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Research Article

STEAM Education and Mathematics Literacy: A Systematic Literature Review (SLR)

Agung Pratikno*, Triyanto, and Farida Nurhasanah

Department of Mathematics Education, Sebelas Maret University, Indonesia

Abstract.

The journey of education has entered a new era where mastery in the fields of science, technology, and mathematics has become the main discourse in all sectors of human life. Development of mathematics learning models that can integrate science, technology, engineering, art, and mathematics (STEAM) through its implementation in learning that is able to trigger students to be creative and critical in the learning process. STEAM provides a new approach in the world of education that can be the ability to innovate and think critically and improve cognitive, psychomotor, and respective aspects. This study discusses how the STEAM model and approach and mathematical literacy skills are studied using systematic literature reviews (SLR) approach. This research aims to provide benefits related to STEAM. This study used Preferred Reporting Items for Systematic Reviews and Meta-analyse (PRISMA) method obtained from journals related to this theme. Data collection was done by specifying the source of the data, namely, Elsevier. From this study, the authors filtered 2968 articles into 1580 based on open access, available subscriptions, and only currently published, which were then filtered into 108 by mathematical subjects. Finally, 20 articles met the criteria for appropriate research admission. The findings of this study show that STEAM is an integrated learning approach that encourages students to think more broadly about problems that occur in the real world, especially mathematical literacy skills. The STEAM-based learning approach provides students with learning experiences that are interconnected with science, technology, engineering, art, and math. This makes students richer in relation to solving problems encountered regarding mathematical literacy.

Keywords: mathematical literacy, SLR, STEAM

Corresponding Author: Agung Pratikno; email: agungpratikno@student.uns.ac.id

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1. INTRODUCTION

Education is a process of maturing human beings to be able to develop civilization that facilitates their lives. The development of learning approaches and models has long been evolving and diverse in accordance with the demands of the development of knowledge and expertise needs at this time. Various Models are constantly being developed to meet the needs of professional expertise. Currently, STEM and various contextual learning models are encouraged to be used in learning, including inquiry

based learning, discovery learning, problem based learning, project based learning, cycle 5 E, placed based learning and field based learning (1).

According to Law No. 14 Year 2005 About Teachers and Lecturers, teachers are professional educators who have the main task of educating, teaching, guiding, directing, training, assessing, and evaluating students in early childhood education through formal primary and secondary education. From this explanation, we can understand that the role of teachers is very important in the process of creating a qualified next generation of the nation, both intellectually and morally. In Indonesia, there are many professions to be teachers, especially the teaching profession that teaches mathematics learning. Mathematics is a way to find answers to problems facing human beings, how to use information, use knowledge of shapes and measures, use knowledge of counting, and most importantly think for ourselves in seeing and using relationships. Mathematics as the queen of science or mother of science, meaning that mathematics is another source of knowledge. There is so much science, its discovery and development depends on mathematics. (2)

Today, educational institutions are competing to develop the skills of their students. Starting from critical thinking skills, creativity, collaboration, and communication. In line with these efforts, education retainers have the initiative to use a learning approach that is able to accommodate the skills needed. One of them is by applying STEAM-based learning.

STEM or Science, Technology, Engineering and Math. Some circles have added the discipline of Art to it, so it became STEAM. STEM initiated by the United States is an approach that combines the four disciplines in an integrated manner into problem-based learning methods and daily contextual events. STEM-based learning methods apply knowledge and skills simultaneously to solve a case. This approach is stated as a 21st century learning approach in an effort to produce human resources with quality cognitive, psychomotor and affective. In America, STEM has been discussed since the 1990s and is still being developed. (3) STEAM-based learning is a learning approach that emphasizes the relationship of knowledge and skills of Science, Technology, Engineering, Art, and Mathematics (STEAM). Where the purpose of integrating the five scientific fields is to help students solve problems that arise in the learning process more creatively.(4)

The learning approach is one of the appropriate and harmonious ways or paths used to present or deliver something teaching material so that the objectives are

achieved effectively and efficiently. Various approaches have been developed and used in learning. Currently, a popular and widely used approach is the STEAM Approach. But as is known, since 15 centuries humans have used various approaches and learning models in understanding knowledge and training skills. This literature review discusses the STEAM Approach and alternative Learning models that can be used in the STEAM approach. It is hoped that the results of this study can provide knowledge about the STEAM approach and alternative learning models to be more effective, efficient and meaningful in life and work.(5)

STEAM is an integrated learning approach that encourages students to think more broadly about real-world problems. The STEAM-based learning approach provides students with a learning experience that science, technology, engineering, art, and math are intertwined. This makes students richer in relation to solving a problem at hand. The fundamental problem with science learning is that students lack understanding of mathematical literacy.

