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Analysis of The Application of The STEAM Approach to Learning In Indonesia: Contributions to Physics Education

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ABSTRACT

Optimizing the learning process in achieving student development requires a special strategy in learning. The strategy can be run by applying the STEAM learning model. The STEAM learning process is expected to prepare the next generation to be ready to face the times, helping to develop innovations in life. The purpose of this study was to analyze the application of STEAM learning in Indonesia, especially the contribution to physics education. The method used in this paper is descriptive qualitative through the study of relevant literature with the objectives of the research conducted. The result of this study is that STEAM can be integrated into various learning subjects and levels of education. In addition, the application of STEAM can help develop the skills of students in the 21st century along with technological developments and increasing demands in modern times. In physics learning, the implementation of STEAM can make students actively involved in the teaching and learning process of physics. Students will be involved in ongoing learning and will assist students in finding solutions to the problems given. This has a positive impact because it can improve creative, critical thinking skills and make it easier for students to understand concepts. The implementation of STEAM in international education is very good, for STEAM learning in Indonesia is still lacking. This is because in implementing STEAM learning, you must have special skills to teach it. Thus, it is very important to develop STEAM starting from human resources and appropriate learning materials.

INTRODUCTION

Education is an effort made to prepare students through learning activities that are aimed to help students actively develop their potential, abilities, and talents (Nasrah, 2021; Collins et al., 2018; Mishra et al., 2020). Education has a very important role in human life because it can improve the quality of human life to be able to develop its potential. The development of the world of education cannot be separated from the effectiveness of the teaching and learning process. The teaching and learning process occurs with the interaction between the teacher and the role of transfer of knowledge and students as recipients of knowledge (Bada & Olusegum, 2015; Pitsoe & Maila, 2012; Koehler et al., 2013). The learning process can be used to measure students' abilities such as observing, asking questions, experimenting, associating and communicating experimental results which are stages in the scientific approach (Serevina & Muliyati, 2018; Gunawan et al., 2019; Gerde et al., 2013). Scientific learning does not only view learning outcomes as the end, but also a process. learning is seen as very important (Defara et al., 2018; Cheng & Tsai, 2013).

In the learning process, students are required to play an active role, especially in discovery activities, while the teacher who originally acted as a learning resource turned into a facilitator of learning activities whose role was to direct (guide) students to solve problems encountered in learning or find concepts themselves being studied (Mendikbud, 2013). The learning process carried out in the classroom according to the view of modern teaching and learning activities requires students to act and be actively involved in every learning activity carried out and children are able to develop concepts that are known by trying (Zainuddin & Halili, 2016; Unluer, 2012). From the results of observations Safriana et al. (2022); Roehl et al. (2013); and Boud et al. (2013) it was found that students were not fully active when teaching and learning activities took place and students more often just sat quietly paying attention to the explanation of the material that the teacher conveyed. Optimizing the learning process in achieving student development requires a special strategy in learning (Naili, 2021; Hattie et al., 2016; Mamurov, 2019). The strategy can be by applying the STEAM learning model.

The STEAM learning process is expected to prepare the next generation that is ready to face the times, help develop innovations in life, STEAM Learning (Science, Technology, Engineering, Art and Mathematics) is an approach in learning that involves students totally in exploring and understanding the substance of meaning of the current lesson (Kang, 2019; Ozkan & Umdu, 2021). In this case, the educator acts as a facilitator and the students explore by collaborating in completing their learning tasks (Ana & Zelela, 2021; Agyei & Voogt, 2012; Van et al., 2015). STEAM is an integrated approach that combines the subjects of Science, Technology, Engineering, Arts and Mathematics as a means of developing student inquiry, communication and critical thinking during learning. The STEAM approach is an adaptation of STEM, which highlights the relationship of two or more content areas to guide instruction through observation, investigation and problem solving (Nasrah, 2021; Herro & Quigley, 2017; Rinke et al., 2016; Chen et al., 2019). STEAM-based learning also requires students to identify a problem, create something to solve problems, collaborate with classmates to solve problems, and communicate effectively and respond to each other's ideas (Kemendikbudristek, 2021). The STEAM approach is used in learning because it plays an important role in providing introductions to students in the early stages of the learning process. Knowledge and skills can be simultaneously imparted to students through STEAM learning.

