



# Integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) in Education in the Era of Technology

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## A B S T R A C T

This study aims to analyze the implementation of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning model in enhancing students' creativity at SMP Swasta Darma. The research method employed is a literature review, examining various references related to the application of the STEAM model in the context of education and creativity. Data were collected through document analysis, which includes previous research, articles, books, and other relevant sources. The findings reveal that the implementation of the STEAM model can enhance students' creativity, measured through indicators such as idea flow, creative thinking ability, cognitive flexibility, and appreciation for art and innovation. The STEAM model allows students to develop creative thinking skills through interdisciplinary learning experiences and complex problem-solving. Additionally, the application of this model encourages collaboration among students in team projects, enabling them to exchange ideas and work together in developing innovative solutions. Overall, the study concludes that the STEAM learning model is effective in enhancing students' creativity and recommends further development of STEAM implementation in formal education.

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## 1. Introduction

Education is a process or system aimed at transmitting knowledge, skills, values, and norms to individuals or groups within society. The primary goal of education is to assist students in developing holistically, including physically, mentally, emotionally, and socially. Cognitive, emotional, and psychomotor education is one of the nation's efforts to produce competent generations. Education, in achieving its goals, requires a framework such as a curriculum that encompasses content, objectives, and designs to achieve the educational goals set by the national education system (Aguilera & Ortiz-Revilla, 2021).

The development of technology over the last decade has shown that the world is progressing, and education is evolving accordingly. In education, efforts to develop students' skills in mastering technology are implemented in every curriculum update conducted by the government. This is to maintain a generation that is ready and reliable. This challenge represents the era of globalization (Arsy & Syamsulrizal, 2021).

In recent years, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach has gained significant attention in the field of education. This approach not only focuses on knowledge acquisition but also on values and skills related to daily life. The STEAM approach is a

comprehensive interdisciplinary learning method that integrates five areas of knowledge: science, technology, engineering, arts, and mathematics. This approach aims to create a dynamic, creative, and innovative learning environment that fosters critical thinking, problem-solving skills, and teamwork among students (Jesionkowska et al., 2020).

According to Science (2023), this approach gives students the freedom to develop broader skills through collaboration, creativity, and critical thinking. It enhances innovation and design skills by engaging in collaborative group projects and improves presentation skills by presenting their exploratory results. The integration of STEAM enhances students' science learning experiences, enabling them to study science more thoroughly and meaningfully through an approach where students actively participate in the process.

(Shorihatul Inayah, 2020) argues that the STEAM approach includes (1) Science in concept generation, (2) Technology by explaining various engineering applications related to materials, (3) Engineering, which can be instructed for creation, (4) Arts, which helps train students' creative thinking skills, and (5) Mathematics used to formulate mathematical equations related to material concepts and calculations.

Previous research conducted by Aisyah Sava in 2023 titled "21st Century Learning Systems as an Effort to Improve Human Resources" stated that in 21st-century learning, the models and methods used must be capable of addressing the challenges of an ever-evolving era. The skills students must possess include critical thinking, communication, and innovation. The methods and learning models used impact students' learning outcomes. The learning system introduced in the 21st century is fundamentally based on the era's development, such as utilizing technology; however, the approach must also shift from teacher-centered to student-centered, encouraging students to enhance their cognitive abilities and skills while fostering innovations that can benefit society in the future (Rahmadila et al., 2023).

A previous study by Iik Nurhikmayanti in 2019 titled "Implementation of STEAM in Mathematics Learning" found that STEAM as a learning approach is a means by which students develop science and technology-based ideas through inquiry in thinking and problem-solving activities based on five integrated disciplines. When problem-solving is based on various disciplines, it becomes highly accurate, engaging, effective, and efficient (Nurhikmayati, 2019).

A study by Neneng Nur in 2023 titled "Implementation of the STEAM Learning Model to Enhance Creativity in Students at RA Al-Manshuriyah Sukabumi City" showed that students with high creativity tend to be more enthusiastic about learning, have better problem-solving abilities, and are more flexible thinkers. Therefore, it is crucial for pedagogical theory to understand how creativity enriches students' learning experiences. Teachers can create learning environments that support exploration, discovery, and creative expression. Teachers can also provide constructive feedback to encourage students' creative potential. Therefore, understanding the teacher's role in enhancing students' creativity is a key component of these theories. Including elements that stimulate creativity in the curriculum can help foster students' creative development (Madani Nusantara et al., 2023).