The importance of mathematical literacy has not been balanced with the quality of education in Indonesia, it can be seen from various types of international level assessments that Indonesia follows, one of which is still ongoing today is the Program for International Student Assessment (PISA) which measures the literacy ability of reading, mathematics students aged 15 years or equivalent to junior high school education. The PISA results show that the mathematical literacy ability of Indonesian students is not optimal. Even though mathematical literacy has a compatibility between literacy and subject content standards because in essence the ability to be achieved in the content standards of mathematics learning objectives is mathematical literacy. Seeing the importance of literacy skills in mathematics learning, students are required to have this ability. Efforts to improve the quality of learning can be through the selection of appropriate and innovative learning models. The demands of students' abilities in mathematics are not just having the ability to count, but the ability to think logically, critically and systematically in problem solving. This problem solving is not just a routine problem but more of a problem faced daily. Such mathematical ability is referred to as mathematical literacy ability. Someone who has mathematical literacy skills not only understands mathematics but is able to use it in solving everyday problems. (6)

Based on the background that has been described, the researcher formulated the formulation of the problem in this study, namely how is the STEAM-based learning approach to mathematical literacy skills.

2. METHOD

This study used PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyse) method. In addition, this research is carried out systematically and correctly in following the correct stages. The stages of PRISMA are as follows: (7)

1. Defining the Topic
2. Determine the Source of information
3. Selecting relevant literature
4. Collecting Articles
5. Analyzing Articles

The need for a systematic review arises from the need for researchers to summarize all existing information about some phenomena thoroughly and unbiasedly. It is possible to draw more general conclusions about some phenomena than is possible from individual studies, or it can be carried out as a prelude to further research activities. (3) Systematic reviews and meta-analyses are at the top of the 'evidence hierarchy'. The main reason for conducting systematic reviews and meta-analyses is to minimize bias and maximize data by gathering all relevant and available evidence on a particular topic. In order to correctly inform decision makers, but not mislead them, a number of key methodological conditions need to be met when conducting this type of analysis. In this article we first review the history of systematic reviews and meta-analyses and then outline the conditions that can lead to right, or wrong, use of this type of study. Also, new variations on the standard systematic review method are explored, with the pros and cons of each outlined. (8)

Three researchers selected studies, extracted data, assessing the quality of the included non-randomized studies using springer. The overall quality of evidence is assessed using grade such as open access, available subscriptions and only currently published as well as subjects. The random effect model was used for the meta-analysis of associations that adjusted for covariates maximally as according to Cheong et al. (9).

3. RESULTS AND DISCUSSIONS

In recent decades, various international assessments, such as PISA and TIMMS, have shown that U.S. student achievement in math and science still lags far behind other

Table 1: Research related to STEAM education and mathematical literacy.

