



Central Java Teachers' Perspective on Science, Technology, Engineering and Mathematics (STEM) Learning

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Abstract

The purpose of the study is investigating central java teachers' perspective about Science, technology, engineering and mathematics or STEM. STEM recently has been becoming the most discussed in education practice. Integrating engineering and technology with science and mathematics will help teachers to deliver material using real world problem. Using project based learning to solve the problem can enhance students' interest, collaboration, discipline, critical and creative thinking skills. In fact, survey research showed that 35 of 72 teachers in central java do not know about STEM and teachers that have implemented STEM in the class have difficulties while teaching it. The highest hurdles teachers met was time allocation. Indonesian curriculum has a lot of materials that should have delivered in a limited time makes teachers hard to implement STEM in the learning process. Followed by teachers' difficulties to integrate between science, technology, engineering and math because there is no curriculum materials to guide them and other difficulties are school infrastructure, students motivation, and lack of preparation. Time allocation, school infrastructures, STEM integration, and preparation are the most hurdles that teacher met in the class.

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INTRODUCTION

STEM is an acronym that commonly used to describe an integrated education practice in the area of science, technology, engineering, and mathematics (Esin, 2018). Science is a process of learning that develops our interest and understanding of the world and the skills of collaboration, critical thinking and experimental research. Technology refers to the literacy of using technology to solve real-life problems. Engineering is an intricate process of designing and reasoning, which includes problem formation and prototype testing. Mathematical thinking refers to embracing mathematical methods and analysis to resolve the problems and/or to reveal the data gained in the activities (English 2015; Kelley & Knowles, 2016).

According to Chonkaew, Sukhummek, & Faikhamta (2016), necessary skills needed for 21st century people are creativity, innovation, communication and collaboration, critical thinking and problem solving, technology literacy, media literacy, and information literacy. STEM recently has applied in many countries and reports show that STEM is able to enhance students' engagement, students' achievements, learning outcomes, understanding material, critical thinking, analytical thinking and creative thinking skills to identify and solve their own problem (Acar, Tertemiz, & Taşdemir, 2018; Chonkaew et al., 2016; Hu, Chiu, & Chiou, 2019; McClure et al., 2017; McDonald, 2016; Stylianidou et al., 2018).

STEM enable teachers to integrate science to other subjects using application in real world problem by project-, problem- and design-based learning students will be more prepared in meaningful ways. Even now, STEM has been enhanced through further integration with arts, language, social studies, etc. and enable students to work in collaborative groups in real-world connections learning so that STEM can develop students' engagement and communication skill. (Havice et al., 2018; Wang, Moore, Roehrig, & Park, 2011)

Integrating engineering and technology with science and mathematics helps teachers to increase students' technology literacy and helps teacher to deliver concepts in the classroom and make students easier to understand the instruction in order to achieve higher score and learning outcomes

(Havice, Havice et al., 2018; Stohlmann et al., 2012). However, STEM enables students to learn outside classroom by project based learning so can develop students' talents and attitude. Students are able to apply science and engineering into their daily life and environmental problems so they can directly experience problem solving and analytical thinking process. Furthermore, through problem based learning students can develop their creative and critical thinking skills (Dailey et al., 2018).

STEM integration will be effective if teachers can explain procedures and concepts from multiple perspectives and it needs a deep understanding of the material. Teachers also need to know the pedagogical strategies that will be able to support students to actively participate in learning process; guide students in inquiry, designing and doing experiments (Chonkaew et al., 2016). Thibaut et al., (2018) Lee et al. (2018) and Wang et al., (2011) declared that the effectiveness of STEM implementation depends on teachers' efficacy toward STEM. Teacher efficacy can be explained as teachers' belief of their own capabilities in the learning process. This teachers' sense of abilities is associated with enhancement of students' motivation and achievement (Stohlmann et al., 2012). In addition, Stokes, Evans, & Craig, (2017) stated that teachers' experience and knowledge is required to create the teachers' perspective on a successful STEM. Therefore, teacher has to have self-efficacy, certain skills and knowledge so that teachers can integrate science, technology and engineering concepts into the classroom successfully (Ogan-bekiroglu & Caner, 2018). Teachers also should be provided with professional proficiencies that will enable them to lead students in the STEM learning process and always develop their teaching strategies (Kennedy & Odell, 2014).

