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Development and Challenges of STEAM Learning Implementation in Elementary Schools: A Comprehensive Literature Review

Galih Majesty Erawan[1*], Neni Mariana[1], Suryanti[1]
[1*]Universitas Negeri Surabaya, Surabaya, Indonesia

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ABSTRACT

Objective: *This study is a comprehensive literature review on the development and challenges of STEAM learning implementation in elementary schools.* ***Methods:*** *The research method used is a literature review of articles and journals on Google Scholar in 2019-2024 totaling 10 articles that discuss the development and challenges of STEAM learning in elementary schools. Data analysis using qualitative descriptive methods.* ***Results:*** *The focus of the research is the development and challenges of STEAM implementation in elementary schools. The results showed that there are several developments in the implementation of STEAM learning in elementary schools with various new innovations in its application, ranging from the choice of topics, models, to the learning media used. The implementation of STEAM Learning develops by utilizing contextual learning that departs from real events in students' lives to collaborate and create a work, utilizing the surrounding environment as a learning tool (fertilizer making activities, JAKA games, sribu gymnastics exercises, and the implementation of mathematics in learning and students' daily lives), making projects that depart from the local wisdom of the area where students live (batik crafts), utilizing new technology (robots for learning activities), utilizing used material processing activities (Glass Bottle Music), utilizing innovative modules ("Beruang Antik" module), and also innovative learning media (Tak Tik Butarna Media). On the other hand, there are still various challenges in the process of implementing STEAM learning in elementary schools which include: pedagogical challenges, technical challenges, facility challenges, learning resource challenges and the timing of STEAM learning implementation.* ***Novelty:*** *The novelty of this research is that the literature review used is sourced from Google Scholar so that the results of the study can provide information about the development and challenges of STEAM implementation. This research focuses on what are the developments and challenges of implementing STEAM learning in elementary schools.*

INTRODUCTION

Just as technology continues to develop, the world of education is also experiencing various developments. Like STEM learning which developed into STEAM learning. (Aguilera Morales & Ortiz-Revilla, 2021) STEM (science, technology, engineering, and math) is an educational approach that is now accompanied by a variant of STEAM (STEM + Art) (Okwara & Pretorius, 2023). Both educational approaches seek to renew the scientific literacy of young people, and, with the inclusion of the arts, student creativity is described as a key skill that should receive special attention (Yilmaz, 2021). Others argue that the A (for art and design) in STEAM is an essential addition to the original STEM approach (Marmon, 2019). Art and design allow for more divergent thinking in students, providing room for more creative solutions to problems (Granville et al., 2024; Sanchez Milara & Cortés, 2019; van de Kamp et al., 2016). So, it can be concluded that the development of STEM into STEAM is an effort to update the scientific literacy of the younger generation with an essential addition in the form of art as a form of creativity

and divergent thinking with the letter "A" symbol added to STEM so that it becomes STEAM.

In addition to experiencing development, STEAM learning also encounters various challenges. (Yulianti et al., 2024) states that there is a need for clear guidelines, comprehensive frameworks, and practical examples to support educators in integrating STEAM effectively into various educational contexts. In addition, (Boice et al., 2024) it also states that teachers need support, autonomy, and flexibility to adopt STEAM integration approaches that best suit their classroom and school contexts. So, it can be concluded that the application of STEAM still experiences various challenges such as the absence of clear guidelines, comprehensive frameworks, practical examples, and flexibility in its application to suit the classes and schools they teach (Herro et al., 2019; Yim et al., 2024).

A significant area lacking investigation involves comprehending how the shift from STEM to STEAM caters to the particular requirements and circumstances of elementary schooling (Decorte & Vlieghe, 2024; Khairullina et al., 2022). Even though the focus of STEAM on innovative and non-linear thinking has received considerable attention, its actual application in elementary classrooms is still not sufficiently examined (Lu et al., 2022; Quigley et al., 2019). This research plays a role in analyzing the significance of STEAM education in elementary settings, where essential skills like creativity and analytical thinking are nurtured. By emphasizing the growth and obstacles associated with STEAM education, this study connects the historical transition from STEM to STEAM with its practical effects for early learners.

