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Research Article

Literature review: a STEM approach to improving the quality of science learning in Indonesia

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Abstract

The application of STEM learning as a preventive approach is expected to help students interpret learning, especially science, so that it influences to improving learning quality. This is expected to be able to answer the challenge of creating a high-quality generation that focuses on the integration of science, technology, engineering and mathematics. STEM integration is related to contextual issues that support each other in science learning that is related to life. In this study, a review was carried out on research articles of STEM learning application which included four disciplines, namely science, technology, engineering, and mathematics, involving pupils in the investigation process that resulted in understanding and explanation supported by relevant evidence. The investigation process involved 20 articles related to the STEM approach, then analyzed. The results of the literature review show that the approach bar be able repair of learning grade. However, in its implementation there are various views regarding the role of various disciplines in STEM integration. The results of the literature review are expected to contribute to recommendations for implementing the STEM approach in improving the quality of learning.

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Introduction

The Organization for Economic Cooperation and Development (OECD) noted that the ranking of the Indonesia Program for International Student Assessment (PISA) based on the 2018 survey was at the bottom of the list. For reading competency scores, Indonesia level is 72 out from 77 countries. For Mather number is ranked 72. While the Science grade is 70. This value tends to be stagnant in the last 10 - 15 years. As a step to increase the value of Indonesia's PISA, Minister of Education and Culture (Mendikbud) Nadiem Anwar Makarim prepared a strategy to implement holistic learning to develop superior Indonesian human resources (Kasih, 2020)

The STEM integration program in learning is a learning program that combines two or more fields of science contained therein (Science, Technology, Engineering, and Mathematics) (Laboy-Rush, 2010). The use of the STEM approach in learning is a new approach in the development of the world of education that runs in more than one scientific discipline. The combination of several disciplines such as Science, Technology, Engineering, and Mathematics (STEM) in learning is expected to be able to improve the quality of education in Indonesia, therefore be contend with neighboring state. STEM does not yet have the right framework and even requires greater efforts to produce competitive students in the fields of STEM (Zeidler, 2016). Each of the STEM disciplines principle is other epistemological opinions. Science try to expand an concept of nature by testing generalizations of hypotheses, and developing in students a predetermined set of beliefs about their native environment (Williams, 2011).

STEM education is starting to develop in various countries around the world. Several countries that have implemented STEM education for ± 3 decades and are increasingly significant in recent years include the United

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States, Taiwan, Finland, Australia, Vietnam, China, and the Philippines. STEM literacy, namely awareness of several disciplines such as science, technology, engineering, and mathematics and getting to know some of the basic concepts of each discipline should be an educational priority for all students (Bybee, 2010; National Engineering Academy and National Research Council, 2014). an integrated approach to STEM education argues that student interest, success and motivation will be enhanced with focus daily problems and eventually amount of students chase careers in STEM will increase (Sayang, Pearson & Schweingruber, 2014). In accordance with the cognitive themes that develop from the learning sciences, integrative STEM activities are examples of constructivist practices in education. They present a context and structure to arrange noetict understanding of science and mathematics and push learner to vibrant build contextual awareness of science and mathematics, there by supporting remembering and assignment of learning (Sander, 2009).

Therefore, in this study the authors intend to discuss the integration of STEM education in learning and its impact on improving the quality of education. This study formulas is "How can the influence of the STEM approach in learning improve the Indonesia education quality?

Method

The research method apply literature study with adopt analyzing some articles. Review the documents by discussing and evaluating previous similar research on STEM approaches to learning.

The phase of the literature review method contain; 1) Manuscript filtering. The articles analyzed were achieve by searching for relevant literature online using several well-known online research databases related to education, STEM and science (ERIC and google scholar). Articles used from 2008 to 2020. The articles studied are journal articles in English and Indonesian. Articles should focus on the integration of at least three STEM disciplines. Articles that study a combination of only two disciplines, for example interdisciplinary mathematics and the integration of science or technology in mathematics, are excluded. 50 Articles provide clear descriptions of the STEM approach. By reviewing the title and abstract, the selected articles are examined by the researcher to determine whether the articles are suitable for the research objectives. A total of 10 articles met the criteria for inclusion in the final review. 2) Analysis. the analyzed using qualitative content with correlation between content and context. Articles were analyzed based on subcategories according to their respective research questions. Categories are useful for grouping studies according to the variables studied. During the systematic review process, some subcategories emerge and others are refined to reflect emerging information (Paramita, Dasna, & Yahmin, 2019).

