GAINING SCIENCE TEACHERS' PERCEPTIONS TOWARD STEM EDUCATION IN INDONESIA

Uswatun Hasanah
Research Center for Education, National Research and Innovation Agency
Jl. Gatot Subroto No.10, RT.6/RW.1, Kuningan Bar., Kec. Mampang Prpt.,
Kota Jakarta Selatan, Daerah Khusus Ibukota Jakarta 12710
uswatun.hasanah.2@brin.go.id

ABSTRACT

This study focused on teachers' perception of Science, Technology, Engineering, and Mathematics (STEM) education as an initial step in Indonesian curriculum development. It was expected to provide information about how STEM education emerges into Indonesian curriculum and what the challenges of STEM implementation from teachers' view as a significant element in education. Twenty-five in-service teachers participated in the STEM professional development program in South Sulawesi, Indonesia, which was divided into four sessions; Presentation, Simple Experiments, and Developed Experiments. The last session of the program was an Interview which was conducted for data collection. The findings revealed that STEM is considered an old instruction in Indonesia but emerges as a new term to most teachers. Furthermore, teachers need support from the government to improve the capabilities for well-implemented STEM class. Some challenges are also revealed as part of the government's responsiveness.

Keywords: Teacher perceptions, STEM education, Challenges, Professional development

INTRODUCTION

STEM education is an integrated education combining two or more of STEM subjects including scientific inquiry, technology, engineering design, and mathematical analysis into an interconnected learning standard, such as teaching behaviors, curriculum matter, and educational policy. It aims to encourage the country's potential STEM talents and enhance its competitiveness. In addition, STEM as a teaching instruction positively affect the student's skills and attitudes toward science; strengthen students' interest in science, technology, engineering, and mathematics; and keep students focus on modern science and technology (Kelley & Knowles, 2016; Oyana et al., 2015; Sari, Alici, & Sen, 2017).

STEM was not only an issue that has roused the attention of American educational circles but also the focus of curriculum development in many countries (Fan & Yu, 2016). In Indonesia, curriculum development has been marked by the implementation of school-based management. It involves reforming the national education objectives, decentralizing management from the government of schools, and implementing the 2004 curriculum, KTSP curriculum, and 2013 curriculum. The new curriculum goal is promoting students' ability to apply knowledge in real-life situations (Suprapto, 2016b) that is also known as a part of STEM education. Further, the government has been socializing the importance of STEM as one of the best approaches to fit the current education system (Depdiknas, 2016). Unfortunately, due to many teachers in Indonesia, this socialization program, however, apparently can be accessed only by a limited number of teachers, and the understanding of STEM education among Indonesian teachers is still under expectation.

Previous researchers confirmed that teachers are an essential element in the curriculum development process, their roles are growing, and implemented curriculum will be more accessible with the trained teachers (Elliott, 1994; Konokman, Yelken, Karasolak, & Cesur, 2017; Oliver, 1965). In STEM Education, the teachers should provide an environment that enhances the self-confidence of the students so that the students is not afraid of making mistakes; give the students with the theoretical and practical information that enable them to have high-level thinking skills as well as the academic knowledge in Science, Technology, Engineering, and Mathematics courses; help the students make innovations the new information (Akran & Asiroglu, 2018). Teachers assist the curriculum development process through their knowledge of curriculum, teaching experiences, and feedback or evaluation (Konokman et al., 2017). They are the most significant influence on whether the new curriculum is appropriate to the current curriculum and implemented successfully into practice (Driel, Beijard, & Verloop, 2001; Driel, Bulte, & Verloop, 2005).

For this reason, teachers' perceptions are considered as a critical issue to grasp how STEM education can be implemented in Indonesia. To this end, in-service teachers are expected to show positive attitudes towards STEM in Indonesia and provide any beneficial information on STEM and STEM implementation in the future based on their experiences. Researcher emphasize the background in contributing to curriculum development in Indonesia, to the teaching quality improvement, and contributing to the literature on STEM education in Indonesia. The following research questions guided the study.