The new thing in this research is that the literature review used is sourced, which come from newest research in 5 years, during 2019-2024, so that the study results can provide information about the development and challenges of implementing STEAM learning in elementary schools. This research focuses on the developments and challenges of implementing STEAM learning in elementary schools. This makes this research relevant and can significantly contribute to the literature on the development and challenges of implementing STEAM learning in elementary schools.

RESEARCH METHOD

This research uses a preliminary study with a descriptive research design and does not test hypotheses (Abubakar, 2020) but uses a descriptive research design. Researchers carried out this preliminary research to find out the actual situation at school and add information related to problems in more detail (Saphira & Prahani, 2022). The results of this research are used to improve innovative learning models and tools in the school to improve elementary school students' critical thinking skills.

This type of literature study research uses the SLR (Systematic Literature Review) method. The SLR (Systematic Literature Review) method is used to track, find, and evaluate all relevant research to answer research questions (Istiqomah & Juansah, 2024). Researchers will evaluate various articles that are relevant to the research topic. The data collected by researchers are articles that discuss the implementation of STEAM in

elementary schools. The articles collected are the results of searches through Google scholar from 2019 to 2024 with topics that are following the research objectives, namely the development and challenges of STEAM implementation in elementary schools. The process of analyzing the data obtained was carried out in a qualitative descriptive manner. Qualitative research was chosen because it allows researchers to focus more on the process and meaning obtained from the perspective of the research subject through an inductive and descriptive approach.

In order to guarantee that the literature review thoroughly examines the evolution and obstacles of STEAM within primary education, particular criteria for inclusion and exclusion were established during the selection phase. Articles that were accepted met the following conditions: (1) they were published in journals that are peer-reviewed, (2) they focused on the execution, growth, or challenges of STEAM learning, especially in primary education, and (3) they were written in either English or Bahasa. Emphasis was placed on newer publications (2019–2024) to maintain relevance to contemporary educational methods. Articles were dismissed if they: (1) concentrated exclusively on STEM, neglecting the "A" (arts) aspect, (2) did not relate to primary education, or (3) failed to provide empirical data or practical considerations for integrating STEAM.

The selection process commenced by exploring databases like Google Scholar with search terms such as “STEAM in primary education,” “challenges in STEAM learning,” and “STEAM development.” Initially, 150 articles were discovered. After a first evaluation based on titles and abstracts, 85 articles were narrowed down. These were then reviewed again using the aforementioned criteria, leading to a concluding set of 40 articles that offered thorough insights into the evolution and challenges of STEAM education in primary schools.

The data analysis technique used in this study refers to the opinion of Miles and Huberman in (Akmala et al., 2024), which explains that the steps of data analysis consist of: 1) data reduction, 2) data presentation, and 3) conclusion drawing. In this study, the steps of data analysis were implemented as follows: 1) data reduction: done by sorting the articles that have been successfully collected from Google Schoolar based on important points that are in accordance with the research objectives so that they can be used as a basis for concluding. 2) data presentation: the research data is presented in the form of narrative text, which includes brief descriptions, charts, and relationships between individuals in the writing. 3) drawing conclusions: from the process of data reduction and presentation, verification of information can be carried out which becomes the conclusion of the research.

RESULTS AND DISCUSSION

Results

The research results derived from analyzing the summaries of documented articles that became literature review materials related to the development and challenges of STEAM learning implementation in elementary schools are shown in Table 1.

Table 1. Research results on the development and challenges of STEAM learning implementation in elementary schools

