STEM-Based Learning Analysis to Improve Students' Problem Solving Abilities in Science Subject: a Literature Review

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Article Info	Abstract
	STEM is one of the learning paradigms that integrates science, technology, engineering and mathematics. The combination of several learning methods is implemented to make students achieve certain abilities, like problem solving skills. Problem solving becomes a very important part in learning because it can motivate students and make them having a better cognitive level. The purpose of this study is to describe the effect of STEM learning on physics material applied in schools to the problem-solving abilities of students. The method used in this research is meta-analysis where the researcher analyzed several articles as needed. Articles were limited to the last 5 years of publication, namely 2014 - 2019. Searching for articles used the Scholar, Eric, and Elsevier search engines. From the searching results, it was obtained 21 relevant articles according to the needs of researchers. Then, from 21 articles that were obtained as many as 86% were research articles that used questions or teaching materials as STEM-based learning media and 14% were review articles. The keywords used in the search were STEM, problem solving and physics. Based on the analysis conducted it can be concluded that learning through the STEM approach can improve students' problem solving abilities.

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INTRODUCTION

The development of the 21st century had an impact on society. One impact is seen in the education system. Technology as a source of information develops creative ideas, and improvisation in the scientific field (UNESCO, 2008). The development of information and communication technology (ICT) and its use is implied in learning (Farisi, 2016). The 21st century requires some preparations, one of the preparations that must be possessed is the problem solving ability (Hidayat, *et al.*, 2017). In facing the globalization era, one's success in life is determined by one's thinking skills in solving problems (Susilo, 2012). Nugraheni, *et al.*, (2014) stated that one of the fundamental goals in learning mathematics is that students have problem solving abilities. The ability of problem solving can be reflected in the way someone resolves problems accurately, precisely, in harmony, and rationally (Pistany, *et al.*, 2015; Polya, 1971). However, it seems that Indonesia still needs a specific strategy to deal with this (Safitri, *et al.*, 2019). Based on TIMSS data (Trends International Mathematics and Science Study) shows that Indonesia has a low level of scientific ability (IES, 2017).

The results of the 2016-2017 World Economic Forum showed that Indonesia experienced a decline in global competitiveness, from 37 to 41 (a total of 138 countries) (WEF, 2016). Problem solving skill can train someone to think critically, logically, and creatively (Sumarmo, 1994). A problem that is solved scientifically will make students dare to make decisions. Jonassen, *et al* (2010) states a problem contains conditions that encourage someone to solve it, only sometimes someone does not know how to solve the problem. One way to overcome a problem is to use a learning model. Learning models that can be used to improve problem solving skills are Project-Based Learning (PjBL), Problem Based Learning (PBL), and Discovery Learning. Learning models are selected and adapted to the material and characteristics of students (Afrina, *et al.*, 2016). In addition to the learning model of the problem-based practical module, learning can also increase student independence (Fidina, *et al.*, 2012)

The application of PjBL in science learning can improve cognitive abilities (Baran & Maskan, 2010), science process skills (Özer & Özkan, 2012), and effective learning (Cook, *et al.*, 2012; Movahedzadeh, *et al.*, 2012). The PjBL learning model can help students construct initial knowledge (Capraro, *et al.*, 2013). In addition to PjBL learning, the application of PBL learning can improve students' cognitive levels, and problem solving abilities (Susilo, 2012). One learning model that is integrated and in accordance with the current era of globalization is STEM (Becker & Park, 2011). STEM is one of the learning models that drives the success of the 21st century skills. The STEM learning system is integrated with several sciences, namely: science, technology, engineering, and mathematics. Through STEM learning, students have the ability, skills, and confidence in subjects through an interdisciplinary approach (Beers, 2011; Corlu, *et al.*, 2014).

The integration of STEM in learning can be seen in the activities of reading, writing, observing, and problem solving skills (Mayasari, *et al.*, 2014). STEM makes students have better, independent, and logical problem solving abilities (Stohlmann, *et al.*, 2012). STEM learning is expected to be meaningful to students through integrated knowledge, concepts, and skills (Afriana, *et al.*, 2016). STEM provides demand on students to solve problems and become well-defined outcomes through peer collaboration (Han, *et al.*, 2015). At present STEM learning is very important to solve global issues and problems facing the world (Reeve, 2015). STEM that has been integrated with problems makes students learn to solve problems. The application of effective STEM learning based on problem solving becomes one of the scopes of science skills (Permanasari, 2016; Adlim, *et al.*, 2015; Nugraheni & Suyanto, 2017). The purpose of this study is to provide an explanation of the STEM-based learning system to improve students' problem solving abilities.