Results and Discussion

This research is based on an article that examines research activities on the STEM approach in science learning published in the period 2008 - 2020. According to experts, the STEM approach has several meanings, so in this article the authors synthesize the definition of the STEM approach based on these opinions. Expert opinion regarding the application of the STEM approach describe in table 1.

Table 1.

Details of the Selected Articles

STEM Approach in Indonesian Education		
Author	**Title**	**Journal**
Widarti, Rokhim, & Syafruddin (2020)	Development of electrolysis ….	Jurnal Pendidikan IPA Indonesia
Arlinwibowo, Retnawati, & Kartowagiran (2020)	Type of Implementation of STEM Education in Indonesia	Jurnal Universitas Arsitektur & Teknologi Xi'an
Abdurrahman, Suyatna, & Nuangchalerm, (2019)	TEM-integrated newtonian dynamics effects…	Jurnal Ilmiah Pendidikan FisikaAl-BiRuNi
Abdurrahman, Nurulsari, Maulina, & Ariyani, (2019)	Design and Validation of Inquiry-based STEM Learning Strategies as Effective ….	Journal for Education of Gifted Young Scientists
Paramita, Dasna, & Yahmin, (2019)	Literature Review: STEM Integration….	Jurnal Pembelajaran Kimia
Milaturrahmah, Mardiyana, & Pramudya, (2017)	Mathematics Learning Process with Science, Technology, Engineering …	Jurnal Fisika: Conf. Seri 895 (2017) 012030

Theme 1. A Fun, Interesting, Fun and Exciting Approach

Teacher will be support in the classroom if they understood their material deep, thus they can flatten concepts and procedures from a lot of perspectives. What is more important is the need to be able to turn questions into learning moments that will help spark student interest in STEM (Ejiwale, 2012). Twenty-eight participants felt that science learning through designing and making science-based toys offered a learning environment that was fun, interesting, active, enjoyable and fun (Siew, Amir, & Chong, 2015). Participants expressed the view that the level of self-confidence of teachers and students in learning chemistry at school on voltaic cell material was carried out based on STEM-PjBL education assisted by instructional videos 78.6 and 89.2. Therefore, it is necessary to develop teaching materials with appropriate approaches and methods that can support chemistry learning on the topic of electrolysis cells in the form of STEM-PjBl-based textbooks assisted by learning videos featuring triple representatives (Widarti, 2020). Inquiry-based STEM learning strategies (Generating motivation and interest in science, increasing curiosity, in-depth discussion, analyzing, compiling, and constructing ideas) (Abdurrahman et al. 2020).

Theme 2. Increased Student Motivation

After one day attending the STEM-PjBL workshop, participants believed that STEM-PjBL was able to go up student encouragement to learn science and also motivate teachers to strengthen and repair the teaching and learning process, students gain motivation and when they are stimulated by their peers who develop self-esteem (Siew, Amir, & Chong, 2015)

Theme 3. Offer Opportunities to be Creative

Participants noted that learning with science-based toys was more than just playing with toys for fun. They believe that designing and making science toys themselves is a promising approach that offers students the opportunity to create something new and develop creative thinking skills (Siew, Amir, & Chong, 2015). STEM has been and will continue to provide for everyone - to provide the new knowledge and technology needed to overcome challenges (Supranto, 2016). Integrated STEM offers students the opportunity to carry out learning in real-world situations. Integrated STEM offers students the occasion to carry out learning in daily life situations as opposed to studying STEM fragments separately (Tsupros, Kohler, & Hallinen, 2009). Real and direct experiences that have the potential to increase student interest in STEM and STEM careers include mentoring programs, internships, afterschool that focuses on STEM subjects or health, and participation in math and science competitions (Miller, Chang, & Hoyt, 2010). STEM through Project Based Learning which makes students more aware of the need for clean water in the future (Stohlmann, Moore, & Roehrig, 2012).

Theme 4. Develop HOTs Abilities and Problem Solving Skills

Details of the articles studied regarding the STEM approach to HOTs ability and problem solving skills are shown in Table 2.