Author	Article title	Results
(Rakhmawati et al., 2024)	Implementation of STEAM Learning in Low Grade in Elementary School	Based on the literature review of several articles, the conclusion in this article is that STEAM learning in low grades, especially in elementary schools, is contextual learning, where children are invited to understand events that occur within the scope of life so that children explore all their abilities and bring up different works from individuals and groups. Collaboration, cooperation, and communication are applied in the learning process because STEAM is done in groups to stimulate the ability to take responsibility and solve problems both personal and interpersonal to learning and be able to construct an understanding of the material presented.
(Arianto et al., 2024)	Implementation of Robotics to Improve Steam Learning at SD Muhammadiyah Beji, Gunung Kidul Regency, Yogyakarta	The results of the training showed that students were very enthusiastic about the activities and had a greater interest in science and technology. On the other hand, the teachers also gained a better understanding of STEAM-based learning and how to integrate it into their curriculum. The program succeeded in creating a learning model that can be adopted by other schools, as well as providing references to innovative learning methods to increase students' interest in learning. The training is expected to inspire students to aspire to be technologists in the future.
(Kumalasari & Hasanah, 2023)	Evaluation of STEAM-Based PjBL Implementation in Grade V Primary IPAS Learning	One of the efforts that can be made to overcome these problems is through STEAM learning based on PjBL (project-based learning) with products tailored to product differentiation strategies. The products produced are 1) Making teraterium, 2) Role Play 3) Poster and 4) Power Point then measured quantitatively using evaluation research. Based on data analysis of the data in the table above, it is known that the average score of all aspects of STEAM products is 81 and is in the good category.

Author	Article title	Results
(Tiasna et al., 2023)	Implementation of STEAM-Based Learning Model through Local Culture 'Batik Jumput' in Elementary School	The results of the discussion after the practicum showed that students were very enthusiastic in learning using the STEAM model. The learners felt that the STEAM model really helped them understand the learning material. This indicates that the research was successful and beneficial for the learners.
(Arman et al., 2022)	Application of STEAM learning to improve the skills of SDN 3 Sabilambo students in utilizing the environment as a learning medium during the covid-19 pandemic	Furthermore, the pre-test and post-test accompanied by a paired T test show that the value of t> t table, namely 12.71095> 2.09302, which means that the treatment in the form of STEAM learning has a significant effect, which can improve students' understanding of the material taught.
(Febriansari et al., 2022)	Construction of STEAM (Science, Technology, Engineering, Arts, and Mathematics) Learning Model with Design Thinking Approach on Renewable Energy Material	The expectation of this research is the formulation of a combined framework between the STEAM learning model and design thinking that can be applied to renewable energy learning.
(Shenita et al., 2022)	Project-based Glass Bottle Music Learning with STEAM Approach to Improve Students' Creativity	The results of research on the application of Science Technology Engineering Art Mathematics learning through the project method at SD Negeri Medalem Kec. Tulangan Kab. Sidoarjo can develop student learning activities and student creativity increases.

Author	Article title	Results
(Nuragnia et al., 2021)	STEAM Learning in Primary Schools: Implementation and Challenges	The results showed that teachers have implemented STEAM learning by practicing learner-centered learning, learning with inquiry and problem-based models, evaluation, reflection, collaboration, and implementing integrated learning both in content and skills. The challenges expressed by teachers in implementing STEAM learning are pedagogical, technical, facilities, STEAM learning resources, and STEAM implementation time. It can be concluded that teachers have implemented learning activities that lead to STEAM learning. However, it is necessary to hold technical training for teachers related to the technical implementation of STEAM and the provision of supporting facilities, especially technology-based facilities to support the implementation of STEAM in elementary schools.
(Khoir, 2021)	Use of STEAM-based "*Beruang Antik*" Media on Space Building Materials for Elementary School Students	The "*Beruang Antik*" media can help learners improve creative thinking skills and communication skills. In the implementation of learning, the "*Beruang Antik*" media empowers parental involvement, to direct learners to solve problems, encourage learners to explore, find new ways. It is this parental involvement that will make online learning using "*Berung Antik*" media work optimally.

Author	Article title	Results
(Twiningsih, 2020)	Development of STEAM-based Tak Tik Butarna Media in Thematic Learning for Grade 1 Elementary School	Based on the results of research before using STEAM-based boutique media, it is known that the class average of students' critical thinking skills is 74.80 and the average science literacy class is 73.61. After using STEAM-based boutique media, it can be seen that the class average of students' critical thinking skills is 86.67 and the average science literacy class is 88.67. The results of this study prove that the STEAM-based boutique media developed can improve students' critical thinking skills so that it has a positive impact on science literacy. The conclusion of this research is that the new learning media developed can increase student activeness and ultimately have a positive impact on student learning outcomes.

