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STEAM-BASED LEARNING TO ENHANCE TECHNOLOGY AND INNOVATION SKILLS OF ELEMENTARY SCHOOL STUDENTS

Abstract
This research aims to explore how the application of STEAM-based learning can improve technology and innovation skills in primary school students. The issue raised is the need to understand the effectiveness of STEAM methods in improving students' ability to face modern technological challenges. The writing of this article uses a systematic review method based on several references in the form of books and scientific publication articles from various open source library sources. The results of this study show that students are not only better able to use technology, but also show improvements in creativity and critical thinking skills. These findings are of great significance as technology and innovation skills instilled at an early age become the foundation for the development of higher competencies at an advanced level which is crucial in the field of education. This study therefore provides important insights into the integration of STEAM learning in the primary education curriculum and its long-term implications for improving the quality of human capital.
Keywords: STEAM, Technology Skills, Innovation, Students, Primary School.

INTRODUCTION

The development of education around the world is currently undergoing a transformation along with the rapid development of technology, so that the role of education in preparing young people who are skilled to face various challenges is increasingly complex. One learning approach that is widely applied to improve student skills in the 21st century is the STEAM (Science, Technology, Engineering, Art, and Mathematics) approach. This approach provides an opportunity to creatively integrate various disciplines in the curriculum, while emphasising the importance of technology and innovation skills for students. In Indonesia, the implementation of STEAM-based learning in primary schools is increasingly relevant along with the increasing need to prepare students to face challenges in the ever-evolving digital and global era. Thus STEAM-based learning with a holistic approach enables the integration of various disciplines creatively and innovatively in increasing the relevance of learning for students.

Emphasis on the development of technology and innovation skills in the context of STEAM is important at the primary education level, as the foundations of students' knowledge and skills begin to be built from early school age. In addition, the trend of rapid technological development and the demand for skills and knowledge in various fields trigger the need to adapt teaching methods that can encourage students to think critically and creatively (Kemal Yürümezoğlu et al., 2024) (Ronnie Videla-Reyes et al., 2023). Despite the emergence of this innovative educational approach, many primary schools in Indonesia still face challenges in implementing STEAM-based learning. Limited knowledge of the STEAM curriculum among educators, and lack of adequate resources and training for teachers result in suboptimal implementation (Н. А. Моисеенко et al., 2022) (О.Л. Мохова et al., 2022).

Therefore, the problem in this study was formulated to explore how the implementation of STEAM-based learning can effectively improve technology and innovation skills in students at the primary school level, while identifying the barriers to such implementation. The main objective of this study is to investigate the effect of STEAM-based learning in improving

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students' technology and innovation skills at the primary school level. The importance of this study lies in its contribution to the development of more effective pedagogy in primary education. By improving technology and innovation skills among students, it is expected that there will be an improvement in their readiness to face challenges in an increasingly technology-related world.

METHODS

This research is a qualitative study using a systematic review method based on various reference sources in the form of books and articles from various open source libraries. Systematic review is a research method for identifying, evaluating and interpreting all relevant research results related to certain research questions, certain topics or phenomena of concern. (Siswanto, 2010). Thus the stage carried out is to describe important issues relevant to the STEAM-based learning approach. The systematic review method used is synthesis by summarising various expert opinions through articles and other scientific publications with meta-synthesis and data integration techniques to obtain new theories and concepts or a deeper and more comprehensive level of understanding (Perry & Hammond, 2002). (Perry & Hammond, 2002).

The data sources used in this research are books and articles that are relevant to the topic of this research. Data sources were obtained online using digital libraries such as Google Scholar, Garuda, Semantic Scholar and Elsevier. Search and selection of articles using keywords that match the topic. The data collection technique uses cumulative research results that have relevance to previous research and the included studies allow generalisation of the focus on the research topic area. Data analysis uses the content analysis method, which is an analysis of the content that focuses on the relevance of the independent curriculum to national education goals and 21st century needs. (Schreier, 2024).