Researchers and Years	Journal	Research Results
Nam-Hwa Kang : 2019	Asia-Pacific Science Education	STEAM initiative in South Korea and reviewed the studies about its effects on teaching and learning. Based on a literature review, evidence of the effects, challenges, and further research topics were identified. Studies have shown that the STEAM initiative was well received by teachers. In terms of increasing teacher capacity to teach integrated STEAM lessons, studies in South Korea found that teacher professional development courses increased teachers' recognition of the initiative and confidence in teaching STEAM.
Chih-Hung Wu , Chih-Hsing Liu and Yueh-Min Huang :2022	International Journal of STEM Education	A teaching material was designed for the STEAM activity, and an empirical experiment was subsequently conducted. The empirical experiment of STEAM activities with our design teaching material (micro:bit with artifcial intelligence-based concept) was conducted at a university and an elementary school; a total of 145 questionnaire sur- vey data were collected after the activities. University student participants were 20–24 years old and the elementary school student participants were at the K5–K6 level. The results showed that perceived usability directly infuenced learning intention and strengthened the relationship between learning attitudes and intention. The ARCS plays a criti- cal moderating role that positively infuenced perceived usability and strengthened its efects on learning attitudes. Regarding the mediating efects, cognitive load negatively infuenced perceived usability
Yeping Li	International Journal of STEM Education	The results show that research in STEM education is increasing in importance internationally and that the identity of STEM education journals is becoming clearer over time.
Jihyun Hwang : 2019	Large-scale Assess Education	The fndings indicated necessity of cultural factors in addition to the attribution theory to understand students' helplessness in learning mathematics better
Denise Reis Costa : 2023	Large-scale Assess Education	Our fndings reveal that a three-factor CFA model is well-suited to the analysed data and that a weak measurement invari- ance model performs best. By including contextual variables in the modelling, we also highlight the diferences in Scandinavian students' profles. Specifcally, higher eco- nomic social cultural status (ESCS) consistently led to higher math profciency across all three countries. Norway did not show any gender diferences in math profciency, response time, or exploration behaviours. Experience with math tasks at school led to more exploration behaviours across all three countries. Swedish and Norwegian stu- dents who had more experience with pure math tasks at school were likely to obtain higher mathematics achievement scores and tended to interact more frequently with the testing platform when answering the three math items

industrialized countries. At the National level, the math, science, and reading achievement levels of California public school students in grades 4 and 8 on the National Assessment of Educational Progress have been below the national level in recent years. Locally, according to the 2018 California Student Performance and Progress Assessment

(CAASPP), statewide across all grades, only about 38% of students meet or exceed math standards (California Department of Education, 2019a, b). The low student performance outcomes at CAASPP demonstrate major challenges in teaching and learning the new CCSSM.(3)

STEAM is a learning in which there are elements of science, technology, engineering, and mathematics, to encourage children to be active, creative and exploratory. Today's world that we live in has experienced rapid development in all aspects of the digital age. The digital age is characterized by increasingly rapid technological changes. The development of science and technology is very necessary so that Indonesia can compete in the digital era. The core of technological development is the competence of human resources in Indonesia in the fields of science, engineering, technology, art, and mathematics which can be called STEAM (Science, Technology, Engineering, Arts, Mathematics). The STEAM (Science Technology Engineering Arts Mathematics) learning method is one of the important keys to the world of education facing the digital era. STEAM encourages the development of science, technology, engineering, art, and mathematics to be more creative.(1)

STEAM education is based on the premise that STEM and the arts function more effectively when combined alone than when used singly. STEAM is a new theme, but the collaboration between art and STEM is not a new idea. Eisner and Powell also describe the view that art and science are in different worlds, and emphasize the similarities that can be seen across different disciplines. The STEM to STEAM movement provides a new language for shaping thinking across disciplines (10). This STEAM learning method is referred to as a method that is in accordance with the characteristics of 21st century learning. 21st century learning is learning that prepares the 21st century generation with three main subjects in learning, namely: (1) learning and innovation skills; (2) Information, media, and technology; and (3) Life and career skills. (11)

STEAM is a meta-discipline where teachers of science, technology, engineering and mathematics teach an integrated approach and each disciplinary material is not divided but handled and treated as a dynamic whole. The implementation of STEAM in school learning has been widely carried out in various subjects. One subject that can also use STEAM as a learning approach is mathematics.

In mathematics learning, the implementation of STEAM can be done by understanding the relationship between existing mathematical concepts and other disciplines contained in STEAM. The relationship between these concepts can be built through the

ability to think critically, creatively and problem-solving abilities so that it will produce an idea or complex skills to formulate a solution to the problem at hand. The implementation of STEAM is carried out in an integrated manner, meaning that the approach taken is to connect the disciplines contained in STEAM with existing mathematical concepts to produce an idea, idea, solution or product.(12)

Further quoting from Nurhikmayati (12) According to STEAM it is divided into three levels or tiers. At level 1, the project given is short, meaning it is only to be completed in a short period of time (2-6 learning periods). Level 2, the duration of project completion can be within 1-3 months and students are asked to make reports in the form of e-portfolios, posters, videos.

