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Emerging Trends in STEAM Education: Advancing 5C Skills for Future-Ready Learners

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Abstrak

Berdasarkan hasil pengamatan, ditemukan beberapa permasalahan dalam pendidikan, yaitu penggunaan pembelajaran konvensional, penerapan pendekatan kompetitif dan individualis oleh pendidik dibandingkan dengan pendekatan kolaboratif, serta minimnya kesempatan yang diberikan pendidik kepada siswa untuk mengembangkan keterampilan komunikasi. Kajian ini bertujuan untuk mengidentifikasi pentingnya penerapan model pembelajaran STEAM, penyebab permasalahan, serta upaya yang dapat dilakukan untuk meningkatkan keterampilan 5C siswa. Penelitian ini menggunakan pendekatan Systematic Literature Review dengan metode PRISMA. Data dikumpulkan melalui pencarian artikel di database Scopus menggunakan aplikasi Publish or Perish. Sebanyak 14 artikel yang memenuhi kriteria dianalisis secara mendalam untuk menjawab tujuan penelitian. Hasil penelitian menunjukkan bahwa model pembelajaran STEAM adalah pendekatan pendidikan inovatif yang efektif dalam menanamkan keterampilan 5C pada siswa, meliputi berpikir kritis, kreativitas, kolaborasi, komunikasi, dan kepercayaan diri. Integrasi STEAM dengan model pembelajaran lain memungkinkan siswa mendapatkan pengalaman belajar yang relevan dan aplikatif dalam menghadapi berbagai kebutuhan pendidikan. Dengan penerapan STEAM, generasi muda dapat lebih siap menghadapi tantangan global melalui keterampilan yang komprehensif dan relevan.

***Kata kunci*:** *Model Pembelajaran,* STEAM*, Keterampilan 5C*

Abstract

Observations reveal several issues in education, including reliance on conventional teaching methods, educators' preference for competitive and individualistic approaches over collaborative ones, and limited opportunities for students to develop communication skills. This review aims to explore the importance of implementing the STEAM learning model, the underlying causes of educational challenges, and strategies to enhance students' 5C skills. The study adopts a Systematic Literature Review approach using the PRISMA method. Articles were retrieved from the Scopus database with the assistance of the Publish or Perish application. A total of 14 relevant and eligible articles were critically reviewed and analyzed to meet the research objectives. The findings demonstrate that the STEAM learning model is an innovative educational approach that effectively instils 5C skills—critical thinking, creativity, collaboration, communication, and confidence—in students. The integration of STEAM with other learning models provides students with relevant and practical learning experiences to address diverse educational needs. Implementing STEAM prepares future generations to face global challenges with comprehensive and relevant skill sets.

Keywords: Learning Model, STEAM, 5C Skills

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1. INTRODUCTION

Education is currently experiencing major changes as a result of the wave of globalization and technological revolution. Based on observations, the problems that occur are 1) conventional learning still exists, so the focus is on memorizing and repeating information rather than problem solving, critical analysis, and experimenting. 2) Educators still use a competitive and individualistic approach rather than a collaborative one, and 3) educators do not provide enough opportunities for students to improve communication skills. In line with opinion which states students' critical and creative thinking abilities are still relatively low (Putri et al., 2023; Yazar Soyadı, 2015). Students do not master the content of inventive problem-solving topics; students are unable to produce innovative products because they do not master inventive problem-solving skills. The cause is a lack of teacher training in

developing students' skills. Learning is less interesting for students; learning is done by watching what the teacher does. Pobserving learning, the learning model used by the teacher is less varied (Kiong et al., 2022; Sari et al., 2021). Although computational thinking is important for the digital era, it has not yet been fully implemented into the learning process.

STEAM learning offers a complete solution to overcome various skills problems that arise in the current era. This model combines art, mathematics, science, and technology to prepare students to face the challenges and take advantage of opportunities in the modern world. STEAM is one way that can be done and symbolizes 21st century skills (Science, Technology, Engineering, Arts and Mathematics) (Apriandi et al., 2023; Prasetyo et al., 2021). STEAM education is considered important for producing individuals who are able to face and solve complex global problems. STEAM is designed to enrich students' problem solving skills through engagement in higher order thinking practices aimed at conceptualizing basic principles of problem solving (Suryani et al., 2024; Syafe'i et al., 2023).

