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SYSTEMATIC LITERATURE REVIEW OF THE STEAM MODEL LEARNING FOR DEVELOPING STUDENTS' 21st CENTURY CHARACTERS AND SKILLS

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ABSTRACT

Globally, learning approaches that combine various scientific fields are in great demand today in education form to improve the outcome of education. In accordance with the needs of life of the 21st-century which requires educated humans not only in the field of science, but also in various other skills such as critical thinking, creativity, mindfulness, communication, and collaboration skills. This research will discuss STEAM (Science, Technology, Engineering, Art, and Mathematics) as a new paradigm that uses multidisciplinary science in a learning approach to develop 21st-century knowledge, skills, and characters. This study uses a literature review with Systematic Literature Review (SLR). The STEAM model can provide new experiences for educators and students to deepen their knowledge based on reality, provide creative opportunities in work, and train communication and collaboration between fields of science with other students. The STEAM model develops learning that improves the quality of learners in terms of cognitive, affective, and psychomotor in solving problems.

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1. INTRODUCTION

Education is one of the main sectors in building civilization, especially in the 21st century. The world of the 21st century not only needs education that provides knowledge but also requires better and competent skills and character in the world of work (Surti et al., 2022). Critical thinking, creative thinking, collaboration, communication, leadership, entrepreneurship, and other talents are required in the workplace of the 21st century (Annisa et al., 2018; Erdem, 2019; Fitriyah & Ramadani, 2021, 2021; Mu'minah et al., 2020; Padmadewi et al., 2018; Priantari et al., 2020; Waluyo & Wahyuni, 2021). The skills cannot be advanced only through teacher-centered teaching approaches; relatively, instruction should be student-centered to avoid relying on teachers as learning resources and to provide students the chance to engage in new teaching approaches (Sulastri & Cahyani, 2021).

One of the fundamental processes in education is learning. It is crucial to experiment with a teaching strategy that helps students learn content, perfect their skills, and develop positive character traits for the demands of 21st-century employment. The requirements of the 21st-century occupation call for abilities to resolve issues that arise in the actual world. According to Bialik et al. (2015), there are numerous significant changes and challenges for people in the 21st century. Climate

change, financial instability, and other changes that occur call for people who can handle things properly and effectively. Undoubtedly a proper learning process is necessary to get ready for any potential future challenges. The STEAM model is one of the popular learning paradigms right now in the fields of research and education.

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STEAM is one of the learning models that uses a contextual approach by studying the phenomena that occur around us (Imamah & Muqowim, 2020). Five disciplines—Science, Technology, Engineering, Art, and Mathematics—are combined to form STEAM. This STEAM approach to education is distinct from conventional instruction, which exclusively emphasizes one branch of science. By combining several disciplines, STEAM strives to give students insights into choosing their occupations so they can pursue careers across a variety of fields as outcomes of the skills they have acquired (Mu'minah et al., 2020).

STEAM provides a new perspective on instructional practices. So far, learning is more often teacher-centered, and teachers have not been able to become good facilitators. (Bertrand & Namukasa, 2022) states that the STEAM model not only provides opportunities for students to explore and analyze problems so that they can be applied in life but also provides educators with new experiences in integrating more than two fields of science into learning. According to Kim dan Park (Quigley et al., 2017) issue resolution requires a blend of art concepts to foster creativity combined with engineering and technology.

According to Sulastri and Cahyani's research, the STEAM approach gives pupils the chance to actively participate in activity projects to develop their critical and creative thinking abilities (Sulastri & Cahyani, 2021). Research (Priantari et al., 2020) defines the results of learning as the STEAM model can hone the ability of students to think more complexly and respect each other because they carry out learning through activity projects. This study tries to identify the STEAM model as a learning technique that is best practice in international education based on previous presentations. This study explores how the STEAM approach helps students learn the skills, knowledge, and character needed for the 21st century.

2. REVIEW OF LITERATURE

2.1 21st Century Education: Knowledge, Skills, and Characters

The educational landscape must transform significantly in the twenty-first century. Education should balance the development of science-related cognitive ability with the

development of post-educational skills and character. According to the Boston, Massachusetts-based Center for Curriculum Redesign, there are four dimensions to education: knowledge, skills, characters, and metacognition (Bialik et al., 2015).