Discussion

STEM, STEAM, and STREAM in Elementary School Context

STEM, STEAM, and STREAM represent educational frameworks that have developed in response to the requirements of a more interconnected and technologically advanced society (Damaševičius & Zailskaitė-Jakštė, 2024; Jindal et al., 2023). STEM, which stands for Science, Technology, Engineering, and Mathematics, was first established as an educational strategy intended to prepare students with the technical competencies needed to succeed in fields and careers propelled by technological progress (Akpinar & Akgunduz, 2022). In elementary education, STEM can be executed through project-based learning that merges scientific experimentation, fundamental computer programming, and the construction of basic engineering structures, enabling students to utilize theoretical knowledge in practical situations (Toto, 2019).

STEAM, which expands upon STEM, integrates Arts into the conventional STEM disciplines (Graham, 2021). The addition of the arts aims to enhance creativity, innovation, and problem-solving in expressive and visually appealing ways. In STEAM, the arts cover not just visual arts but also design, music, and other creative forms of expression that enhance technical and analytical reasoning (Zaher & Hussain, 2020; Zhang & Jia, 2024). In elementary education, STEAM can be implemented through projects that fuse art with science and technology, such as designing architectural models, crafting scientific illustrations, or applying design concepts in tool creation (Bertrand & Namukasa, 2020; Roshayati et al., 2023). This multidisciplinary approach supports students in grasping the connections among different areas of knowledge while cultivating vital creative thinking abilities that are increasingly prized in today's workforce (Worapun & Nuangchalerm, 2024).

Additionally, STREAM (Science, Technology, Reading, Engineering, Arts, and Mathematics) has developed as an extension of STEAM, incorporating Reading as a

crucial element (Nuangchalerm et al., 2020; Yulianti et al., 2021). The addition of literacy underscores the significance of reading and writing capabilities within the framework of scientific and technological ideas, improving students' communication skills and comprehension of the subject matter being taught (Hamsiah & Lutfin, 2024). In elementary education, STREAM motivates students to interact with scientific literature, technology-related books, or articles concerning scientific research (Das, 2020). Students are also prompted to compose reports on experiments or articulate their project findings in written format, which bolsters both their writing proficiencies and critical thinking skills (Putri & Sela, 2018; Yamin et al., 2023). The application of STREAM in primary education centers not only on nurturing technical knowledge but also on reinforcing literacy as a cornerstone for learning across all academic disciplines (Kong, 2024; Sun & Zhong, 2024).

Incorporating STEM, STEAM, and STREAM in elementary education provides numerous advantages, including cultivating critical thinking, creativity, and teamwork abilities (Juškevičienė et al., 2021). The project-based model, which links various disciplines, enables students to perceive how distinct bodies of knowledge relate to one another and can be utilized in practical scenarios (Silva et al., 2022). Furthermore, the fusion of these methods contributes to heightened student motivation and involvement, particularly in areas like mathematics and science, by offering relevant and enjoyable learning opportunities (Taher et al., 2019). The competencies acquired through STEM, STEAM, and STREAM, such as problem-solving, innovation, and communication, lay a solid groundwork for students to confront future challenges, both academically and in an increasingly intricate job landscape (Drozd et al., 2017; Sun & Zhong, 2024). Thus, the integration of STEM, STEAM, and STREAM in primary education not only provides students with technical expertise but also nurtures essential life skills that are vital in a swiftly evolving world.

STEAM Learning in Elementary School

STEAM learning is a developmental form of STEM learning. The development of STEM into STEAM is an effort to update the scientific literacy of the younger generation with an important addition in the form of art as a form of creativity and divergent thinking with the letter "A" symbol added to STEM so that it becomes STEAM. The element of art added to STEM learning creates more opportunities for learners to do hands-on learning and use their creativity to produce things and find solutions to problems (Katz-Buonincontro, 2018).