The STEAM learning approach has a positive impact on the learning process, the STEAM approach can develop students' cognitive skills, and attitudes (Naili, 2021; Conradtly & Bogner, 2020; Hsiao & Su, 2021). In STEAM learning, children are not only taught theoretical knowledge but also engineering and technology practices that connect schools, communities, work, and the global world (Ayu, 2020; Anisimova et al., 2020; Boy, 2013). STEAM learning can encourage students to explore existing abilities, in their own way and also lead to different and unexpected works from each individual or group. In addition, the ability to collaborate, cooperate and communicate can be raised in the learning process because this approach is carried out in groups (Lestari et al., 2021; Quigley et al., 2017; Bahrum et al., 2017). STEAM learning is also used as an approach in teaching physics to students. STEAM learning can be applied to physics learning, which will help students actively build their own knowledge and understanding through projects.

In physics learning, based on the 2013 curriculum, the basic competence in physics subjects is that students have the ability to make decisions to solve problems in everyday life by involving the role of physics as the impact of technology in the future, through the scientific process (Lestari, 2021; Docktor & Maestre, 2014; Smetana & Bell, 2012). Components of 5 fields of science in the STEAM approach (science, technology, engineering, art, and mathematics) will make learning physics more attractive to students. Learning with the STEAM approach will help students understand the components of science, technology and engineering in a simpler and more interesting way and are supported by art and mathematics content.

Based research on Sri Lestari (2021) learning with the STEAM approach assisted by spectra-plus physics can train creativity and soft skills of students, according to 21st century skills. In research Safriana (2022); Chung et al. (2021); Jacques et al. (2020) learning with a STEAM-based problem-based learning model affects the creative abilities of students in the material of optical instruments. Then Ayu (2020) the product of STEAM implementation in inquiry-based physics learning is proven to be an appropriate, influential, and effective strategy in increasing students' mastery of the concept of mechanical wave material on simple pendulum.oscillations Based on the above background, the aim of this research is to analyze the application of STEAM learning in Indonesia, especially to the contribution to physics education

RESEARCH METHOD

The method used in this paper is descriptive qualitative through literature study that is relevant to the research objectives. This type of qualitative descriptive research is a research method that utilizes qualitative data and is described descriptively to obtain the information sought (Sugiyono, 2019; Ramdhan, 2021). Literature study is a research approach that is carried out by looking for references on the basis of theories that are relevant to the case or problem being studied (Hermawan, 2019; Sugiyono, 2019).

In the literature study process, the selected articles are articles that are relevant to the writing being studied. In addition, the study sources do not only come from journals but also from other scientific sources such as books and proceedings. The results of the literature obtained are then used as a source of data in the writing that is carried out. This study focuses on STEAM in Indonesia. The following is a research flowchart that can be seen on Figure 1.

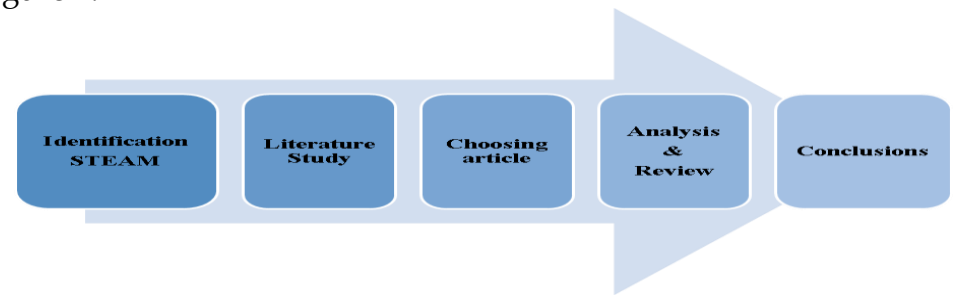

Figure 1. Flowchart

RESULTS AND DISCUSSION

STEAM

STEAM is a new innovation in education by combining several components in science into one unified learning concept. Before the existence of STEAM, the concept of STEM

(Science, Technology, Engineering and Mathematics) first emerged without any art (art). The Ministry of Education and Culture stated that learning with the STEAM approach is an approach that focuses on the relationship between knowledge and skills that aims to overcome problems. STEAM stands for Science, Technology, Engineering, Art, and Mathematics (Kim & Park, 2012; Tabiin, 2020; How & Hung, 2019). Experts define STEAM with different opinions. According to Anggraeni (2021) STEAM is a learning approach that involves the activeness of students, this approach combines two or more STEAM disciplines or combines one STEAM discipline into another discipline (Connor et al., 2015; Perignat & Katz –Buonincontro, 2019). Pasani and Amelia (2021) describes STEAM as an approach that focuses on the problem-solving process through the integration of five disciplines including Science, Technology, Engineering and Mathematics. According to Liliawati et al. (2018) STEAM is an approach to learning in which art elements have a positive, rich and strong impact so that it is expected to make learning more effective and meaningful. From several expert opinions, it was concluded that STEAM is a science that combines science, technology, engineering, art, and mathematics into an integrated approach that can be applied in learning in schools