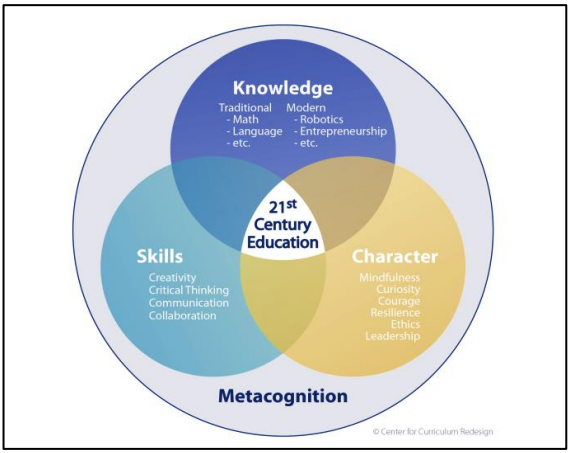

Figure 1. 21st-Century Education (Bialik et al., 2015: ii)

According to Figure 1 above, metacognition, which offers an awareness of the learning process of reflecting on oneself and how to learn that is based on three other dimensions, namely knowledge, skills, and character, is what propels 21st-century education (Bialik et al., 2015). The knowledge of the 21st century was split into traditional and modern knowledge, followed by the skills that were learned, such as critical thinking, collaboration, and creative thinking (Annisa et al., 2018; Bialik et al., 2015; Erdem, 2019; Lestari, 2021; Mu'minah et al., 2020; Priantari et al., 2020; Waluyo & Wahyuni, 2021). Furthermore,

mindfulness, curiosity, courage, resilience, ethics, and leadership are needed traits in the 21st century (Bialik et al., 2015; Lestari, 2021; Padmadewi et al., 2018). It will be necessary for these three dimensions to exist worldwide as well as in the national community. In order to be capable of solving the problems of the day, one must have the required skills, knowledge, and character. That is because information in the 21st century is expanding, widening, and moving more quickly, necessitating a management-ready education (Erdem, 2019).

The National Research Council Washington DC (2012) identified several skills to be acquired in the 21st century that are built from the educational process such as intrapersonal, interpersonal, cognitive, values, and attitudes competencies. Expected intrapersonal competencies such as intellectual openness, work ethics, and conscientious, then expected interpersonal competencies such as teamwork, collaboration, and leadership (Bialik et al., 2015; Fitriyah & Ramadani, 2021; Lestari, 2021; Mu'minah et al., 2020; Padmadewi et al., 2018). In addition, cognitive abilities like active listening, communication (both oral and written), and having a creative and innovative spirit are currently in demand. These abilities are related to cognitive processes and strategies like critical thinking, decision-making, adaptive learning, and problem-solving (Bertrand & Namukasa, 2022; Bialik et al., 2015; Erdem, 2019; Fitriyah & Ramadani, 2021; Kim, 2016; Lestari, 2021; Mu'minah et al., 2020; Priantari et al., 2020; Waluyo & Wahyuni, 2021; Zubaidah, 2019). These values shape a person's character while engaging with the environment, educational results that build values and attitudes are also necessary for the 21st century.

Traditional knowledge cannot exist in the 21st century without contemporary knowledge. According to Bialik et al., (2015), the information required in the 21st century involves and strikes a balance between traditional and contemporary knowledge. This includes both traditional knowledge—such as that found in languages, math, chemistry, sociology, and economics—and contemporary knowledge—found in fields like robots and entrepreneurship (Bialik et al., 2015). As digital literature is increasingly popular today, for instance, knowledge and digitization are essential for making it easier to communicate information, locate learning resources, and transfer material efficiently. These factors also make interactions faster and simpler (Erdem, 2019; Hirschman & Wood, 2019).

Then, there are the 4Cs, or creativity, critical thinking, communication, and collaboration, which are the abilities of the 21st century. Critical thinking describes problems by fusing several concepts and ideas with science to make the best decision, therefore creativity and critical thinking skills are essential in problem-solving (Annisa et al., 2018; Padmadewi et al., 2018; Rahmawati, 2018; Waluyo & Wahyuni, 2021). Skills like critical thinking and creativity take time to develop, but they can be learned and developed (Bertrand & Namukasa, 2022; Erdem, 2019). Through discussion in learning activities in the form of case studies that demonstrate collaboration in communication to identify solutions methodically and rationally, critical thinking may be taught and practiced (Fitriyah & Ramadani, 2021; Priantari et al., 2020; Waluyo & Wahyuni, 2021). Even though communication and collaboration skills are necessary for critical thinking as well as creative thinking, and because combining and cooperating ideas with others requires

collaboration skills to arrive at the best problem-solving, critical thinking and creativity skills are also linked to these two skills (Erdem, 2019; Hirschman & Wood, 2019; Priantari et al., 2020).