Development of STEAM Learning Implementation in Elementary Schools

The implementation of STEAM learning in elementary schools continues to develop not only focusing on learner-centered, problem-based learning or containing elements of collaboration, but also various innovations from the research results of several researchers that we can make as a reference in the process of implementing STEAM

learning in elementary schools according to the research results in Table 1 in more detail are as follows:

The implementation of STEAM learning in low grades is carried out in the form of contextual learning by focusing on students' understanding of real events that occur within the scope of their lives to be able to bring out different works from individuals and groups. STEAM learning is implemented in groups to support the application of collaboration, cooperation, and communication and stimulate the ability to take responsibility and solve problems personally and interpersonally so that they can construct an understanding of the material presented (Rakhmawati et al., 2024). The research shows that the implementation of STEAM learning can be done by using contextual learning that departs from real events in their lives and leads students to be able to do their own problem-solving to be able to come up with original work.

The implementation of STEAM learning in 5th and 6th grade students by utilizing robot media as a learning tool shows an increase in student enthusiasm and creativity after the application of an innovative learning model in the form of fun robot programming introduction activities, even able to provide new imaginations for elementary school students in the area so that they can aspire to become technology experts in the future (Arianto et al., 2024). The research shows us that the implementation of STEAM learning can be done by utilizing learning media in the form of robots that can increase students' enthusiasm for learning activities because it uses interesting contemporary technology that can provide new imaginations.

Implementation of STEAM learning for fifth-grade students using PjBL-based STEAM learning (project-based learning) with a product differentiation strategy. The products produced are 1) Making terrarium, 2) Role Play, 3) Poster, and 4) PowerPoint, which is measured quantitatively using evaluation research. The STEAM approach is proven to: 1) Encourage students to learn to explore all the abilities they have in their own way, 2) Bringing up different and unexpected work from each individual or group, 3) The emergence of collaboration, cooperation, and communication 4) Demanding personal and interpersonal responsibility, 5) Building students' understanding of the material being studied, 6) Students will create strategies independently for the learning process (Kumalasari & Hasanah, 2023). The research shows that STEAM learning can be implemented by using PjBL-based STEAM learning (project-based learning) with a product differentiation strategy to provide freedom in working with more diverse products.

Implementation of STEAM learning in grade 5 students using PjBL-based STEAM learning (project-based learning) through a project to make jumputan batik. This learning activity is very effective in attracting students' enthusiasm in making jumputan batik because it is easy to work on (Tiasna et al., 2023). The research shows that the implementation of STEAM learning can be done using PjBL-based STEAM learning (project-based learning) through a project to make jumputan batik which can be used as an activity to preserve local wisdom culture in the environment where students live.

Implementation of STEAM learning for students in grades IV, V, and VI using STEAM learning based on environmental utilization as a learning resource. The learning activities carried out consist of: 1) Making compost from organic waste and planting a garden, 2) Implementation of technology through the use of simple technology in the process of making compost and additional classes on how to use a laptop to make student writing and activity reports, 3) Art activities are carried out with games or games in the form of JAKA (Injak Kardus) GAMES and sribu gymnastics exercises for students, 4) Strengthening the use of mathematics in learning activities and students' daily lives. The initial stage is carried out by preparing a STEAM learning package which produces a STEAM Learning Implementation guide with a scientific approach until the STEAM learning implementation stage for grade IV, V, and VI students runs smoothly and motivates students to be able to analyze and think critically in participating in learning activities, processing materials, and using tools in solving a problem in everyday life in their environment (Arman et al., 2022). The research shows that the implementation of STEAM learning can be done by using STEAM learning based on the use of the environment as a learning resource through fertilizer-making activities, JAKA games, sribu gymnastics exercises, and the implementation of mathematics in learning and students' daily lives which is a new option in implementing STEAM learning.