The advantages of the STEAM model are: 1) students' knowledge in the field of science with this learning shows positive results, 2) students are taught to be able to think actively, creatively and innovatively in solving problems, 3) students can create their ideas through the use of the latest technology, 4) abstract concepts are bridged through this study in science, research, technology and art (Eka Sari et al., 2023; Syafe'i et al., 2023). Apart from the advantages of the STEAM model, it also has disadvantages, such as educators being able to integrate various scientific disciplines, requiring more thorough planning and requiring investment in equipment, materials and teacher training. So that in its application to learning activities, of course the facilities and infrastructure needed are adequate and support the learning process (Azzahra, 2024; Kibirige & Teffo, 2014).

STEAM can be used to help students integrate the various disciplines necessary to enhance their learning experience as well as allowing them to investigate, ask questions, or practice innovative skills. Additionally, evaluating students and assessing multidisciplinary projects, while ensuring equal emphasis on each STEAM subject and development of relevant competencies, is a significant challenge (Azzahra, 2024; Spyropoulou & Kameas, 2024). The STEAM learning model has become one of the most relevant and effective approaches in modern education, preparing students for a future full of challenges and opportunities (Nur & Nugraha, 2023; Zandkarimi., 2013).

From this explanation, it encourages researchers to analyse literature about the benefits of the STEAM learning model in improving 5C skills. The purpose of this review is to analyse the importance, causes, efforts associated with implementing the STEAM learning model in improving 5C skills. Thus, it can equip students with the skills necessary to innovate and contribute positively in global society and also help form a generation that is ready to face and overcome the challenges of the 21st century.This is done so that students can learn relevant skills and knowledge to face future challenges and to respond to the dynamics of the times and the needs of society which continue to develop (Kuo, 2008; Rizaldi et al., 2020).

2. METHODS

This research uses a Systematic Literature Review (SLR) with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) method used in this research which refers to certain research methods and developments used to collect and evaluate relevant research on certain topics. One of the benefits of research using the SLR method is the ability to identify, study, evaluate and interpret any available research with a topical focus on certain phenomena of interest (Farodisa & Sari, 2023). The stages of Systematic Literature Review with PRISMA consist of five stages, namely: defining

eligibility criteria, defining information sources, selecting literature, collecting data, and selecting data items (Rohmaya, 2022). Figure 1 show the prisma diagram done in this study.