Following the dimension of information and skills, it is crucial for students to develop 21st-century characteristics, such as mindfulness, curiosity, courage, resilience, ethics, and leadership, which may be taught both within and outside of the classroom (Bialik et al., 2015). For instance, self-awareness, self-management, knowledge, and reflection are correlated to mindfulness. So, for example, curiosity is connected to passion, enthusiasm, motivation, initiative, etc. The qualities of courage required in the 21st century include, among others, optimism, inspiration, confidence, cheer, and resilience linked to hard work, self-control, adaptability, and flexibility. Fairness, loyalty, acceptance, respect, responsibility, reliability, efficiency, consistency, negotiation, and so on are all aspects of ethics and leadership.

2.2 STEAM Model Learning

Most people who emerged in STEM and STEAM in recent years are in great demand for a multidisciplinary approach to education and instruction to build collaboration inside the science field (An, 2020). According to the results of the analysis of STEM paradigms, STEAM emerged (Razi & Zhou, 2022). The Steam model is a method of learning that combines two or more sciences from among science, technology, and social humanities to develop 21st-century abilities. It offers change, new perspectives, and knowledge development (Annisa et al., 2018; Bertrand & Namukasa, 2020, 2022; Mu'minah et al., 2020; Santillán-Aguirre et al., 2020; Zubaidah, 2019).. Previously to

the STEAM paradigm, there was a STEM strategy devoid any artistic components. The Rhode Island School of Design's John Maeda then initiated and supported the integration of art because it is a crucial component of developing creative thinking and the foundation of innovation (Priantari et al., 2020; Razi & Zhou, 2022; Zubaidah, 2019). Inability to emphasize thoughts or ideas, but rather to teach students how to think critically and solve issues, the purpose of art in the STEAM model is not to draw or color (Annisa et al., 2018; Zubaidah, 2019).

The STEAM model approach intends to motivate students to explore their potential in their own ways, which will immediately encourage each student to express a variety of types of creativity (Imamah & Muqowim, 2020; Mu'minah et al., 2020). The STEAM model's emphasis on creativity can motivate students to develop their critical thinking abilities while working on projects, solving issues, and collaborating with others to achieve tasks using phenomena that occur in their immediate environment (Imamah & Muqowim, 2020; Priantari et al., 2020). The STEAM model is an approach that links several fields of science to encourage the skills of students, one of which is the addition of elements of art. The inclusion of art components in the STEAM paradigm, according to (Mu'minah et al., 2020), improves meaningful learning by requiring students to develop their talents and apply them by producing realistic works.

Taylor (2016) defined the STEAM learning model complements the STEM learning model that was previously in place; it merely expands the study and scope of knowledge integrated into the learning process. Its curriculum offers opportunities for

teachers to develop school-based curricula from several fields of science with a humanistic approach and the role of teachers as educators, not just as teachers; teachers can develop curricula by integrating various types of fields of science.

3. RESEARCH METHODOLOGY

This study used a literature review with the Systematic Literature Review (SLR) method. To develop 21st-century abilities and characters, this research will describe several explanations and reviews of topics ranging from fundamental to sophisticated relevant to understanding the STEAM model. Books, journals, and proceedings were used as primary sources of data for the study from Google Scholar, ERIC, ResearchGate, and so on, while the official websites providing the required material were used as secondary sources. The steps taken in the literature review of this study, namely:

1) Choosing topics that are interesting and important to review.

2) Looking for articles, books, or proceedings on STEAM model learning and twenty-first-century education.

3) Sorting through and identifying the data sources discovered to comprehend their benefits and drawbacks, similarities and differences.

4) Developing a methodical framework to facilitate the preparation of reviews.

5) Assembling a literature review and conducting data analysis using the framework.

6) Revisiting the findings of the literature review.

4. RESULTS AND DISCUSSION

The teachers acted as facilitators and used constructivism and contextual methods in STEAM model learning, which offers students the chance to discover and deepen their understanding as they learn. The STEAM model's application's CONCEPT is classified into two areas: the first is instructional content, which includes problem-based delivery, discipline integration, and problem-solving skills; the second is the learning context, which consists of dimensions related to instructional approaches, assessment practices, and equitable participation (Quigley et al., 2017: 10).

One of the competencies for problem-based delivery in the STEAM approach is instructional content. Developing problem-based delivery abilities is crucial for its development. Teachers must be well-prepared for it to develop lessons. For instance, there is relevance between content and situations according to learning standards to consider cohesive disciplines while preparing material from multi-disciplinary sciences and employing multiple methods for problem-solving (Pramudyani & Indratno, 2022; Quigley et al., 2017; Razi & Zhou, 2022; Surti et al., 2022). Discipline integration in education helps utilization of techniques and information from numerous scientific disciplines. Its use in terms of integrated scientific procedures, knowledge, and skills, as well as the occurrence of a blended learning process to develop problem-solving skills, is what STEAM is all about (Herro et al., 2019; Quigley et al., 2017). Furthermore, problem-solving skills in STEAM aim

to build problem-solving skills from various points of view in the field of science, namely science, technology, engineering,

art, and mathematics (Herro et al., 2019; Herro & Quigley, 2016; Quigley et al., 2017).