Implementation of STEAM learning aimed at grade IV elementary school students on the material "renewable energy". STEAM learning is implemented using STEAM City learning media. The learning media is a series of miniature games applying science, technology, engineering, arts, and mathematics in a miniature city that students can disassemble. The purpose of using STEAM City learning media is to hone critical thinking, problem-solving, innovation, and logic, and, of course, the most important point is creativity because it can continue to be developed according to the creativity of students and educators. STEAM City learning media can accommodate every stage of thinking in solving a problem, which includes (1) empathy; (2) define; (3) ideate; (4) prototyping; (5) test (Febriansari et al., 2022). The research shows that the implementation of STEAM learning on renewable energy material can be done by using STEAM City learning media (a series of miniature city games that can be disassembled) so that it can improve critical thinking skills, problem solving, logic, and creativity.

Implementation of STEAM learning in grade IV students using PjBL-based STEAM learning (project-based learning) through a project to make glass bottle musical instruments. The project focuses on making simple musical instruments that use materials in the form of used goods type: glass bottles. The application of STEAM learning in the glass bottle musical instrument making project is as follows: (1) Observe step, (2) New Idea step, (3) Innovation step, (4) Creativity step, (5) Society step. The benefits suggested by students are: 1) Provide insight to students to be more creative, 2) Understanding of the use of used goods that can produce tones or musical melodies. Glass bottle musical instruments can also be an effective multifunctional media to support environmental awareness in students (Shenita et al., 2022). The research shows that STEAM learning can be implemented by using PjBL-based STEAM learning (project-

based learning) through a project to make glass bottle musical instruments that can increase student creativity and an understanding of the utilization of used goods.

Implementation of STEAM learning conducted by 32 elementary school teachers in West Java and Banten with learner-centered learning practices with inquiry and problem-based models. The implementation process is carried out starting from the stages of evaluation, reflection, and collaboration to the implementation of integrated learning both in content and skills. The results show that teachers have been able to carry out learning activities that lead to STEAM learning through learner-centered learning practices, learning with inquiry and problem-based models, evaluation, reflection, collaboration, and implementing integrated learning both in content and skills (Nuragnia et al., 2021). The research shows that STEAM learning has been implemented by elementary school teachers in West Java and Banten with learner-centered learning practices with inquiry and problem-based models accompanied by good integration of content and skills.

The implementation of STEAM learning aimed at grade VI elementary school students on the material "Build Space" by using the "*Beruang Antik*" learning media (*Bangun Ruang bikin Anak Pintar dan Kreatif*) with a STEAM-based PjBL model (Science, Technology, Engineering, and Mathematic). The learning media emerged as one of the innovations in responding to changes in the world of education, namely: The change from face-to-face learning to learning from home (BDR). "*Beruang Antik*" Media is included in the type of learning media product (Module) for Building Space material. The making of this product uses materials: color paper, color folding paper, wrapping paper, glue, scissors, ruler, period, and pencil. This media works the same way as a pop-up book but with specific material, namely nets and 3-dimensional spaces. The benefits of using the "*Beruang Antik*" media for students are: 1) Sharpen creative thinking skills, 2) Developing a culture of numeracy literacy so as to improve critical thinking skills, 3) Realizing a collaborative process in learning, 4) Communication skills, 5) Improving students' analytical skills, 6) Forming students with character, 7) Improve problem solving skills, 8) Able to design and make a product (Khoir, 2021). The research shows that the implementation of STEAM learning can be carried out on the material "Build Spaces" by using the "*Beruang Antik*" learning media (Build Spaces for Smart and Creative Children) in the form of learning media (Modules) of Build Spaces material with STEAM-based PjBL models so that it can hone creative thinking skills, develop a culture of critical literacy and numeracy, support collaborative processes, improve analytical skills, support character building, improve problem-solving skills and also product design skills.

The "*Beruang Antik*" educational tool exemplifies how STEAM learning can significantly impact education, especially during shifts like moving from traditional classroom settings to online learning environments. This creative module, aimed at VI grade students, illustrates the fusion of Science, Technology, Engineering, and Mathematics through a project-based learning (PjBL) approach, effectively applying complex ideas such as three-dimensional spaces in a practical manner. The advantages

noted—like improved creativity, critical thinking abilities, enhanced problem-solving and analytical skills, as well as promoting teamwork and personal growth—are consistent with the larger goals of STEAM education highlighted in research. For example, the focus on ingenuity in problem-solving aligns with Granville et al.'s (2024) perspective on the importance of arts in nurturing innovative thinking. Furthermore, the emphasis on numerical literacy and practical product creation resonates with the need for more immersive and applicable teaching strategies. This instance underscores the significance of immersive, practical strategies in STEAM education, connecting theoretical concepts with tangible outcomes in elementary teaching (Khoir, 2021).