Prior research showed that Taiwan teachers relatively low confidence in their engineering design knowledge. In addition, teacher with higher self-efficacy in engineering design tended not to be cheerful when teaching STEM in class because they have not been trained to integrate engineering design with other STEM learning topics into their teaching (Kelley & Knowles, 2016). However, curriculum leads teachers to usually focus on one or two subjects except for elementary school. This causes teachers are not familiar with the engineering content and engineering process (Chai, 2019).

DeCoito and Myszkal (2018) also report that teachers with higher self-efficacy in synthesized knowledge of STEM as well as positive attitudes toward STEM education may not be skilled at integrating STEM subject. The overwhelming stress might lead to the fact that teachers with higher self-efficacy in engineering design tended to show negative attitudes toward STEM education. The stress caused by the strict curriculum and teachers' duty for preparing students to pass national examination and entrance examination. They also less likely to think that STEM education could help students solve real-life problems.

Dare, Ellis, & Roehrig(2018) declared that teachers have some hurdles presenting successful STEM integration: (1) a lack of curriculum materials for STEM, make teachers struggles to balance the various components of STEM in classroom, (2) the need for creating engaging experiences for students, and (3) the need for assessments in integrated STEM, (4) struggling for balancing science and engineering design.

To address the need to improve STEM education in Central Java, the authors conducted a survey to assess Central Java teachers view about

STEM and examine the STEM education that has been implemented.

METHODS

The journal uses survey method. Based on Levy and Lemeshow (1999), survey design has two steps: deciding sample from the population and the survey media. The subject was elementary school and high school teachers in Central Java with minimum one year teaching experience and the study use online survey. The survey starts from September to November 2020. The survey is about teachers' opinion on STEM and teacher's difficulties while implementing it.

RESULTS AND DISCUSSION

Table 1 shows the characteristic of participants who join in the survey research. Both male and female teachers with the minimum one-year experience are participated. Teachers in the urban and rural area, elementary, junior and senior high school teachers also participated. There is no significant different between teachers' perspective on STEM.

Table 1. Characteristic of Participant

		Elementary School	Junior High School	Senior High School
Gender	Male	17	14	6
	Female	20	11	4
School Area	Urban	11	5	4
	Rural	4	3	2

Teachers' Knowledge about STEM

First, we asked teachers' knowledge about STEM. Surprisingly, 40.9% teachers do not know about STEM integration. It means that STEM even this is the commonly known in other countries, teachers in central java do not know about it. Then,

we asked teachers to watch a brief explanation video about STEM. From the interview, some teachers also explained that actually they already did the STEM integration in their learning process but they have not known if it was STEM.

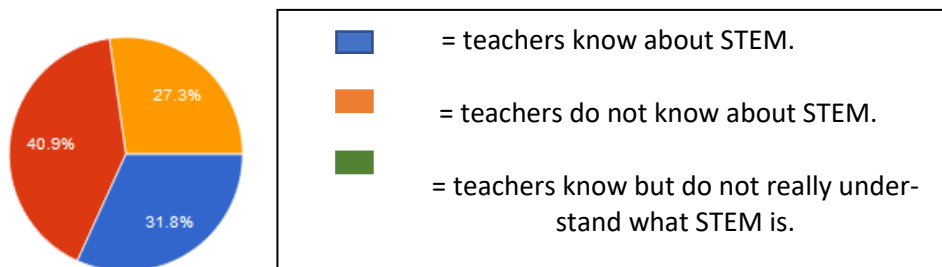


Figure 1. Teachers' Knowledge about STEM.

Teachers' Opinion on STEM Gain Students' Interest on Learning Process and Introduce Real World Problem

Next, we asked teachers' opinion on STEM. Teachers think that STEM is important for students to gain students' interest to learning process and introduce real world problem to students in the early years. Other opinions, teachers think that using STEM also let students to directly implement their knowledge so it is not only all about theory but also experience. Some teachers also add that it is important to make the learning process more interactive. Prior research also showed that STEM education that has implemented also enhanced students' interest towards STEM and motivated students to work in the STEM field (Acar et al., 2018; Han, 2017; Malone et al., 2018; McDonald, 2016; Proudfoot et al., 2018; Schmidt & Kelter, 2017; Yildirim, 2016)

Enhance Positive Attitudes

Teachers agreed that STEM also can help students to understand and adapt faster their real world problem. STEM project based learning also allows students to increase their positive attitude such as critical and creative thinking, students' interaction, discipline, autonomous, and students will be interested and participate actively in learning process.

