 2022), which shows that the application of STEAM positively impacts physics learning and improves students' concept understanding even though it requires special expertise from teachers. In addition, the STEAM approach can improve students' mastery of concepts because this approach provides learning experiences that integrate knowledge, skills, and attitudes and places students as active learners (Jannah et al., 2022). This suggests that the STEAM approach can help students to understand scientific concepts better through an integrated approach between various disciplines. STEAM learning can strengthen understanding by allowing students to learn in a real and relevant context to link academic concepts with applications in everyday life (Rakhmawati et al., 2024).

STEAM learning can also positively influence improving students' critical thinking skills (Amiruddin et al., 2022). This research aligns with that conducted by Anggraeni and Suratno (2021), which shows that a learning model that combines the 5E learning cycle with the STEAM approach can improve critical thinking skills. At the engagement stage, the teacher asks students questions in the form of contextual problems to stimulate students with HOTS questions so that students begin to think and discuss the problem (Anggraeni & Suratno, 2021). Furthermore, STEAM learning encourages students to think critically by observing problems, comparing observations, and finding the right solution (Lestari, 2021). The results of research conducted (Putri et al., 2023) also support that STEAM-based blended learning can improve students' critical thinking skills by creating a learning environment that supports thinking activities. Similarly, the findings of (Syukri et al., 2022) highlight that STEAM-based learning oriented towards active student involvement can stimulate students to think critically so that students actively ask questions, discuss, and express opinions.

The STEAM approach can encourage students to solve problems, and problem-solving is done with critical thinking (Khoiriyyah et al., 2022). This shows that learning that integrates STEAM elements can help students develop better analysis and evaluation skills. In addition, this study also shows that STEAM learning can improve students' argumentation skills (Andriani, 2020). This shows that the STEAM approach can help students develop the ability to construct arguments based on scientific evidence. This is by applying STEAM to learning, namely preparing students to be able to solve problems, make decisions, and communicate and collaborate (Ulfayani et al., 2022).

Some studies also show that STEAM learning can improve students' problem-solving ability. Research conducted (Adriyawati et al., 2020) shows that the integration of STEAM with the PjBL learning model in science learning encourages students to see the relevance of science knowledge to the phenomena of everyday life, develop curiosity, and improve problem-solving skills. Applying STEAM-PjBL learning can also improve problem-solving skills because, in each meeting, students are trained to identify problems, analyze information, draw conclusions, and create relevant solutions or works (Triprani et al., 2023). This highlights that the STEAM approach can help students develop the ability to identify problems, formulate solution strategies, and

evaluate the proposed solutions. The integration of STEAM based on PjBL is suitable for integration because it can bring up creative and critical ideas and solutions, making it easier to solve problems (Fitriyah & Ramadani, 2021).

The STEAM approach can also be integrated with various learning models, such as STEAM Learning, Project-based Learning (PjBL), Problem-based Learning (PBL), Inquiry, Hybrid Learning, and Blended Based Learning. However, in this study, the learning model that is more integrated with STEAM is the STEAM learning model. STEAM is one of the 21st-century learning models that focuses on developing soft skills, such as creativity, problem-solving, collaboration, and critical thinking (Damayanti et al., 2023). The STEAM learning model is designed to integrate science, technology, engineering, art, and mathematics in learning, which aligns with the STEAM approach's essence (Darmadi et al., 2022). This integration allows for a more systematic and comprehensive implementation and allows educators to design learning activities that suit students' needs. Moreover, the STEAM learning model supports students' concept understanding and the development of 21st-century skills, such as critical thinking, creativity, and collaboration, which are the primary targets of the STEAM approach (Amiruddin et al., 2022).

Furthermore, Project-based Learning (PjBL) learning models are also commonly integrated with the STEAM approach. Project-based learning invites students to actively engage in the learning process by addressing real-world challenges collaboratively through projects that require concrete application of knowledge and skills (Tubagus et al., 2024). The STEAM (Science, Technology, Engineering, Arts, Mathematics) approach is more integrated in Project Based Learning (PjBL) because this combination makes the learning process more dense and essential (Cahyani et al., 2023). The PjBL learning model integrated with the STEAM approach has five stages that can facilitate the development of students' creative thinking (Rohman et al., 2021). Each stage in this learning encourages students to work together, communicate with friends, solve problems, and take responsibility (Fitriyah & Ramadani, 2021). Although the STEAM-based Project-Based Learning model can be applied to improve 21st-century skills, its application requires a long time for implementation (Safriana et al., 2022).

CONCLUSION

Fundamental Finding: Based on the results and discussion, implementing the STEAM approach in physics learning has a significant positive impact on developing 21st-century skills in students. The STEAM approach improves various aspects, such as creative thinking, critical thinking, concept understanding, argumentation, and problem-solving skills. The most measurable skill through the STEAM approach is creative thinking skills. In addition, this study found that suitable learning models integrated with the STEAM approach are STEAM Learning and Project-Based Learning (PjBL) because they can make the learning process more robust and meaningful. This confirms the importance of STEAM integration in the education curriculum to prepare students for increasingly complex future demands. **Implications:** The results of this

study provide a strong basis for developing more effective learning strategies in physics education. For educators, STEAM is a learning model to increase student interest and skills. **Limitation:** In this study, the limitations are related to the limited sample coverage and limitations in a particular educational context, namely only reviewing the 21st-century skills measured and the learning models integrated with the STEAM approach. So, this study still needs to be further tested in a broader and more diverse context to strengthen the generalizability of the findings. **Future Research:** Future research is recommended to explore the effectiveness of the STEAM approach in a broader and more diverse educational context, such as suitable learning materials integrated with the STEAM approach, the effectiveness of the STEAM approach at each level of education to find out the extent to which this approach is relevant in various stages of student development. Learning media that can support STEAM integration that supports student engagement.

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