1. What are teachers' perceptions on STEM education and STEM implementation in Indonesia?

2. What are teachers' perceptions on the challenges of STEM implementation in Indonesia?

BACKGROUND

STEM Education

In the 1990s, The National Science Foundation (NSF) started using the acronym "SMET" standing for "Science, Mathematics, Engineering, and Technology" and then it changed to the new term, STEM, in 2001. In the last two decades, NSF has used STEM to refer to the four separate and distinct fields. In fall 2007, they realized that the acronym of STEM is ambiguities; thus, STEM education retitled become "Integrative STEM Education." The notion of integrative STEM education includes approaches to explore teaching and learning between and among any two or more of STEM subject, and between a STEM subject (Sanders, 2009). The specializations of each subject are explained as follows (Burghardt & Hacker, 2004; Kelley & Knowles, 2016):

1. Scientific inquiry. Preparing students to think and act like real scientists, ask questions, hypothesize, and conduct investigations using standard science practices.
2. Technology. As objects, knowledge, activities, and decision.
3. Engineering design. As an approach to delivering STEM education creates an best entry point to include engineering performs into current secondary curriculum.
4. Mathematics thinking. Providing the necessary rationale for students to learn mathematics through valuating design solutions and see the connections between what should be learned in school with what is required in STEM career skills.

Nowadays, STEM Education is known as a multidisciplinary subject that covers the daily life experience of the student to create more interactive, precious learning process and to prepare highly competent workers for the future global marketplace. Moore et al. (2014) designated a framework that includes six principles for STEM education. Those are including the inclusion of math and science content, student-centered pedagogy, the means of making mistakes, group collaboration, engaging and motivating lesson, integration of engineering design of redesign challenge (Moore et al., 2014).

STEM education does not only talk about STEM disciplines but also pedagogy and curriculum. The curriculum emphasizes problem-solving of real-world challenges among the four subjects. STEM pedagogy describes the teachers' role in STEM instruction (Margot & Kettler, 2019). The practical instruction in STEM concepts relies on the use of the effective

instructional method (Smith, Rayfield, & McKim, 2015). Further, instructional methods can be defined as the specific techniques used to present educational content as well as one of the most significant determinants of student attention, learning, and retention (Cronbach & Snow, 1981; Sallee, Edgar, & Johnson, 2013). STEM has been around for quite a long time without response until educators in 1957 concurred on the estimation of STEM for guaranteeing America's edge in the worldwide economy (White, 2014), it was simply advanced of late in Indonesia due to constrained sources. The idea of STEM in Indonesia became well known recently, particularly in advanced education level. It is reliably created in the training area, and specialists, educators, and events were gone to it (Suprapto, 2016a).

The development of STEM gives chances to every single level student to ace abilities and substance fundamental for 21st-century learning and through utilizing an assortment of movement-based learning models, understudies are given chances to quicken to a thorough profundity of information (Meyrick, 2011; Shernoff, Sinha, Bressler, & Ginsburg, 2017). It includes issue-based and venture-based discovering that enables understudies to investigate genuine issues all the while creating cross-educational program abilities, for example, thinking skills, reasoning skills, collaboration, problem-solving, creativity, and research skills that could be valuable for choosing vocations in science. Students currently assume real-world connections to what they are learning, or else they may completely disengage (El-Deghaidy & Mansour, 2015; Havice, Havice, Waugaman, & Walker, 2018) that they conceivably find in STEM instruction. Further, doing what students need is not as simple as they anticipate. Given the previous study, STEM instruction has met several implementation factors from the students side, educators, government, and also educational programs (Hasanah & Tsutaoka, 2019; Kanadh, 2019; Siew, Amir, & Chong, 2015). Thus, serious efforts are being made to transform traditional learning approaches to effective STEM instruction particularly in preparing the readiness for education, in considering teachers as a critical element of education who create a strong positive correlation with students' academic performance, majoring in STEM field as well as pursuit of a career in STEM area (Awad, Salman, & Barak, 2019; Shumow & Schmidt, 2013).