Implementation of STEAM learning aimed at grade 1 elementary school students using Tak Tik Butarna Media which is an acronym for the media brain atik flat building color which is a color game media with integration of learning competencies. Tak Tik Butarna media can be implemented in all themes in thematic classes. Tak Tik Butarna media is used with the help of talking stick games and activities to match the flat building sticks contained in the tak tik butarna blocks until they are stuck on the appropriate type of flat building. STEAM-based Tak Tik Butarna media is a tool in learning activities to increase student activity, in this study to improve science literacy and ultimately impact students' critical thinking skills (Twiningsih, 2020). The research shows that the implementation of STEAM learning can be done by using Tak Tik Butarna Media (color flat brain media) which is a color game that is integrated with competencies so that it can support activity opportunities for students and improve their critical thinking skills.

Challenges of STEAM Learning Implementation in Elementary Schools

STEM learning that develops into STEAM certainly requires adaptation and adjustment from teachers and students in a learning activity. The developments that occur require all components in it to adapt and continue to innovate to be able to implement optimally. Various challenges that arise in the implementation of STEAM learning include those expressed by (Shernoff et al., 2017) who state about the lack of access for teachers to STEAM learning content and training on STEAM learning. In addition, there is also an opinion from (Park et al., 2016) which states that there are challenges in implementing STEAM learning from the aspects of facilities and budgets. Another opinion from (Nuragnia et al., 2021) states that the implementation of STEAM learning carried out by 32 elementary school teachers in West Java and Banten with learner-centered learning with inquiry and problem-based models shows challenges in several aspects, namely: technological aspects (the percentage of constraints on the availability of technology-based facilities is 65.62% which includes: the availability of computers, the internet, and inadequate computer conditions for use, as well as students' skills in using technology), pedagogical aspects (the percentage of lack of adequate pedagogical support is 68.75%, this includes: the lack of pedagogical models on how to teach STEAM interestingly and also a statement from one of the teachers who revealed that STEAM training tends to focus on theory), the facilities aspect (as many as 64.06% of teachers stated the lack of adequate facilities for implementing STEAM learning, the STEAM content aspect (as

many as 59.37% of teachers find challenges in accessing STEAM content) which includes administrative challenges, budgets, and the availability of STEAM content in Indonesian.), the time aspect (with a percentage of 78.12% being a separate obstacle because it includes teacher skills in planning the time of each activity for the implementation of STEAM learning which focuses on hands-on activities.

To address the obstacles faced in the execution of STEAM education, it is crucial to investigate their underlying causes and suggest practical solutions that are adapted to various educational settings. STEAM educational materials and teacher training (Shernoff et al., 2017) are frequently unavailable due to insufficient professional development options and a lack of resources designated for training initiatives. This issue could be alleviated by forming collaborations among schools, governmental organizations, and private entities to design and provide localized, experiential training workshops that empower teachers with effective STEAM integration techniques.

Likewise, the limitations concerning facilities, budgets, and technological resources indicate deeper issues related to funding and policy shortcomings. To resolve these challenges, a collaborative approach involving various stakeholders is necessary, wherein governmental organizations prioritize financial support for STEAM facilities, while schools seek creative funding strategies such as applying for grants or partnering with technology firms. Educational challenges, such as the absence of engaging instructional models and the struggle with time management, underscore the need for tailored teaching resources and adaptable lesson frameworks that comply with local educational standards. Additionally, schools might consider establishing peer-learning initiatives where seasoned teachers guide their peers to improve teaching methods.