RESULTS AND DISCUSSION

The implementation of STEAM approaches in primary education has shown great potential in improving students' technology and innovation skills. Recent research shows that technologies such as augmented reality, virtual reality and 3D printing in learning can have a positive impact on student engagement. By creating interactive, immersive and sensory learning environments, students become more motivated to be active in teaching and learning activities. Thus the learning experience should support students' creativity and problem solving (Birt et al., 2017). Integrating STEAM elements in the curriculum requires close collaboration between educators and technologists to ensure that the tools and methods used are appropriate for students' needs. The STEAM curriculum development process must take into account the local context and specific needs of students in Indonesia. By studying the historical and political development of STEM, iSTEM and STEAM, we can design approaches that are relevant and effective in the Indonesian educational context. The importance of focusing on the development of 21st century skills in STEAM learning should be supported by professional training and improving teachers' ability to teach STEAM (Razi et al., 2022). This is important because the successful implementation of the STEAM curriculum is highly dependent on teachers' understanding and ability to adopt innovative and interactive teaching methods (Berrens Torruella et al., 2020).

This research shows that the application of STEAM learning has a significant positive impact on students' technology and innovation skills which can be seen from the increased ability to use technology tools, think critically, and collaborate on innovative projects. This is supported by previous research conducted by Kemal Yürümezoğlu et al. (2024) and Ronnie Videla-Reyes et al. (2023), who emphasised that active project-based learning can bridge the gap between disciplines in technology and science education. In addition, the results obtained are also consistent with the findings of (Н. А. Моисеенко et al., 2022) who reported a positive relationship between STEAM methods and the improvement of students' critical thinking skills. However, there are also some differences, the study by (О.Л. Мохова et al., 2022) states that not all STEAM implementations are successful, depending on teacher readiness and available facility support. Thus, this study also fills a gap in the literature on STEAM pedagogy by

showing that by providing adequate training for teachers and optimising resources, better results can be achieved.

In the STEAM approach, software should support creativity and innovation, therefore using new technologies well can improve the innovation ability of students at various levels of education, including primary school (Aisling Leavy et al., 2023). For example, interactive applications such as project-based learning covering science, technology, engineering, arts and maths can help students understand difficult concepts and encourage their critical thinking. Therefore, the use of innovative software in education not only improves academic understanding, but also prepares students for future challenges. Based on research results, it is known that software designed specifically for STEAM activities shows good results in increasing students' interest in learning and influencing students' positive attitudes towards learning (Chih-Hung Wu et al., 2022). This approach suggests that students' ability to innovate can be enhanced through hands-on experience with technology while demonstrating the practical benefits of the software they use. Therefore, good development planning should involve collaboration between STEAM experts to enhance the learning experience and provide better outcomes for students (Aisling Leavy et al., 2023).

STEAM-based learning is applied in primary schools as a strategy to enhance students' technological skills that serve to prepare them for challenges in an increasingly technology-integrated world. Feedback from students confirmed their positive experiences in learning by using technological tools and devices, as well as their ability to apply such knowledge in the context of everyday life. Some research results that support this conclusion are Kemal Yürümezoğlu et al. (2024), who showed that project-based learning in STEAM content was able to improve students' technological skills at the primary school level. In addition, research by Ronnie Videla-Reyes et al. (2023) also emphasised that arts integration in STEM education provides a space for students to express their creativity and thus contribute to a better understanding of technology. Another study by Lutfi et al. (2023)explained that STEM integration in science learning can improve students' entrepreneurial character. Thus, the results of this study reinforce the importance of adequate structural support to support the success of STEAM. So that by integrating technology learning in an interactive and collaborative STEAM context, students will be better prepared to face global challenges and contribute to the development of a better society.