Teachers' perception of STEM Education

Gurol (2004) & Tasdemir (2003) in Konokman, et al., (2017) confirmed that no matter how well the new system in education is, it will not achieve its objectives unless teachers as implementers can fulfil their task efficiently. Otherwise, teachers are seen not only as active curriculum

implementers but also as primary elements giving feedback about the current curriculum to improve it. Teachers are expected to manage the curriculum at least implementation level by mastering principles of teaching, significances, contents, learning-teaching approaches, educational technologies, and evaluation processes. Thus, teachers contribute to the curriculum development process with their practical experience, knowledge of curriculum, and feedback about the implemented curriculum.

Some studies have been investigating teachers' perception in STEM education for in-service teachers as well as pre-service teachers (Calisici & Sumen, 2018; El-Deghaidy & Mansour, 2015; Erdogan & Ciftci, 2017; Hammack & Ivey, 2016; Pitiporntapin, Chantara, Srikoom, Nuangchalerm, & Hines, 2018). Erdogan & Ciftci (2017) and Calisici & Sumen (2018) have worked with pre-service teachers' perceptions on STEM through training and activities in Turkey. The background of this study is to reveal pre-service teachers' perception of STEM Education in Turkey, however, without considering in-service teachers' perception. The data collection was conducted through interviews and analysed by content analysis. The result showed that pre-service teachers show positive attitudes toward STEM Education. Besides, the pre-service teacher should be supported through the seminar, conferences, etc. to have the necessary content knowledge and pedagogical knowledge related to STEM education and provided with the required resources and materials.

On the other hand, El-Deghaidy & Mansour (2015) and Hammack & Ivey (2016) have studied in-service teachers perception in Egypt and the United States of America. The benefit of STEM education has been emphasized in the direction of teacher perceptions because of its contribution to creative thinking and creativity. It also revealed that teachers have felt lacking in STEM education knowledge, especially in engineering, application, science, and technology. These previous studies also recommended a STEM professional development program in order to strengthen the content, curricular, and pedagogical knowledge to teach STEM effectively. However, articles did not further identify in-service and pre-service teachers' perceptions toward STEM and the possible challenges at the same time that can be very helpful in STEM curriculum development.

Some studies have been conducted in US, Egypt and Turkey, but there is no study have been done in Indonesia. Further, Different from the previous research that primary focus on one experience "pre-service or in-service experiences", not "pre-service and in-service experiences" (Calisici & Sumen, 2018; El-Deghaidy & Mansour, 2015; Erdogan & Ciftci, 2017; Hammack & Ivey, 2016; Pitiporntapin et al., 2018). Further, none of the study considered teachers' perception on STEM challenges (Calisici &

Sumen, 2018; Hammack & Ivey, 2016; Pitiporntapin et al., 2018; Srikoom, Hanuscin, & Faikhamta, 2017).

METHOD

Participants

This study employed phenomenological research which tries to understand people's perceptions and perspectives relative to a particular situation (Leedy & Ormrod, 2015). In this case, Researcher intended to gain teachers' perception of STEM education and STEM implementation based on their understanding and experiences. This study was conducted in Pangkep Regency located within 49 km from Makassar, the capital city of South Sulawesi, Indonesia. The participants were recruited from 38 sub-districts in Pangkep. 25 in-service physics teachers attended the professional development program. It consisted of six new teachers with less than ten years of teaching experience and 19 experienced teachers with more than ten years of teaching experience. Further, 14 teachers were randomly selected and interviewed. All participants had an academic degree in science and taught physics in the senior high school level.

Data Sources and Analysis

In this study, teachers' perceptions on STEM are based on their experiences, understanding, and beliefs which were measured with preconditions through professional development program (Calisici & Sumen, 2018; El-Deghaidy & Mansour, 2015; Erdogan & Ciftci, 2017; Hammack & Ivey, 2016). Twenty-five participants were grouped with four to five teachers in each group. To ensure anonymity, all names of participants have been coded.