## 2. Research Methods

This research article discusses the application of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning model in the context of the Technological Era, aiming to embrace innovation and creativity in education at SMP Swasta Darma Medan, using the literature review method. A literature review is a process that involves gathering, reading, taking notes, and managing relevant literature materials to support the research topic. The process of sourcing references was conducted through Google Scholar, the internet, and searching various other relevant bibliographic sources and documents. This method aims to gather as many pertinent references as possible to provide a deeper understanding of the application of STEAM in education. By using this literature

review approach, the study can gain insights into how STEAM in the technological era can foster innovation and creativity among students, without the need for direct fieldwork. Instead, this research utilizes data from available bibliographic sources and existing documents.

### 3. Results and Discussion

STEM, which stands for Science, Technology, Engineering, and Mathematics, was first introduced by the National Science Foundation (NSF) in the United States in the 1990s as part of an educational reform movement aimed at improving the STEM workforce and promoting STEM literacy. This was also intended to enhance the global competitiveness of the United States in science, technology, and innovation. Initially, the term SMET was used but was later changed to STEM, which is now more widely recognized. The four STEM disciplines—Science, Technology, Engineering, and Mathematics—can be summarized as follows:

1. Science enables individuals to develop an interest and understanding of the world around them, including the physical and material worlds, while also fostering collaboration, research, critical inquiry, and experimentation skills.
2. Technology encompasses various fields that involve applying knowledge, skills, and computational thinking to enhance human capabilities and meet human needs and desires.
3. Engineering involves the skills and knowledge required to design and build machines, devices, and processes that solve real-world problems.
4. Mathematics helps individuals interpret and analyze information, simplify and solve problems, assess risks, make decisions, and better understand the world by modeling both abstract and concrete issues (Davidi et al., 2021).

The emergence of STEAM (Science, Technology, Engineering, Arts, and Mathematics) as an educational approach addresses the need to enhance student interest and skills in these disciplines. By incorporating "Arts" into STEM education, STEAM promotes increased student engagement, creativity, innovation, problem-solving abilities, and other cognitive benefits. This interdisciplinary approach aims to better equip students with the skills required for the workforce, including teamwork, communication, and adaptability, which are essential for career and financial advancement (Sari, 2020).

STEAM is a comprehensive learning model that encourages students to think critically about real-world problems. It also supports meaningful learning experiences and problem-solving. The interconnectedness of science, technology, engineering, arts, and mathematics is emphasized, providing students with a holistic understanding of various disciplines (Ragil et al., n.d.). STEAM is a method of education that leverages the five disciplines—science, technology, engineering, arts, and mathematics—as a problem-solving framework. It fosters collaborative learning environments, where students work together to apply knowledge across disciplines in practical contexts (Rohman & Musa, 2022). Components of STEAM:

1. Involvement: Parents or teachers encourage children to engage more actively in STEAM-related activities based on prior experiences.
2. Explore: Teachers or parents provide opportunities for children to explore tools and materials, allowing them to develop their own understanding.
3. Explain: Teachers and parents assist children in expressing and understanding what they have learned.
4. Elaborate: Teachers or parents help children deepen their conceptual understanding and adapt practical skills.

5. Evaluation: Teachers or parents guide children in evaluating the learning activities they have undertaken.

The concept of STEAM emerged as a model to break down the boundaries between traditional disciplines, enabling science, technology, engineering, arts, and mathematics to be integrated into a unified curriculum. The 21st century opens new horizons for the "nonlinear holistic design of complex systems" and demands interdisciplinary approaches as well as new conceptual tools and principles. The increasingly complex world requires skills to tackle its challenges, and schools are expected to teach more than just simple reductionist disciplines. This calls for relevant and creative curricula that are "non-traditional" (Halimatul, 2021).

Encouraging creativity within STEAM learning is essential to making student thinking more independent and flexible. It also improves creative self-efficacy and problem-solving skills (Amelia et al., 2022). Research shows that creativity can be learned through example and practice. Therefore, teachers are expected to model creative values and behaviors while maintaining a collaborative classroom atmosphere.

The development of creativity in the classroom is highly influenced by how teachers implement activities and the types of activities they use. There are many varying beliefs among teachers about creativity and their ability to foster it in their students. These differing, and sometimes conflicting, beliefs can hinder the practice of creativity in the classroom. Furthermore, the lack of research on the process of teaching creativity remains a major challenge.

On the other hand, while creativity is often associated with the arts and arts education, it is important not to prioritize the final product over the artistic process itself. A misconception about STEAM learning is that the arts focus primarily on the finished product, rather than on the learning process involving thinking, planning, creation, or performance of art. This emphasis on the final product can, in fact, stifle student creativity (Qulsum, 2022).