The Function of STEAM

In learning, the STEAM approach serves as a means for students to be more active and can create an idea based on science and using technology so that they can explore solving problems based on five disciplines. K-13 which has been determined by the government and applied in schools, is expected to make students who have creative, innovative and productive abilities and are able to take part in life facing world civilization (Permendikbud, 2013). STEAM-based learning is in accordance with the expectations and objectives of the 2013 curriculum by offering meta-disciplinary education in developing thinking skills and creativity in solving problems. This agrees with Buinicontro (2017); Cook and Bush, (2018); Harris and De Bruin, (2018) which explains that integration in STEAM is able to provide new opportunities for students to apply the design learning process directly and can produce products with the right creativity and problem solving abilities. The ability to think and creativity are two important aspects that must be possessed by students in order to face the era of increasingly high globalization (Soh et al, 2010; Turiman et al., 2012; Kereluik et al., 2013).

In the teaching and learning process, STEAM-based learning is very important to apply because there are several advantages including being able to prepare the next generation of the nation who is ready to face the era of development, helping to develop innovations in life, increasing student interest in the profession in the STEAM field, making learning more in line with life, helping students to build self-concept actively, and increasing student literacy about STEAM.

21st century skills are also related to STEAM because in the 21st century skills include critical thinking, creativity, collaboration, and communication skills. In accordance with the objectives of 21st century skills, STEAM also requires students to analyze a problem, and create something to solve the problem, be done collaboratively between classmates in order to solve problems, and communicate effectively and respond to each other's ideas (Guyotte et al., 2015; Sen et al., 2021). According to Ramadani (2020); Ruangsiri et al. (2020); Ata-Aktürk and Demircan (2017) the STEAM approach provides students with opportunities to innovate and solve problems through planning, teamwork, design, and

communication. STEAM products do not only contain cognitive aspects, but will contain several other aspects, namely affective and psychomotor which can be developed in general by students in facing the era of the industrial revolution 4.0 (Mu'minah, 2020; Setiyawin & Sulistyaningrum, 2021; Kismawardani & Hariyono,2022). The complexity of the 21st century demands abilities from various fields and STEAM-based learning can be a preparation and practice to face everything (Wijaya et al., 2015). Thus, cognitive abilities and creativity must continue to be developed in all forms, one of which is through STEAM-based learning that combines design, creativity and innovation in the disciplines of science, technology, engineering and mathematics so as to develop the skills needed to face globalization and science and technology.

STEAM-based EDP (Engineering Process Science)

In implementing STEAM-based learning, students are encouraged to be able to find systematic and iterative ways to design objects, processes, and systems to meet human needs and desires (engineering). The technical element in STEAM can be started from a problem, need, or desire with measurable criteria which are then tested to explain the existing limitations. In developing STEAM innovation, it can be applied by making the arrangement of processes used by engineers in creating a particular product or technology to match the established criteria. This process is known as the Engineering Design Process (EDP) (Mangold & Robinson, 2013; Hafiz et al., 2019; Winarmo et al., 2020).

1. Ask (find problems and solutions)
   At this stage students are asked to identify problems that arise, then asked to be able to find the right solution to the problem. Next, determine the criteria for continuing into the design process that will be created to be a solution to these problems.
2. Imagine (imagining the product)
   At this stage students who have found a solution then imagine the product that will be produced as a problem solving by exchanging ideas with fellow friends. Such as determining product shape, product size and product manufacturing steps.
3. Plan (product planning)
   At this stage students describe the product design that will be made with a complete sketch. The details of the product are designed as well as possible.
4. Create and Improve (create and test products)
   At this stage students create products that have been designed in the previous stage. However, a trial is carried out according to the criteria and limitations first, so that the product created will be in accordance with the criteria and standards.