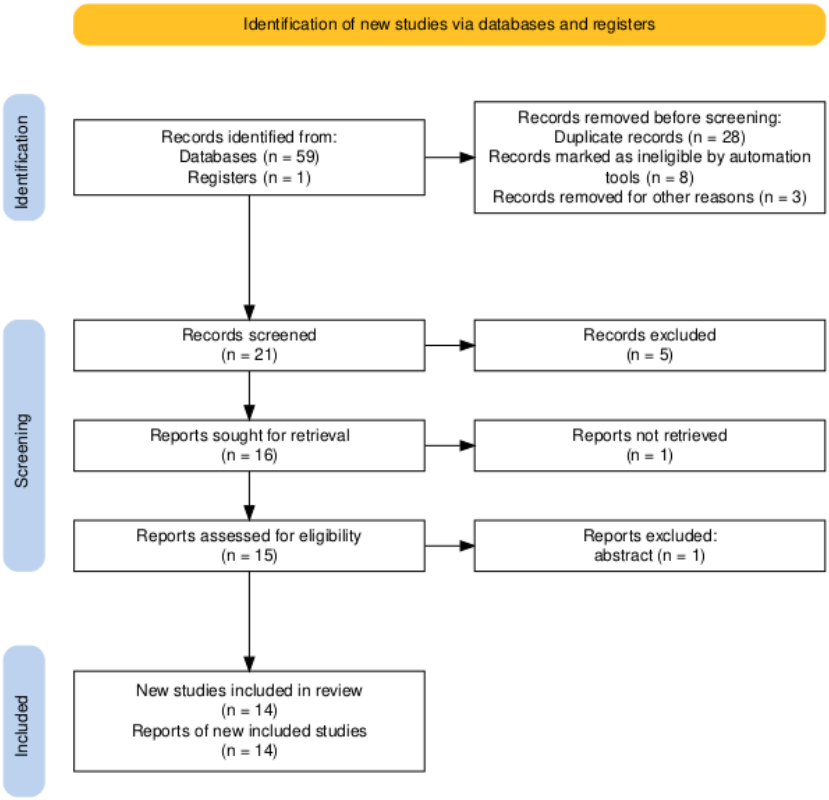

Figure 1. Prisma Diagram

Systematic Literature Review (SLR) analysis using the prism method carried out in this research is as follows: 1.) Defining eligibility criteria, in this step, a thorough literature review preparation procedure is required. Currently, researchers have found research topics, especially the STEAM learning model to improve student skills. Next, researchers used search criteria for articles from 2020 to 2024, which were based on Scopus sources, with the title words being skills and the keywords STEAM learning. 2.) Definition of information sources, this step begins by looking for items that meet the requirements at the planning stage. To search for articles, use Scopus with the help of the Publish or Perish application. 3.) Selecting literature, Journal publication criteria for the last four years relating to the STEAM learning model to improve student skills are from 2020 to 2024, which is based on Scopus sources, with the title words being STEAM learning skills and keywords used in this research.

Then continue by collecting data, currently, at least 59 Scopus articles, plus one existing article, meet the requirements. Therefore, the criteria available for including and excluding articles from the population resulted in a total of 21 articles meeting the literature selection criteria. To assess how well the topic of the article matches the research objectives, a total of 21 articles found during the data collection stage were then selected by quickly reading the full text of the article. In the next step, each part of the article must be linked to the research objectives to determine which articles are eligible. On the other hand, the title, abstract and conclusion of the research do not match the research objectives. After the selection process is complete, the data collected will be presented in narrative form. After 14 articles were deemed appropriate and appropriate, the researchers reviewed and analyzed them to meet the research objectives.

3. RESULTS AND DISCUSSION

Results

One of the most innovative and effective approaches to contemporary education is the STEAM learning model. This method combines five major disciplines to create a holistic and interdisciplinary learning experience. The use of the STEAM model is critical to improving students' skills, preparing them for future challenges, and ensuring that they have skills that are relevant and needed in the 21st century. The results of the analysis found 14 articles from Scopus that met the eligibility criteria in accordance with the objectives of this research. The results of the article analysis are in Table 1.

Table 1. STEAM Learning Model in Improving 5C Skills

No.	Name	Title	Results
1	(Bedar & Al-Shboul, 2020)	The Effect of Using STEAM Approach on Developing Computational Thinking Skills among High School Students in Jordan	Thus, a STEAM approach learning environment is one of the effective methods of teaching that improved computational thinking.
2	(Bedar & Al-Shboul, 2020)	Developing 22nd century skills through the integration of STEAM into smoke absorber project to	It shows that STEAM improved students' critical thinking, creativity, collaboration and communication skills, and caring of environmental problems (5C), in addition to information, media, and technology skills.
3	(Setyarto et al., 2020)	Development of 21st Century Skills in Mathematics Learning with STEAM in MTs Negeri 2 Wonogiri	The conclusions in this study include: 1)Implementation of development Critical Thinking and the results of the Critical Thinking Integration Questionnaire showed 50.32% were categorized as good; 2)Implementation of development Communication and the results of the Communication Integration Questionnaire showed that 52.80% were categorized as very good; 3)Implementation of development Collaboration and the results of the Collaboration Integration Questionnaire showed 50.18% were categorized as good; 4)Implementation of development Creativity and the results of the Creativity Integration Questionnaire showed 52.42% were categorized as very good.
4	(Suganda et al., 2021)	STEAM and Environment on students' creative-thinking skills: A meta-analysis study	The results of the analysis showed that STEAM learning can improve students' creative-thinking skills.