Many schools still lack STEAM programs and are unprepared to plan or implement them. Below are some recommendations for planning future STEAM education:

1. Set a Budget: The first step is planning the budget. Even without a specific budget, it is essential to consider the costs and possibilities involved. It is important that no additional costs are imposed on teachers or students that were not previously budgeted. Clear communication is vital, and support from school leaders, parents, and the community is crucial (Boice et al., 2021).
2. Determine Location and Learning Space: Planning the location is important to ensure the smooth execution of activities. Activities can be conducted in regular classrooms, art rooms, large spaces (auditoriums), or even outside the classroom.
3. Identify Available and Needed Resources: Resources may include classroom space, technology, furniture, program availability, and even a list of local organizations that can participate in STEAM programs. Seeking assistance from other teachers can be highly beneficial. Traditional classroom furniture may not be suitable for STEAM learning, so it would be ideal to have a dedicated collaborative learning space for STEAM activities where appropriate discussions can take place.
4. Develop Curriculum: Planning for the integration of STEAM into the curriculum is critical. Start by considering the required standards. Decisions regarding annual and semester activities, including scheduling for STEAM activities, should be made carefully. This plan should also include assessments for STEAM learning. It is crucial not to assess STEAM activities solely through written tests. A rubric should be developed to track student progress (Fadhilah, 2022).

In addition to suggestions for planning STEAM education, here are some recommendations for its implementation in the classroom:

1. Ask for Help Early and Often: Don't hesitate to seek support from the school principal and other teachers from different classes and schools. Teacher forums are essential for continuous collaboration and staying updated on educational trends.
2. Be Flexible: Especially at the beginning of the program, be open to discovering new and unexpected outcomes. This is part of the learning process. Maintain a positive attitude and promptly consider improvements (which can be done with students).
3. Keep an Open Mind: Give students the opportunity to take responsibility for their learning and how they express themselves. Although teachers may have the best ideas for implementing STEAM, students may have their own ideas and processes. As a teacher, position yourself alongside or behind the students, not in front of them, as they learn.
4. Let Students Lead: One of the biggest questions teachers face when starting STEAM education is: Do students know more about technology, engineering, arts, and other STEAM concepts than the teacher? This is one of the best aspects of STEAM! The role of the teacher is to help students set goals, motivate them with patience, organize their thinking, develop ideas, expand their skills, prepare them to work in teams, and guide them through challenges and solutions. It's about coaching and providing support as students solve problems (Fadillah, 2022).

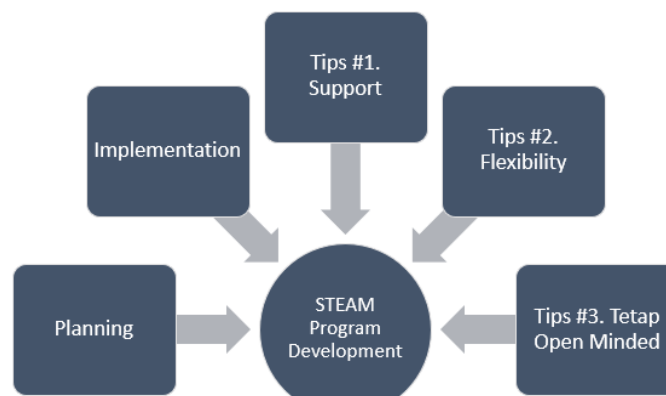


Figure 1. STEAM program development

#### 4. Conclusion

Education 4.0 plays a significant role in the ongoing revolution, where the integration of technology supports and enhances educational processes. In turn, education is central to driving the Education 4.0 revolution. STEAM (Science, Technology, Engineering, Arts, and Mathematics) is a sub-specialization of science that integrates these five disciplines into a cohesive approach that can be applied in school learning. STEAM can be introduced at any level of education, providing students with an opportunity to engage in multiple disciplines simultaneously. This method allows students to explore various topics and perspectives while solving problems and tackling challenges, thus preparing them for the increasingly complex real world. The STEAM learning method significantly influences students' creativity. Numerous studies have already implemented STEM learning approaches using specific teaching models, revealing improvements in student learning outcomes as well as critical and creative thinking. These findings align with the demands of learning in the Society 4.0 era, which calls for students to be more critical and creative in order to compete in the future job market. Therefore, STEAM education is not only beneficial for developing students' academic abilities but also for fostering essential skills required in the evolving global landscape.

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