Application of STEAM in Education

The application or implementation of STEAM in education today continues to grow from year to year (Zubaidah, 2019; Atmojo, 2020; Mu'minah, 2020; DeJarnette, 2018; Quigley & Herro, 2016). This can be seen through the results of publications carried out by authors from various countries in journals or proceedings. In addition, the application of STEAM does not only focus on one level of education, for example in elementary school, but is also applied to junior high school and high school levels. on. In addition, this also applies to the subject of learning that is carried out not only focusing on one subject. The

following Table 1 presents the application of STEAM in education in the world and in Indonesia.

Table 1. Application of STEAM in Education

Article title	Author's name	Results
The World (International)		
A Review of Studies on STEM and STEAM Education in Early Childhood	Akturk, & Demircan (2017)	Based on the results of the review obtained, learning that was initially STEM then became STEAM can contribute and update the learning of preschool children in Turkey. In addition, STEM and STEAM education is considered an interdisciplinary approach from primary school education to post-doctoral education.
STEAM Education in Korea: Current Policies and Future Directions	Hong (2017)	This research was conducted in Korea which focused on three elements of education, namely teachers, students, and educational content. The results of this study indicate that classroom learning using the STEAM approach has a good impact on three main components (1) Preference for science, (2) Ability to perform Self-directed learning, and (3) Creative and integrative thinking Ability
Acquisition of 21st century skills through STEAM education	Singh (2021)	The results of this study indicate that the application of STEAM can actually help develop students' skills in the 21st century along with technological developments and increasing demands in modern times.
STEAM education: student learning and transferable skills	Bertrand & Namukasa (2020)	This research was conducted in Canada with the findings that the STEAM approach which is carried out comparatively can build character outside the disciplines being occupied. In addition, the skills taught can develop with which includes: critical thinking and problem solving; collaboration and communication; and creativity and innovation
Design thinking gives STEAM to teaching: A framework that breaks disciplinary boundaries	Henriksen et al. (2019)	The results of this study state that STEAM is broader than just the integration of art into STEM. A more creative, real-world-driven view of education, and based on problems or projects that exist in nature or the real world. In addition, by developing learning content and experiences that offer creativity, authenticity, real-world examples, and a problem or project driven focus, it's not enough just Yes, the teacher gives an

Article title	Author's name	Results
		argument, but students need more of a guiding framework in learning.
	Indonesia	
Trends and Implementation of Blended Learning in the STEAM Sector: A Study in Indonesia	Putra et al. (2021	The results of this analysis find that the STEAM approach in blended learning has a positive impact on students' learning activities such as student learning achievement, student activity/involvement, and student learning motivation/interest
Strengthening Education for Generation Alpha through Loose Parts-Based Steam Learning at Early Childhood Education	Nugraheni (2019)	Based on the results of the analysis conducted in this paper, it was found that in an effort to improve the critical skills of students the need for good literacy skills as a basic reference in the STEAM learning that is carried out. This is because the STEM approach in Indonesia is still minimal and has only recently been introduced.
Implementation of STEAM in Mathematics Learning	Nurhikmayati (2019)	results of this article state that STEAM can be implemented in learning at every level of education. In addition, STEAM learning can also develop other abilities and skills that are useful for students to face the challenges of the globalization era in the future.
Steam-PBL: Strategy for Developing Problem-Solving Ability in Early Childhood	Putri & Taqiudin (2021)	The results showed that STEAM-PBL learning in PAUD was carried out through the stages of reflection, research, discovery, application and communication. In addition, after going through this process, there was an increase in the problem-solving ability of students who initially fell into the criteria of "Not yet developed" and "Starting to Develop" increased to "Developing as Expected" and "Developing Very Well". learning with the contribution of STEAM in it.
Application of STEAM Innovative Learning in Elementary Schools	Nurhasanah, & Zelela (2021)	The results of research that have been carried out show that STEAM learning can have a positive impact on students especially in carrying out their duties and functions more effectively, punctually, and improve student performance in the classroom.

Table 1 shows the results of a review conducted on the application of STEAM in education in the world and in Indonesia. At the international (world) level, the application of STEAM in learning/education is very well known. One of the reasons is that it can have a very significant impact on students both in soft skills and skill outcomes (Madden et al, 2013; Wahono, et al, 2020; Jamil et al, 2018; Conradty and Bogner, 2018;

and Hadinugrahaningsih et al, 2017). In addition, STEAM can be integrated into various learning subjects and educational levels. That way, it can be a special advantage for STEAM with a note that it also has its drawbacks.