Teachers also stated that STEM help science to integrate with other subjects not only mathematics, but also arts, language and even computer. In addition, STEM aids students to prepare for working. Students will have high responsibility, find their talent and adapt to technology from STEM problem and project based learning.

Moreover, teacher also declared STEM problem based learning can also promote higher order thinking skill, because students are asked to solve real problem and sometimes requested to not only solve by theory, but also create its application. Through discussion, it also can increase students' inquiry. Teachers added that STEM will also

promote gender quality. Women will more interests on science, technology, math, and engineering and also students will directly join to learning process.

In brief, STEM in central java teachers' opinion can help teachers to gain students interest, make learning process fun, promotes students' inquiry and creative, critical thinking skill, integration to other subjects, and increase students' positive attitudes. Similarly, existing research stated that STEM using integration between science, technology, engineering, and mathematics. It allows students to work in group to solve real world problem so it can increase students' critical thinking, analytical thinking, creative thinking, and students' engagement (Chonkaew et al., 2016; Han, 2017; Lai & Lai, 2018; Rogaten & Rienties, 2018; Warin, Talbi, Kolski, & Hoogstoel, 2016; Yildirim, 2016).

Teacher difficulty in teaching STEM

After asking teachers opinion on STEM, we asked whether teachers have ever implemented STEM in their class and have problem while teaching it or not. In fact, all teachers have hurdles while implemented it.

Figure 2 shows the highest problem that teachers face while teaching STEM is time allocation. Indonesian curriculum has a lot of materials that should be given to students in a limited time so that make teachers find hard using STEM in the class. It followed by STEM integration. Teachers said that there is no references in the curriculum to guide them to implement STEM in the learning process. School infrastructure also become a problem for teachers. Not many teachers in Indonesia update with technology and still lot of schools in Indonesia are not provided by laboratory or other stuffs that can provide STEM learning. Teachers in Indonesia have many administrations to do, for example lesson plan, syllabus, evaluation process, and others. STEM needs preparation and for some teachers, it will need more time for preparing and can increase their stress.

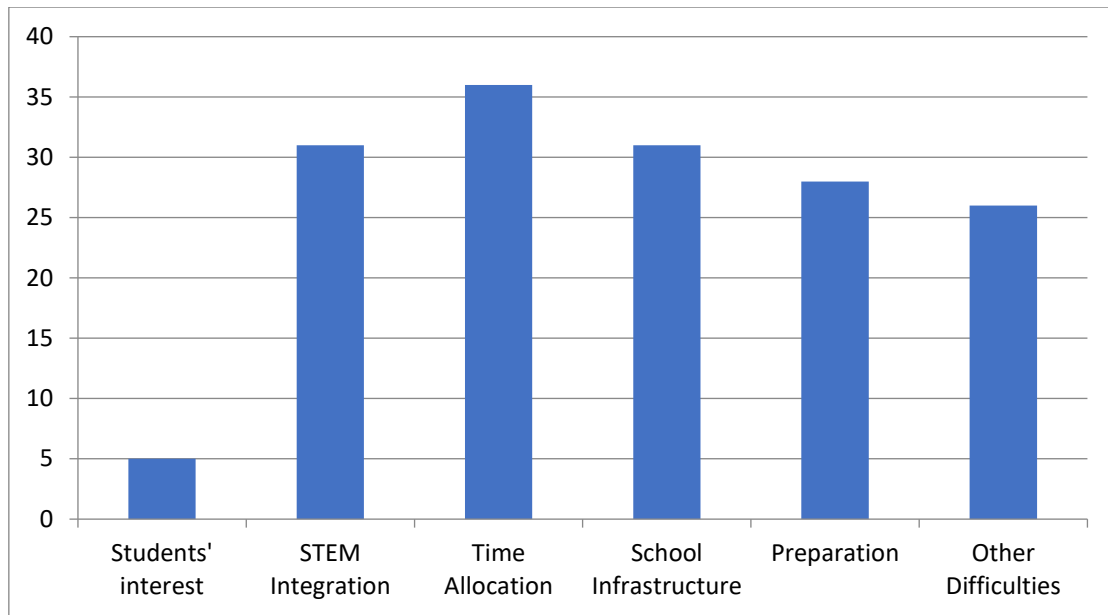


Figure 2. Teachers Difficulties while Teaching STEM

Students' Motivation

The first aspect we want to see is whether teachers are having hurdles from students' interest. Teachers answered that some of them have difficulties to gain students' interest to the learning process. They often see students are daydreaming during learning process. Not all students also being motivated in science even teacher gives them some projects. Too many students in the class also become obstacle to some teachers. Students will be more interested to play around with their friends than give attention to teacher and do the project.