METHOD

A literature review conducted systematically and structured is used to analyze and describe STEM-based learning. Through a systematic confirmation process by selecting items by Meta-Analysis (Soeharto, *et al.*, 2019). The steps taken are: (1) establishing subject criteria and operational definitions; (2) designing a search strategy; (3)

searching and screening to identify; (4) describe and examine articles that have been obtained; and (5) doing synthesis. Researchers conducted an article search process with search engines Scholar, Eric, and Elsevier. They analyzed several articles by conducting special searches and restrictions on the year of publication. This study only concerned at the last 5 years of research, namely 2014 to 2019. From the limitation, the researchers obtained 21 relevant articles. Keywords and article information are 1) year of publication, 2) research material (physics), 3) STEM learning, and 4) problem solving. After finding relevant articles, researchers conducted a STEM-based learning analysis to improve students' problem solving abilities. A literature review conducted is based on abstract analysis, research methods, instruments, and the results of STEM-based learning analysis to improve problem solving skills.

RESULTS AND DISCUSSION

STEM learning is one of the efforts to overcome human resources in the global era (Yulia & Ramli, 2019). STEM learning training is one way to introduce STEM in education (Chiu & Money, 2011). The purpose of STEM learning itself is to integrate, implement problem-based learning (STEM Literacy). STEM learning can improve literacy (Sampurno, *et al.*, 2015; Ismail, 2016) and improve student learning outcomes (Becker & Park, 2011). When someone has the ability to solve problems, students will correlate cognitive knowledge with thought activities (Tan, 2004; Izzaty, 2006). This makes the problem solving ability very important to be applied in learning (Cahyani & Setyawati, 2016) and directs her knowledge of problem solving (Fitriyah, *et al.*, 2018). The results of the study from Astuti, *et al.*, (2020) stated that the ability of students in solving problems is still relatively low, namely by taking 2 schools and then giving 2 problem solving problems to be solved. The results of the comparison of problem solving abilities for the two schools are shown in Graph 1 and Graph 2 (Astuti, *et al.*, 2020).

The results of the comparison of two problem solving questions in school A are presented in graphical form as in Figure 1.
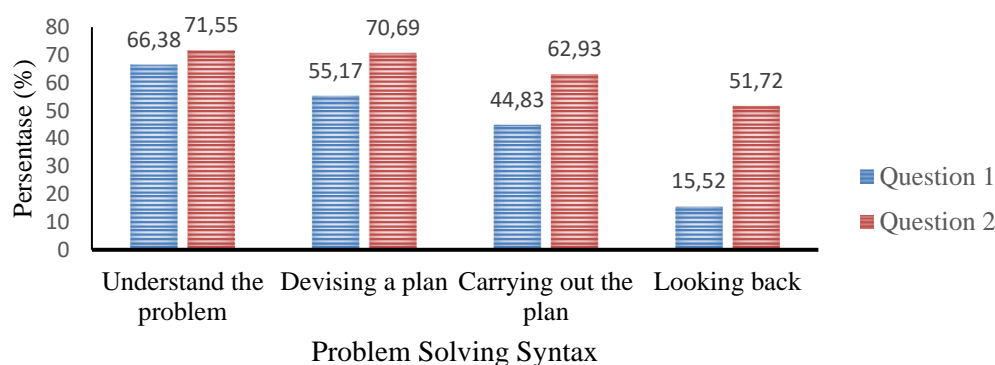

Figure 1. Comparative Score of School Problem Solving Ability A

The results of the comparison of two problem solving questions in school B are presented in graphical form as in Figure 2.
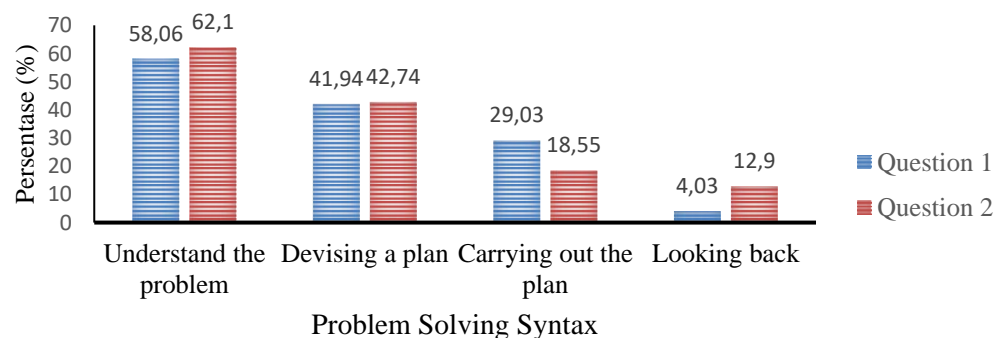

Figure 2. Comparative Score of School Problem Solving Ability

Of the four indicators of problem solving Polya,> 50% of students are only able to achieve 2 indicators of problem solving in Polya, in which students are only able to understand and make plans (Astuti, *et al*., 2020). Several studies have been conducted to investigate the use of STEM learning models that have an impact on learning. The results showed that STEM can encourage students to have the creativity and environmental literacy (Permanasari, 2016), affect professional abilities and social behavior (Surjanen, 2015). STEM is integrated with several scientific fields so that its existence becomes one of the solutions in the education system because students will be trained to understand a problem using the knowledge they have and to design solutions on them (Nava & Prasetyo, 2018). Based on the results of the analysis of the article conducted, in general, it explains the effect of STEM in learning, especially on the problem solving abilities of students. Of the 21 articles analyzed 86% of articles were research results and 14% of articles were the result of review articles from several relevant articles. In the research article, it appears that the researchers used the experimental control method to see the difference between before and after condition being treated.