The stages of STEAM learning provide strategies for fostering learners' critical thinking in Table 1.

Table 1. The Stage of STEAM Model Learning

No.	Steps	Learning Process	Knowledge Disciplines
1	Provide essential questions	Before beginning learning activities, learners use the essential questions as a brainstorming tool and a general overview. Then, review and analyze cases. Use critical and creative thinking to discuss cases in essential questions given by teachers.	Science, Technology, Engineering, Art
2	Design projects that students will complete.	Groups of students are formed. Then, students discuss how to choose a project, the steps involved in completing it, where to find relevant information, and how to account for the time and challenges that they will experience during the project's completion.	Science, Technology, Engineering, Art, Mathematics
3	Arrange and plan the schedule of activities	The students create an activity schedule to finish the assignment in groups. Then, students determine the period and steps of the project completion process. Students present an activity schedule to the teacher.	Science

4	Monitoring the development of the projects that the students are working on.	First, the students carry out planned product design. Then, the students predict the period and equipment needed to finish the project. The students form habits for the 4C skills in this process. The students learn to develop the character of the 21st century by working in groups. The teacher monitors how the students are progressing with their projects following the schedule of tasks they have established. The teacher follows up on how each activity is going for the students.	Science, Technology Engineering, Art, Mathematics
5	Prove and assess the project results	The finished project is the subject of presentations by the students. Next, the students give feedback on their friends' work while they are in between groups. The teachers grade each group's projects that include STEAM model components.	Science, Technology Engineering, Art, Mathematics
6	Evaluate learners' experiences	Each student's experience is evaluated by the teacher. Evaluation using a STEAM approach. In the scientific approach, teachers assess students' scientific capability in observation, information sharing, analysis, and communication, not just laboratory activities or even required. In the technology approach, the teacher evaluates how the students use both conventional and modern	Science, Technology Engineering, Art, Mathematics

technologies to complete the projects. The engineering approach: the teacher assesses how well students use technological engineering and constructs or creates answers to issues they run through, as when working on projects. The art approach, in which the teacher assesses students' ability to think critically, creatively, effectively communicate, and other skills, rather than just the activity of drawing or producing products with aesthetic components. The mathematics approach assesses students' classification, identification, and other project-related activities in addition to the associated calculations.

References: (Bertrand & Namukasa, 2020; Imamah & Muqowim, 2020; Lestari, 2021; Mu'minah et al., 2020; Pramudyani & Indratno, 2022; Priantari et al., 2020; Sulastri & Cahyani, 2021)

An example of the use of the STEAM model in the study of sciences is (1) Science: To stimulate students' curiosity, teachers can use games or stories to illustrate scientific concepts to students as they examine natural phenomena in their immediate environment. For instance, the project may be made by asking a question about how a volcano erupts, what causes fruit to fall from trees, or what a robot does; (2) Technology: Students utilize the necessary equipment to simulate volcanic eruptions or the equipment required to create design of robots using digital application or manual. For instance, one can use both conventional and cutting-edge tools to make apple

beverages, including spoons, funnels, scales, blenders, and other instruments; (3) Engineering: Students use a variety of media to describe how to operate processes such as mountain eruptions, the production of apple drink goods; (4) Art: Students' aptitude for creating goods that are both simple to use and aesthetically pleasing. For instance, beverage goods may come in appealing packaging that is simple to transport. (5) Mathematics: The duration of the product production process is taken into account by students as they sort, compute, and measure the materials required to categorize the materials required (An, 2020; Annisa et al., 2018; Bertrand & Namukasa, 2020; Lestari, 2021; Priantari et al., 2020).

An example of the use of the STEAM model in the study of social sciences in the humanities, (1) Science: Students learn the concept of planning a learning or educational model that can be analyzed by SWOT analysis and also the concept of financial statements; (2) Technology: To encourage completion, students utilize electronic and non-electronic sources, learning tools, and facilities. Use Microsoft Office tools, Google Scholar, Elsevier, and Emerald as reference sources, for instance, or Google Meet or Zoom for communicating with the team when creating SWOT tables; (3) Engineering: To develop projects, such as learning models to be utilized before teaching practice or financial reports, students do research and investigation; (4) Art: When creating learning plans or financial statements, or when applying the findings of a SWOT analysis, students take notes to solve difficulties; (5) Mathematics: Refers to the computation of each learning stage that is arranged in planning, such as the computation of the length of learning time, the amount of material, and the challenges that will be encountered in the

application of the learning model (Pramudyani & Indratno, 2022; Sulastri & Cahyani, 2021; Walsiyam, 2021).