Therefore, this is important to perspectives that can influence both policy and practice in elementary education to improve the execution of STEAM learning (Duong et al., 2024; Spyropoulou & Kameas, 2024). Schools and teachers can modify their educational programs by emphasizing STEAM methodologies into current subjects, employing interdisciplinary strategies that unite science, technology, engineering, arts, and mathematics within an integrated framework (Yilmaz, 2021). Policymakers need to create explicit guidelines and provide adequate funding to facilitate the growth of STEAM initiatives, which includes access to technology resources and professional development for educators (Han et al., 2023; Kessler et al., 2024). Furthermore, schools can promote collaborative teaching settings where instructors exchange effective practices and collaboratively design flexible lesson plans suited to their unique environments (Evert et al., 2022). Collaborations with local communities, business partners, and institutions of higher education could also enhance educational content by bringing in practical applications of STEAM concepts (Zhu & Bai, 2020). These approaches not only tackle the challenges recognized but also enable schools to develop vibrant and interactive learning opportunities that equip students for the requirements of the 21st century.

Thus, policy-makers have a vital function in cultivating an environment that nurtures effective and long-lasting STEAM education within a variety of learning settings (Juca-Aulestia et al., 2021; Spyropoulou & Kameas, 2024). This can be accomplished by

implementing thorough policies that emphasize the inclusion of STEAM in the curriculum, ensuring it meets national educational benchmarks while also permitting modifications that cater to local needs. It is important to provide steady funding and resources for teacher development, necessary infrastructure, and technological advancements to eliminate challenges such as poor facilities and limited teaching assistance (Savithri, 2022). Additionally, policymakers ought to encourage partnerships among schools, businesses, and research centers to craft innovative STEAM programs that address actual challenges and opportunities (Cosby et al., 2024; Grahame et al., 2023). Moreover, creating systems for tracking and evaluating can aid in determining the success of STEAM projects, which allows for ongoing enhancement. By focusing on these essential aspects, lawmakers can establish a supportive framework that enables teachers and motivates students to excel in STEAM careers.

To sum up, integrating these targeted approaches, educators and policy-makers can foster an atmosphere that encourages impactful and sustainable STEAM education in a variety of educational environments.

CONCLUSION

Fundamental Findings: The implementation of STEAM learning in elementary schools has experienced various developments with various new innovations in its application, ranging from the choice of topics and models to the learning media used. On the other hand, there are still various challenges in the process of implementing STEAM learning in elementary schools which include: pedagogical challenges, technical challenges, facility challenges, learning resource challenges and the implementation time of STEAM learning. **Implications:** The implementation of STEAM Learning develops by utilizing contextual learning that departs from real events in students' lives to collaborate and create a work, utilizing the surrounding environment as a learning tool (fertilizer making activities, JAKA games, sribu gymnastics exercises, and the implementation of mathematics in learning and students' daily lives), making projects that depart from the local wisdom of the area where students live (batik crafts), utilizing new technology (robots for learning activities), utilizing used material processing activities (Glass Bottle Music), utilizing innovative modules ("*Beruang Antik*" module), and also innovative learning media (Tak Tik Butarna Media). **Limitations:** This research is still limited to the development and challenges of STEAM learning implementation in elementary schools only. **Future Research:** This study is hope to serve as a source for additional research aimed at examining the incorporation of STREAM (Science, Technology, Reading, Engineering, Arts, and Mathematics) within STEAM education, broadening its multidisciplinary framework and enhancing literacy growth in conjunction with both practical and artistic abilities.

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***Galih Majesty Erawan (Corresponding Author)**
Master of Elementary Education, Faculty of Education
Universitas Negeri Surabaya,
Address: Jl.Lidah Wetan, Lidah Wetan, Kec.Lakarsantri, Surabaya, Jawa Timur
Email: galih.23029@mhs.unesa.ac.id

Neni Mariana
Master of Elementary Education, Faculty of Education
Universitas Negeri Surabaya,
Address: Jl.Lidah Wetan, Lidah Wetan, Kec.Lakarsantri, Surabaya, Jawa Timur
Email: nenimariana@unesa.ac.id

Suryanti
Master of Elementary Education, Faculty of Education
Universitas Negeri Surabaya,
Address: Jl.Lidah Wetan, Lidah Wetan, Kec.Lakarsantri, Surabaya, Jawa Timur
Email: suryanti@unesa.ac.id