No.	Name	Title	Results
5	(Anggraeni & Suratno, 2021)	The analysis of the development of the 5E-STEAM learning model to improve critical thinking skills in natural science lesson	The teacher triggers student's critical thinking skills by posing HOTS questions at the stage of engagement. The teacher also presents questions for the C4-C6 level at pre-test and post-test.
6	(Rahmawati et al., 2021)	The integration of STEAM-project-based learning to train students critical thinking skills in science learning through electrical bell project	In addition, STEAM-PjBL integration provides an opportunity for teachers to develop their competencies in applying various methods to encourage students in the test results of the test is students achieve mastering (40%) and competent (30%) at a critical level. Only temporary small (3.80%) students no concept of transformation correctly, even after knowing the distance.
7	(Phadung et al., 2021)	A Study of Enhancing Computational Thinking Skills through STEAM Robotics Activities	The findings were that students' learning outcomes indicated a significant improvement in their computational skills after the use of STEAM robotics activities as compared with before, with the statistical level of significance of 0.05.
8	(Wannapiroon & Pimdee, 2022)	Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment	The results revealed that the VCLE design should begin with a face-to-face, classroom learning environment in which the 'gamification' mechanisms were introduced and examined. This was then reinforced by moving the gamification process online outside of the classroom. Furthermore, five VCLE STEAM-ification steps were found to be particularly useful for enhancing creative thinking and student innovation.
9	(Indahwati et al., 2023)	Integration of independent learning and physics innovation in STEAM-based renewable energy education to improve critical thinking skills in the era of Society 5.0 for Sustainable Development Goals (SDGs) 2030	The results showed that integrating Free Learning and Physics Innovation in STEAM-based Renewable Energy Education is an effective approach to improving students' critical thinking skills.
10	(Putri et al., 2023)	Effectiveness of STEAM-based blended learning on students'	The results show steam-based blended learning can improve critical and creative thinking skills on all indicators with

No.	Name	Title	Results
		critical and creative thinking skills	medium to high categories. The improvement of students' critical and creative thinking skills in experimental classes is higher than that of the control class. In addition, there are differences in learning outcomes between control classes and experimental classes.
11	(Syafe'i et al., 2023)	STEM and STEAM Affects Computational Thinking Skill: A Systematic Literature Review *Suci*	Then, the most widely used instrument is the Computational thinking test (n=6) on the important dimensions of CT assessment in the form of problem solving, abstraction, algorithmic thinking, critical thinking, creative and cooperative; integrated in project based activities with a game design model (n=2), producing the most projects in the form of robots (n=4), and overall STEM and STEAM learning activities have a positive impact on CT. Based on the findings, it can be concluded that STEAM activities are able to have more effect than STEM because of the existence of "Art".
12	(Apriandi et al., 2023)	Development and Effectiveness of STEAM-C Integrated Learning Devices to Improve Students' Creative Thinking Skills in Specific Cultural Context	As a result, the STEAM-C integrated learning device is recommended for use in mathematics learning to help students improve their creative thinking skills.
13	(Suryanti, Mochamad Nursalim, Nadia Lutfi Choirunnisa, 2024)	STEAM-Project-Based Learning: A Catalyst for Elementary School Students' Scientific Literacy Skills	The results showed that STEAM-PjBL improved students' scientific literacy skills significantly more than traditional instruction.
14	(Suryani et al., 2024)	Implementation of Relational Database in the STEAM-Problem Based Learning Model in Algorithm and Programming	Based on the research results, it is known that the STEAM Problem Based Learning relational database design is declared valid in Algorithms and Programming in storing lecturer and student activity data during the learning process. This is very important to improve students' ability to think critically and be creative in problem-solving, communication, and collaboration, which is much needed in the Industrial Revolution 4.0

Discussion

Education must be adapted to prepare future generations who are able to handle complex problems in globalization. To be successful in this digital era, students must have the 5C skills: Critical thinking, Creative thinking, Collaboration, Communication and Computational Thinking. The STEAM learning model is an innovative educational method that is successful in instilling these skills in students.This shows that STEAM improves students' critical thinking, creativity, collaboration and communication skills, as well as awareness of environmental issues (5C), in addition to information, media and technology skills (Bedar & Al-Shboul, 2020; Hoque, 2016). Compared to traditional learning approaches and other siled models, STEAM offers a more holistic and relevant approach. However, traditional approaches and discrete models have advantages in mastering specific material and structures, but they do not encourage skills such as critical thinking, creativity, collaboration, communication and computational thinking. As the results in table 1 show that STEAM project-based learning improves students' scientific literacy skills significantly compared to traditional learning (Musliha & Revita, 2021; Nurhadiyati et al., 2021).

STEAM encourages students to analyze problems, evaluate evidence, and make rational decisions. At the same time, combining art and space for experimentation allows students to express their creativity and find new ways to solve problems. The development of STEAM-C integrated learning tools is recommended for use in mathematics learning to help students improve their creative thinking abilities. The five steps of VCLE STEAM gamification were found to be very useful for enhancing students' creative thinking and innovation (Suganda et al., 2021; Wannapiroon & Pimdee, 2022). Therefore, STEAM learning can improve students' creative thinking abilities.