At this time the word literacy is juxtaposed with other words, such as information literacy, media literacy, computer literacy, and subject literacy. Each term basically has something in common, namely the importance of reading and writing skills. Furthermore, the latest meaning of literacy is critical thinking, being able to calculate, solve problems, how to achieve goals, develop knowledge and one's potential. Please note that in the realm of learning, literacy ability is an important ability that must be possessed by every student.(13)

Literacy skills are needed by students in order to master various subjects. In order for students to achieve the goals of each subject (including mastery of the domain of knowledge, skills, and attitudes) then they must have literacy abilities. Thus, it is clear that literacy skills are not limited to cognitive abilities, but abilities that are more complex because they include social aspects, linguistic aspects, and psychological aspects.(14)

Literacy ability is a fundamental thing that must be possessed by students in facing the global era to be able to meet the needs of life in various situations. Science literacy is the ability to understand science, communicate science, and apply science skills to solve problems. To improve science literacy skills in addition to requiring student motivation, teachers also need to consider learning strategies that are in accordance with the conditions and potential of students which in the learning process focuses on providing direct experience and applying the nature of science.(15)

Without all these skills, future citizens will be just as helpless as those who currently cannot write, read, or use libraries. These are the necessary skills of our future literacy, which we all need. However, new information technologies also open up the possibility to expand our literacy in other ways, and many of us will choose to develop additional types of literacy that not everyone may need. But it will bring great benefits to those

who get it. I discuss in two potentially important categories of value-added literacy as follows: quantitative-mathematical literacy and cross-cultural literacy.(16)

Understanding mathematical literacy according to PISA is a person's ability to formulate, apply and interpret mathematics in various contexts. Including the ability to reason mathematically and use concepts, procedures, and facts to describe, explain or estimate a phenomenon. Mathematical literacy helps a person to understand the role of mathematics in life and use it to make informed decisions as a constructive and caring citizen. There are seven components of ability contained in mathematical literacy, namely (1) communication, (2) mathematization, (3) representing, (4) reasoning and reasoning, (5) using problem-solving strategies, (6) using symbols, formal language and techniques, (7) using mathematical tools. (15)

Stecey & Tuner interpret literacy in the context of mathematics is to have the power to use mathematical thinking in solving everyday problems to be better prepared to face life's challenges. Mathematical thinking is intended to include a problem-solving mindset, reasoning logically, communicating and explaining. This mindset is developed based on concepts, procedures, and mathematical facts relevant to the problem at hand.(17)

Mathematical literacy is defined as the ability to use mathematical knowledge and understanding effectively in facing the challenges of everyday life. A person who is literate in mathematics is not enough to only be able to use his knowledge and understanding but must also be able to use it effectively. In general, the above opinion emphasizes the same thing, namely how to use mathematical knowledge to solve everyday problems better and effectively. The philosophy of mathematics education is important because it gives new people the 'glasses' to see the world. It allows people to look beyond official stories about society, mathematics, and education. It provides a thinking tool to question the status quo, because seeing 'what is' is not what 'should' be; It is possible to imagine alternative possibilities. (18)

Although what I offer here is not conclusive, what the example shows is that even widely regarded well in mathematics education discourse, the concept of understanding, is a valuable target of philosophical analysis and criticism. Although such an analysis does not mean that we should abandon the concept, it does mean that we need to be aware of the penumbra of meaning that is revealedand Aporias is released through its deconstruction. We need to use the term with care and precision, clarifying or avoiding its disturbing connotations and Implications. Thus the philosophy

of mathematics education, while offering a valuable thorough and synoptic view and explanation of our field, also serves as a worker under “in clearing the ground a little, and getting rid of some of the garbage that lies on the path to knowledge”. (19)

4. CONCLUSION

The result of this study was that the authors filtered 2,968 articles into 1,580 based on open access, available subscriptions and only currently published then filtered into 108 by mathematical subjects. Finally, 20 articles have criteria for appropriate research admission. The findings of this study show that STEAM is an integrated learning approach that encourages students to think more broadly about problems that occur in the real world, especially mathematical literacy skills. The STEAM-based learning approach provides students with learning experiences that are interconnected with science, technology, engineering, art, and math. This makes students richer in relation to solving problems encountered regarding mathematical literacy.

In line with the implementation of the STEAM model is collaborated with awareness and mathematical literacy skills in an integrated manner, meaning that the approach taken is to connect the discipline of science contained in STEAM with existing mathematical concepts to produce an idea, idea, solution or product and innovation.

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