The implementation of the STEAM model in learning can be beneficial for developing cognitive, affective, and psychomotor aspects that are beneficial in facing the challenges of the 21st century. Because STEAM elements integrate several branches of study, STEAM can be applied to teach science and social humanities courses.

Many educational institutions in Indonesia and elsewhere have adopted the steam model of learning. The elementary, secondary, and higher education levels all use this paradigm. STEAM is considered an effective method for preparing students for the 21st century, particularly for developing the abilities and character required in that century.

Studying acid-base materials in grade 2 at SMAN 11 Jambi City, (Annisa et al., 2018) found that using a project-based learning paradigm significantly improved students' capacity for creative thinking, with a significance value of 0,000 < 0,05. According to research (Waluyo & Wahyuni, 2021), using the STEAM model in high school physics classes, studying with STEAM boosts student interest and can offer a better experience. Additionally, the STEAM model's materials are combined with the qualities required for the 21st century and match the real world so that students can directly experience them. Lestari (2021) used the STEAM model to synthesize the findings of her physics research at SMA Negeri 1 Yogyakarta. With pre-test scores of 1.34 and an average post-test score of 2.78, there was an improvement in critical thinking skills. There was also an improvement in communication and collaboration abilities in cooperation.

Naturally, the goal of this STEAM approach is to assist students in gatherings for the 21st century.

Supported by previous research by Priantari et al. (2020) at the Muhammadiyah 6 Wuluhan Jember Junior High School (SMP) in science subjects, PjBL STEAM has a positive effect on students' critical thinking skills. Fitriyah & Ramadani (2021), who use STEAM in class X MA (*Madrasah Aliyah* or Senior High School) Miftahul Ulum Bettet Pamekasan, Madura in the Department of Science and Social Humanities, said that there was a significant improvement in critical and creative thinking after teachers applied the STEAM model in scientific learning. Sulastri & Cahyani (2021) also showed the results of steam model research in accounting subjects. The findings of the pre-test and post-test in online learning showed an improvement in the students' critical thinking abilities. Then, Bertrand & Namukasa (2020) in mathematics lessons, the application of the STEAM model to learning can develop student learning, adaptability, and transferable skills.

The study's findings (Lin & Tsai, 2021) indicated that students' perceptions of their growing competency and motivation to learn projects utilizing the STEAM approach were favorable. The study's findings (Liliawati et al., 2018) demonstrate that implementing the STEAM model method can improve learners' knowledge of a concept. Additionally, (Kang, 2019) on the implementation of STEAM showed that learning is effective for both cognitive and affective students, with an impact on the affective domain being significant. The Synthesis of Engineering and Art (SEA) research project engaged ten studio art and art education students with nine undergraduate environmental

engineering students to implement the STEAM model. The project was assisted by two engineering education faculty and one art education faculty, and the results of the representations that reflected the synthesis between the fields of engineering and art were displayed (Costantino, 2018).

The effectiveness of the STEAM model in enhancing students' 21st-century skills is supported by previous research (An, 2020; Bertrand & Namukasa, 2020; Lestari, 2021; Mu'minah et al., 2020; Priantari et al., 2020). Numerous studies have shown that using this strategy while teaching students to collaborate better. The primary element affecting the expansion of initiatives to collaborate in learning is the requirement for teamwork in STEAM model implementation. According to several additional research, students' communication skills develop when scientific procedures and problem-solving are used in the classroom because, in essence, deep issue-solving involves collaboration in project activities (Annisa et al., 2018; Bialik et al., 2015; de la Garza, 2021; Erdem, 2019; Waluyo & Wahyuni, 2021).

5. CONCLUSION AND LIMITATIONS

To prepare students for the challenges encountered in the twenty-first century, education must consider that the 21st century requires not only the development of knowledge but also the skills and character of students who can contribute to various fields. The integration of various sciences offered in STEAM model learning provides a new perspective on shaping students to be able to hone and improve their abilities and skills in various fields. The STEAM model can also improve some of the characteristics and skills necessary for the 21st century,

such as teamwork, critical thinking, creativity, and mindfulness. Since the STEAM element itself is the outcome of the integration of various sciences, STEAM can also be implemented in learning at elementary school through higher education levels and in the fields of science and social humanities.

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