Apart from thinking creatively, students are also required to have critical thinking skills. Teachers trigger students' critical thinking skills by asking HOTS questions at the engagement stage (Anggraeni & Suratno, 2021; Apriandi et al., 2023). Research results according to previous study stated that 1) the implementation of creativity development and the results of the creativity integration questionnaire showed 52.42% in the very good category, 2) the implementation of development communication and the results of the communication integration questionnaire showed 52.80% in the very good category, 3) the implementation of development collaboration and the results of the collaboration integration questionnaire showed 50.18% in the good category, 4) the implementation of creativity development and the results of the creativity integration questionnaire showed 52.42% in the very good category (Setyarto et al., 2020).

In the STEAM learning model, 4C skills and computing skills are integrated, which is essential to prepare students to face the challenges of this century. According to the results in table 1, it is stated that the learning environment with the STEAM approach is one of the effective teaching methods that improves computational thinking (Bedar & Al-Shboul, 2020; Payu et al., 2022). STEAM activities are able to provide a greater effect than STEM because of the presence of "Art", the most widely used instrument is the Computational thinking test (n=6) on the important dimensions of CT assessment in the form of problem solving, abstraction, algorithmic thinking, critical thinking, creative and cooperative. The students' learning outcomes showed a significant increase in their computing skills after the use of STEAM robotics activities compared to before, with statistics (Phadung et al., 2021; Syafe'i et al., 2023). STEAM ensures that students not only gain academic knowledge but also practical skills relevant to the real world.

However, the integration of STEAM with other learning models can result in a broader and more comprehensive educational approach to meet a variety of educational needs. By utilizing the advantages of each learning model, this integration ensures that students get relevant and applicable learning experiences. Table 1 shows thatIntegrating

Independent Learning and Physics Innovation in STEAM-based Renewable Energy Education is an effective approach to improving students' critical thinking skills (Gandasari et al., 2020; Indahwati et al., 2023). Steam-based blended learning can improve critical and creative thinking skills in all indicators in the medium to high category (Nardo et al., 2022; Putri et al., 2023). In addition, STEAM-PjBL integration provides teachers with the opportunity to develop their competence in applying various methods to encourage students to achieve mastery (40%) and competence (30%) at critical levels in student test results. STEAM Problem Based Learning relational database design in storing lecturer and student activity data during the learning process, this is very important to improve students' critical and creative thinking skills in problem solving, communication and collaboration which are very much needed in the Industrial Revolution 4.0 (Mutohhari et al., 2021; Suryani et al., 2024).

The findings of previous research show that learning by integrating STEAM can improve students' critical thinking skills in elementary schools (Paska & Waluya, 2024). STEAM integrated learning based on local wisdom helps elementary school students achieve 21st century skills such as critical thinking, creativity, collaboration and communication, with an average increase of over 3,500 in each skill category (Erdoğan, 2019; Khusna & Shufa, 2024). The application of STEAM learning really helps children in solving problems faced by children and can improve children's critical thinking skills. The STEAM approach is able to increase students' creativity and critical thinking power (Era Sativa & Nada Buahana, 2024; Iffiani et al., 2024). The difference between this research and this research is that this research is more important, causes, efforts related to implementing the STEAM learning model in improving 5C skills.

From this discussion, a generalization can be obtained from this research that the STEAM learning model is really needed in the current digital era, because it is a model that can improve skills Critical thinking, Creative thinking, Collaboration, Communication and Computational Thinking for students to help prepare for their future. The STEAM model can also be integrated with other models by using appropriate learning media to maximize the use of the model in learning. To ensure effective and sustainable implementation of STEAM, future research should focus on effectiveness evaluation, curriculum design, teacher training, industry and community collaboration, and technological innovation. Therefore, education has the ability to continually change and develop, providing students for success in their future.

4. CONCLUSION

The systematic research findings obtained include: The STEAM learning model is an innovative educational method that is successful in instilling 5C skills in students. Integrating STEAM with other learning models, students gain relevant and applicable learning experiences to meet various educational needs. Educators also need to be thoroughly trained to successfully implement the STEAM model.

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