Alfika and Mayasari (2018) present essay questions that have been integrated with problem solving problems. Physics is expected to be able to make humans who have good problem solving skills by integrating various scientific studies and used to find solutions to existing problems. Physics consists of various abstract concepts, in studying it requires accuracy, steps, and media (Yusuf & Widyaningsih, 2018). Problem solving skills are an investigative skill in developing solutions (Selcuk, *et al*., 2008) and training students' critical thinking skills through learning to use concept maps to reduce misconceptions (Negoro, *et al*., 2018).The ability of students to solve physics problems can be seen from the way students understand each physics concept and how students form strategies to solve problems (Docktor, *et al*., 2016; Selcuk, *et al*., 2008) The four stages that are often used in solving problems namely: understanding the problem, making plans, implementing plans, and evaluating problems (Yulianti, *et al*., 2018). Solving problems is a form of scientific concept so that it becomes the basic concept of scientific literacy which includes elements of scientific inquiry and scientific knowledge (Abd-El-Khalick, *et al*., 2004; Nentwig, *et al*., 2009). STEM can improve problem solving skills in students in several ways, one of them by making a module or teaching materials based on STEM. The STEM approach uses physics teaching materials that are integrated with local wisdom (Alfika & Mayasari, 2018) can improve student learning outcomes inside or outside school (Nurazizah, *et al*., 2018).

STEM learning makes students more experienced in solving problems because students are given the freedom to design. Students more easily remember and master technology (Kaniawati, *et al*., 2015). If students are used to integrating problems with STEM will help students think critically, logically, and systematically (Kaniawati, *et al*., 2015). STEM learning that was designed to support the success of the 21st century was not in line with the readiness of teachers to accept STEM learning. The lack of will in learning STEM makes STEM unable to be implemented well (Siew, *et al*., 2015; El-Deghaidy & Mansour, 2015; El-Deghaidy, *et al*., 2017). Some training has been held, it's just that the time is too short to make the training not run optimally (Siew, 2015; Duran, *et al*., 2013). The implementation of STEM needs to consider the material and look at research studies (Thibaut, *et al*., 2018).

Seeing the impact of STEM activities in improving problem solving skills, it is necessary to evaluate each lesson (Han, *et al*., 2014). The results of the research of Dewi, *et al*., (2018) showed an increase in the ability of problem solving in students after STEM-based learning. The results of the study can be seen in the Table. 1

Table 1. Pretest and Posttest Results of Problem Solving Ability

	Average		N - Gain	Information
	Pretest	Postest		
Problem Solving	16.11	96.81	0.69	Middle
1	46.05	86.32	0.73	High
2	24.74	87.02	0.82	High
3	4.21	70.00	0.69	Middle
4	1.58	60.00	0.60	Middle
5	0.00	68.82	0.69	Middle

Based on Table 1, it can be seen that there is a significant difference between the pretest and

posttest questions, it can be seen how much increase in each stage, using normalized N-gain can be seen an increase (Dewi, *et al.*, 2018). The post-test results showed a fairly high average value at each stage (Dewi, *et al.*, 2018). The problems faced by the global community today are increasingly complex and continue to change every time so it requires multidisciplinary science and many STEM integration needs in solving problems, if the integration of STEM is less appropriate it will lead to unclear STEM education itself (Wang, *et al.*, 2011). Each student has different thoughts in solving problems (Lasiani and Rusilowati, 2017) so that the presence of STEM to improve problem solving skills does not only have an impact on students but also has an impact on teachers (Yildirim & Sidekli, 2018). Teachers will have better pedagogical abilities than before (Yildirim & Sidekli, 2018).

Teachers need support from various fields of science because of the integration of complex STEMs so that teachers must learn more about technology (Ntemngwa & Oliver, 2018). STEM learning is an interdisciplinary approach that ensures every student can play an active role in learning (Yildirim & Sevi, 2016), this is done to see the improvement in problem solving abilities of each student. Wahoyo & Chang's research results (2019) mention STEM integrated learning makes students more interested and active in learning science. The sex of students can also affect the ability of problem solving in integrating STEM (Park, *et al.*, 2016). STEM is commonly used in primary schools rather than junior high schools and senior high schools (Park, *et al.*, 2016). Schools realize that implementing STEM requires preparation from the school environment where school management and school structures are needed (Debes, 2018; Huet, 2017). The availability of educational materials and resources is often a significant problem (Kim, *et al.*, 2019).

CONCLUSION

Based on the results of the review of articles that have been found, several factors have found that STEM learning is a learning solution, especially in improving problem solving skills. The integrated STEM is expected to be able to overcome the current problems. STEM learning can encourage students to construct initial knowledge and be good problem solvers. Moreover, STEM learning can make students to have higher motivation and systematic way of thinking. Also they become more critical and creative in the process of learning. Therefore STEM learning becomes a learning model in accordance with the current era of globalization because it can answer the problem of multidisciplinary science.

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