Then, currently for STEAM learning in Indonesia is still lacking. This is evidenced by the search results for journal publications which show that most of the results are STEM. However, there have been some who have started to discuss STEAM including the review shown in Table 1. STEAM learning cannot be done simply, but requires knowledge, understanding concepts, learning strategies, and skills. In line with the results of research conducted by T Frisca (2021); Connor et al. (2015); Yakman and Lee (2012) stated that to implement STEAM learning, one must have special skills to teach it. Thus, it is very important to develop STEAM starting from human resources and appropriate learning materials. Because with continuous innovation and then adjusted to the existing urgency, learning will be better in the future.

Application of STEAM in Physics

Learning Physics using the STEAM approach is one solution in creating active, creative, and innovative learning (Azka, 2020; Shatunova et al., 2010; Rahmawati et al., 2019). According to Jesionkowska et al. (2020); Bassachs et al. (2020); Jho et al. (2016), STEAM approach in learning physics can make students actively involved in the teaching and learning process of physics. Students will be involved in ongoing learning and will assist students in finding solutions to the problems given. In this case, students will create their ideas into the latest technology. Art on the STEAM approach can increase the creativity of students in creating a physics learning tool (Suganda et al., 2021); Madden et al., 2013; Watson & Watson, 2013). The STEAM approach can increase the creativity of students, this can be proven through research that has been done by previous researchers.

Research that has been carried out previously, namely in research (Lestari, 2021) learning with the STEAM approach assisted by Spectra-plus creativity and soft skills students project based learning or PjBL-STEAM can encourage students to gain deeper knowledge through active exploration of real-world challenges and problems by integrating each component of STEAM. The application of the activity-based STEAM approach can make the dimensions of knowledge in Physics learning more varied. Through the provision of projects in Physics learning with the STEAM approach, students can hone in finding solutions to existing problems, develop students' skills in creating creative and innovative ideas in accordance with the development of science and technology. The STEAM approach can encourage students to have basic competencies and skills according to the needs of 21st century skills, so that students can find solutions to problems that arise within themselves and their surroundings.

According to Safriana (2022) learning with a problem based learning model based on STEAM has an effect on the creative abilities of students in the material of optical instruments. The STEAM approach was combined with a problem based learning or PBL-STEAM learning model and researchers found that students looked enthusiastic and active during the physics learning process on optical material with PBL-STEAM. Students consider the PBL-STEAM learning model to make it easier to find concepts directly, learning that produces products can improve students' creative thinking skills. This study also found limitations, namely learning using the PBL-STEAM model requires a

long time to produce maximum products and pay attention to controlled classroom management.

Then, Ayu (2020) the product of STEAM implementation in inquiry-based physics learning is proven to be an appropriate, influential, and effective strategy in increasing students' mastery of the concept of Mechanical Waves on Simple Pendulum Oscillations. According to Ayu (2020); Katz-Buonincontro (2018); Erdogan and Ciftci (2017), it is stated that the STEAM approach plays an important role in learning physics because it plays an important role in providing introductions for students in the early stages of the learning process. Knowledge and skills can be imparted to students through STEAM learning. Based on the results of the analysis in this study, it was concluded that the implementation of STEAM in inquiry-based physics learning was proven to be an appropriate, influential, and effective strategy to improve students' mastery of concepts in the Simple Pendulum Oscillation material, because here learning provides learning experiences in cognitive, psychomotor and affective aspects in one package, also places students as active learners.

From the relevant research that has been described previously, it can be seen that STEAM has an important role in learning physics. The role of STEAM in learning physics is: (1) the STEAM approach has an effect on increasing students' creative thinking, (2) Has more ability to integrate each component of STEAM in learning (3) Makes it easier for students to find concepts in physics.

CONCLUSIONS

Based on the results of the literature study that has been carried out regarding the implementation of STEAM in education, this STEAM approach can be integrated into various learning subjects and levels of education. In physics learning, the implementation of STEAM has a positive impact because it can improve creative, critical thinking skills and make it easier for students to understand concepts. The implementation of STEAM in international education is very good, for STEAM learning in Indonesia is still lacking. This is because in implementing STEAM learning, we must have special skills to teach it. Thus, it is very important to develop STEAM starting from human resources and appropriate learning materials. For further research, it is hoped that it can develop STEAM-based learning, especially in Indonesia. In addition, it is also possible to develop an appropriate learning model to carry out STEAM learning. In addition, there is a need for research related to human resources who have special skills to teach STEAM-based learning

LIMITATIONS

This research only uses the literature study method in the STEAM field. In addition, this research only focuses on the contribution of STEAM to physics education learning in Indonesia

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