STEAM education is expected to play an important role in improving students' innovation skills. This approach not only focuses on knowledge transfer, but also encourages students to think creatively and find new solutions to challenges faced. The results of previous research conducted by Н. А. Моисеенко et al. (2022) found that the integration of arts into the STEM curriculum increased students' creativity and ability to innovate. Another study by О.Л. Мохова et al. (2022) also supported that STEAM methodologies that promote collaboration and exploration and increase student interest and develop critical skills related to innovation. Despite the similarity in many studies showing a positive relationship between STEAM and innovation skills, some studies point to challenges in implementation, such as lack of teacher training and resources (R. Videla et al., 2021), (Rahma Hidayanthi et al., 2024). This research shows that the identification and reduction of such constraints is important in order for all students to optimise their innovation potential. As such, this research not only provides evidence regarding the positive impact of STEAM on students' innovation skills but also directs attention to the importance of investment and support in teacher training and educational resource development to achieve greater success in the context of basic education in Indonesia (Sofiia Dembitska et al., 2024), (Ronnie Videla et al., 2023).

This research indicates that STEAM not only aids the understanding of concepts in the field, but also enhances students' collaborative and creative skills (Razi et al., 2022). With project-based learning and experimentation, students can be actively involved in the learning process, which supports the development of innovative skills that are important for their future in the world of work. One way to measure technology and innovation skills is with authentic assessment involving collaborative projects. Thus in creating an evaluation framework for technology and innovation skills, it must consider various factors, such as culture, context, and changes that occur in the learning environment. By incorporating these elements, assessment

can be more appropriate and relevant to the needs of students in the digital age. Studies on STEAM suggest that this education needs to be transdisciplinary, with linkages between different disciplines that can enrich students' learning experiences (Cullough et al., 2022). Therefore, it is important for researchers and educators to continue to look for new methodologies and strategies to measure these skills, so that students are better prepared for future challenges.

In the endeavour to implement STEAM learning in primary schools, a major challenge is the lack of available resources. These resources include not only physical facilities and tools, but also professional development for teachers. Without such support, teachers will find it difficult to incorporate effective STEAM practices in their teaching. Therefore, a lack of resources can hinder innovation in teaching and reduce students' access to interactive learning experiences that are essential for technology skills. Lack of facilities also contributes to low student participation in STEAM education. Meanwhile, uncertainties in relevant skills needs are becoming more pressing. A report on economic diversification strategies in Nevada shows that the need for STEM skilled labour is increasing, but many potential workers do not have the required skills (Andes et al., 2014). In this situation, schools need to prioritise investment in tools and resources for students to get a quality education. This is not only about academic needs, but also to prepare young people to contribute to an economy that relies more on high-tech skills. Quality education requires more than just a good curriculum. Schools must invest resources that support active and collaborative learning, especially in the application of STEAM methods. For example, training for teachers in project-based teaching and the use of the latest technology will create a more engaging learning atmosphere for students. This effort is in line with the recognition that many opportunities in new sectors, such as technology and healthcare, require skills that evolve with industry needs (Brosens et al., 2019). By increasing support for resources and training, schools can be better equipped to facilitate educational innovations that are expected to transform the way students learn and engage in an increasingly complex world.

CONCLUSIONS

The implementation of STEAM-based learning has been proven to successfully improve technology and innovation skills in elementary school students. Through an integrated approach of science, technology, engineering, arts and maths, students not only gain academic knowledge, but also improve their practical problem-solving and innovation skills. This research shows that STEAM programmes such as project-based activities not only improve content comprehension, but also help students to be more socially and emotionally engaged in the classroom. In addition, the application of this approach not only improves technological skills, but also builds students' flexible and innovative character. The implication of the findings of this study academically is that the results provide a strong basis for STEAM education to be introduced more widely in the primary school curriculum, emphasising the importance of integrating relevant disciplines in learning. On the practical side, this study shows that teachers need to be supported with adequate training and sufficient resources to effectively implement the STEAM approach. Overall, the enhancement of technology and innovation skills in students from using this method has a positive impact on the quality of education in Indonesia.

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