Table 2.

STEM Approach to HOTs Ability and Problem Solving Skills

STEM approach to HOTs ability and problem solving skills		
Author (Year)	Title Journal identity	Journal identity
Yusuf & Widyaningsih, (2019)	HOTS profile of physics education students ….	International Conference on Mathematics and Science Education (ICMScE 2018)
Siew, Amir, & Chong, (2015)	The perceptions of pre-service and in-service teachers regarding …	SpringerPlus
Lestari, Astuti, & Darsono, (2018)	Implementation of worksheets with a STEM …	Jurnal Pendidikan Fisika dan Teknologi
Supranto (2016)	Students' Attitudes towards STEM Education…	Journal of Turkish Science Education.

Based on Table 2, it is explained that physics-based STEM learning using PhET media is used to develop students' HOTS abilities. Students' perceptions of learning carried out generally show that students agree with the learning. STEM-based physics learning using PhET media will continue to be developed in various subjects in the Department of Physics Education, University of Papua to improve students' HOTS abilities (Yusuf & Widyaningsih, 2019). Three participants said the view that the workshop encouraged them to find their own solutions for designing and creating projects. They realized that STEM-PjBL gave students the opportunity to work alone with the guidance of an instructor (Siew, Amir, & Chong, 2015). Research on the results of the

implementation of the LKS with the STEM approach in class VIII A students regarding critical thinking skills obtained an increase in n-gain at the pretestposttest score of 0.5 on moderate criteria. This means that student worksheets developed with the STEM approach can improve students' critical thinking skills (Lestari, Astuti, & Darsono, 2018). STEM has been and will keep on to provide for everyone - to provide new knowledge and technology needed to overcome challenges, and to support new goods and services (Suprapto, 2016). Research on the results of the implementation of the LKS with the STEM approach in class VIII A students regarding critical thinking skills obtained an increase in n-gain at the pretestposttest score of 0.5 on moderate criteria. This means that student worksheets developed with the STEM approach can improve students' critical thinking skills (Lestari, Astuti, & Darsono, 2018).

Theme 5. The Effect of the STEM Approach on Literacy Skills

Details of the articles studied regarding of the STEM approach on literacy skills effect are shown in Table 3.

Table 3.

The STEM Approach Can Improve Literacy Skills

The STEM approach can improve literacy skills		
Author (Year)	Title Journal identity	Journal identity
Kelana et al. (2020)	The effect of STEM approach on the mathematics literacy ability….	Journal of Physics: Conference Series 1657 (2020) 012006
Morrison (2006)	TIES STEM Education Monograph Series	http://www.wytheexcellence.org /media/STEM_Articles.pdf
Stohlmann, Moore, & Roehrig, (2012)	Considerations for Teaching Integrated STEM Education	Journal of Pre-College Engineering Education Research *(J-PEER)*
Becker & Park (2011)	Integrative Approaches among Science, Technology…	Journal of STEM Education

Based on table 3, the effect of the STEM approach on the mathematical literacy skills of elementary school teacher candidates is seen in the increase in the average pretest and posttest results of students which shows that the research sample has increased by 10.39 with an average pretest of 30.19 and posttest of 40.58 . Data were processed using SPSS 20. The results showed the sig value. (2-tailed) 0,000 (Kelana et al. 2020). Morrison (2006) describes some of the characteristics of STEM education for students, schools, and classrooms. STEM educated students are problem solvers, logical thinkers, technology literate, and able to connect their own culture to learning. STEM schools prioritize STEM literacy and are culturally relevant to all students, have curriculum materials that support STEM teaching, foster a culture of questioning and creativity, and encourage formative and performance-based assessment practices. STEM education through project-based learning that makes students more aware of the need for clean water in the future (Stohlmann, Moore, & Roehrig, 2012). The findings obtained in this initial meta-analysis suggest that an integrative approach among STEM subjects makes STEM instruction more effective. Specially, the integrative approach shows upper effects at the elementary school grade (Becker & Park, 2011).