But only five teachers comment that they have this difficulty. STEM integration provide problem and project based learning, so it can enhance students' engagement on learning process. Real world problem also makes students more understand the material. Earlier research also showed that STEM education that has implemented enhanced students' interest towards the learning process and motivated students to work to more engaged to study (Han, 2017; Malone et al., 2018; McDonald, 2016; Schmidt & Kelter, 2017; Yıldırım, 2016).

STEM Integration

STEM is an acronym to describe an integrated education practice in the areas of science, technology, engineering, and mathematics. Science enables us to develop our understanding of the world. Technology refers to the literacy of using technology as a vehicle to solve problems.

Engineering plays acritical role in applying concepts and processes across STEM disciplines (Stokes et al., 2017). Engineering is an intricate process of learning by doing, designing, and reasoning, which includes problem formation, predictions of prototype testing, and analysis of prototype testing. Mathematical thinking refers to application of mathematical methods and analysis to resolve the problems and/or to reveal the data gained in the activities. These four dimensions play a vital role in STEM implementation (Copeland, Furlong, & Boroson, 2018; Kelley & Knowles, 2016).

In order to implement STEM in class successfully, teachers have to understand well integration between science, technology, engineering and mathematics (Ogan-bekiroglu & Caner, 2018) so we asked teacher if they have problem while teaching STEM in the class. Surprisingly, almost all teachers stated that they do not know what exactly engineering is and feel hard to integrate engineering and technology. Next, some teachers also answered that they do not feel confidence in using technology. In fact, technology is the fundamental of STEM (Stokes et al., 2017)

Time Allocation

Another problem while teaching STEM is time allocation. Students need more time for making projects and school only provide 45 minutes for senior high school, 40 minutes for junior high school and 35 minutes for elementary school in a meeting whereas students have many materials they should

learn in a semester. DeCoito and Myszkal (2018) research also shows that teachers feel overwhelming with the time allocation because teachers have limited time to teach many materials in a semester. They also need to finish all the materials in a limited time for students' preparation to face final examination.

School infrastructure

Only three teachers answered that school has provided good quality learning equipment. Many teachers stated that their school provides inadequate facilities. It makes teachers feel not ready to implement technology in the learning process. Technology is the literacy of using things as a vehicle to solve problems (Stokes et al., 2017). Teachers do not understand STEM so that they do not know that technology does not mean we should prepare high technology in a laboratory to integrate STEM. Teachers can use a model such as some pieces of papers, scissors, and other daily things to refer as a technology.

Preparation

Almost all teachers stated that they have good preparation for learning process. Some teachers answered that they need guideline or reference to teach STEM and make a good lesson plan. They met hurdles for teachers' administration in Indonesia that need time for making them because it is complicated enough. DeCoito and Myszkal (2018) research also stated that teachers feel overwhelming to prepare the project with their duty to prepare final examination and other administrations.

Other difficulties

Teachers do not really understand about STEM and integration science to technology and engineering, steps in the learning process and how to engage students. Teachers also suggest to make a guideline or STEM training for teachers because there is lack of materials to guide them to teach STEM. It is in line with the research from Dare, Ellis, & Roehrig (2018) research that stated one of the hurdles when teachers implement STEM is there is lack of curriculum materials to help them to integrate between science, technology, engineering and mathematics.

CONCLUSION

STEM is an integration of science, technology, engineering and mathematics that has

been known and applied into learning process. It can enhance students' interest, collaboration, discipline, critical and creative thinking skills. In fact, 35 of 72 teachers in central java do not know about STEM and teachers that have implemented STEM in the class have difficulties while teaching it. Time allocation, school infrastructures, STEM integration, and preparation are the most hurdles that teacher met in the class. Therefore, teachers recommended there should be a guideline book attached in the curriculum to help them to implement STEM in the class.

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