However, implementing the STEM approach in learning also requires commitment from stakeholders in the implementation process in schools (Arlinwibowo, Retnawati,& Kartowagiran, 2020; Maltese, & Tai, 2011). The application of STEM education can develop the interests, attitudes and skills needed in the 21st century, including communication which refers to argumentation skills. In its application, the teacher can choose a strategy that suits the needs and characteristics of the material. Regarding which strategy is the most effective, further empirical testing is needed (Paramita, Dasna, & Yahmin, 2019). STEM education often requires much materials and resources for pupil to investigate solutions to real-world problems through designing, disclosing, testing, and revising their ideas (Stohlmann, Moore, & Roehrig, 2012). Research by (Milaturrahmah, 2017) on the process of learning mathematics with the STEM approach in Indonesia is an aspect of preparation including preparation of media and learning resources, preparation of activity sheets, preparation of practical tools and materials, aspects of implementing learning. Introduction includes preparing students psychologically and physically before the learning process, asking questions about previous knowledge regarding the material to be studied, using the STEM approach in learning, content includes using an inquiry-based learning approach, linking material with everyday life, practice, involving students in practice, students are actively involved in classroom practice, guide students in practice, utilize technology (computers, internet), use active learning strategies, communicate actively with students during learning, assign assignments in groups, use problem solving learning methods, combine STEM in one subject (at least 2 STEM disciplines), students are motivated to like mathematics, develop teaching materials, teach according to their

fields, there is no gap between students. The class for us as teacher is to realize that school subjects need to be connected and not taught in isolation from one another. Students must be able to transfer all learning across curricular areas and make connections that can increase levels of academic achievement. The urgency is clear and many school systems have invested in the need for curriculum reform (Barcelona, 2014).

The National Research Council (2010) notes that in STEM learning, the ability to command the teaching strategies needed to illuminate STEM for students is just as important as teachers who know the various ways in which learners develop STEM knowledge and skills. Other support for teachers comes through federally funded mathematics and science teacher professional development training to help teachers implement STEM integration (Harris & Felix, 2010; Susanti, Prasetyo, & Retnawati, 2020; Mahmudi, Susantini, & Yakub, 2020). This will assist in preparing learners with the tools obligatory to tackle the STEM program. In another study, faculty from the University of Nebraska developed a two-week summer professional development program to help middle and high school science and math teachers carry out engineering lessons. In studying the effect of their lessons found students' interest in mathematics, science, and engineering was recommend (Nugent et al. 2010; Kennedy, & Odell, 2014). A large cadre of leading educational leaders and professional associations strongly advocate improvements in STEM education at the undergraduate level. Many influential groups and organizations recognize the need to reform STEM education and work to improve undergraduate teaching and learning in the STEM field. A number of articles, reports and books have appeared in recent years criticizing current practice and advocating improvements in STEM undergraduate education strategies. Many professional organizations and disciplinary communities have joined the reform chorus, pleading with their members and stakeholders to adopt more flexible, active, collaborative, and friendly pedagogical practices that will reach more effectively to a diverse range of students (Baldwin, 2009; Mutakinati, Anwari, & Yoshisuke, 2018). The aim of our professional development summer institute is to build on the existing literature on increasing the capacity and effectiveness of teachers to teach STEM with attention to content knowledge and their affective perceptions in the context of STEM teaching and learning. Our results show significant gains in the perceptions of efficacy, comfort, satisfaction, and knowledge of participating teachers with regard to STEM education. These results support the effectiveness of our intervention in increasing the capacity of teachers to teach STEM and provide a model for others who wish to respond to calls to increase the quantity and quality of STEM education (Nadelson & Callahan, 2011). These teacher candidates developed a more positive attitude about teaching STEM content and expressed a desire to include place-based pedagogy in their future STEM teaching (Adams et al. 2019; Bancong & Song, 2018).

Conclusion and Recommendations

The STEM approach in learning is used to improve the quality of learning, such as students' HOTS abilities, interests, student motivation, problem-solving abilities, and creating active learning. The results showed that be united approach between STEM subjects had a great effect of science learning quality. However, applying the STEM approach to learning also requires commitment from stakeholders in the implementation process in schools. These teacher candidates developed a more positive attitude about teaching STEM content and expressed a desire to include place-based pedagogy in their future STEM teaching.

Based on the research results it is recommended that the implementation of the STEM approach in education will improve the quality of education in Indonesia.

Limitations of Study

Review the literature by discussing and evaluating previous similar research on STEM approaches to learning.

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