This STEM professional development program was conducted before data collection that aimed to provide initial information as well as teachers' necessity to build successful, sustainable, and integrative STEM education. The program was a four-day training as pictured in Table 1 with MGMP Fisika- Physics Teacher Association- supports.

Table 1:
The Detail of STEM Professional Development Program

TIME	ACTIVITY
1st day	**Introduction** • The definition of STEM education • The role of each subject in STEM education; science, technology, and engineering and Mathematics • The significance of STEM education

	• Teaching strategy for STEM education
2nd day	**Simple Experiments** • Global warming demonstration • Thermal expansion model • Discussion
3rd day	**Developed Experiments** • Spectrometer • Building Rocket • Creating a lesson plan • Discussion, group presentation
4th day	**Interview** • Interview

This STEM professional development program emphasizes several things. Firstly, it is about teachers' understanding of the concept of integration and how to teach S-T-E-M. Secondly, teachers need to have a background in one or more disciplines in STEM, both content knowledge and processes, and the interdisciplinary methods that are developed from the four main subjects. Lastly, the STEM teachers' preparation program should be different from science teachers' preparation, technology teachers' preparation, or mathematics teachers' preparation program because it represents the integration of disciplines (Pimthong & Williams, 2018). There are four activities; as mentioned above Introduction, Simple Experiment, developed experiments, an interview, and the content cover the concept of Science, Technology, Engineering, and Mathematics and the implementation.

Introduction activities aimed to provide an overview or initial concept about STEM education to all participants. It was divided into three sessions with two speakers; these sessions talked about the definition of STEM education, the importance of STEM education, the role of technology and engineering in STEM education, as well as teaching strategy in STEM education. Meanwhile, the simple experiment part was divided into two sessions, utilized the teaching material provided by the facilitator. In this session, researchers started giving a picture of how STEM instruction is conducted through the physics experiment based on the indicator in the Indonesian curriculum. All participants were observed simple STEM experiments as brainstorming to be ready for integrated STEM experiments in the next session. This activity was followed by a discussion at the end of the course. Furthermore, the third activity was developed with two sessions. In this part, the teacher conducted and controlled more complex experiments that were also based on the Indonesian curriculum. This session aimed to picture STEM education as a simple method that is not as

tricky as teachers imagine. In the end of this session, teachers in a group were in charge of creating and presenting a lesson plan based on their experiment.

In the last part of the professional development program, a semi-structured interview as data collection in this study was conducted with nine experienced teachers and five new teachers. It looked more like natural conservation with the participant doing most of the talking and the researcher doing most of the listening. The researcher also took notes for each participant to script a piece of valuable information, recorded the conservation to discover how we have influenced the flow of the story, and at the end, the result.

In this session, Researchers asked some questions as follows:

1. How did your pre-service teacher training like? Did STEM exist?
2. Have you ever heard about STEM education before the professional development program?
3. How do you think about STEM instruction comparing to conventional instruction?
4. What value can you get from STEM education? Which subject is the most difficult?
5. What do you think about STEM impact on the student's knowledge and skill?
6. What challenges that you think might be found in STEM education through physics class?

To explore the diversity and discover comprehensive data, the participants were divided into two groups; new teachers (0 to 10 years of teaching experience) and experienced teachers (more than 10 years) — this data analysis aimed to point out the common and the consistency of participants in answering the questions. After finishing the interview session, the data analysis started by making a summary with the table description for each item.

RESULTS

In this section, the teachers' perceptions of STEM education are displayed based on the order of interview questions. The first question was asking the experience of teachers during their training; undergraduate and/or graduate level.

Table 2:
Science Teachers' perceptions of their experiences during pre-service training

Category	Participant
I have never found STEM Education during my pre-service training and never conducted STEM class	Six experienced teachers
I have never found STEM Education during pre-service training, but I have done some STEM classes	Three experienced teachers and all five new teachers

According to Table 2, all teachers revealed that STEM education does not exist in the university level in Indonesia for the last 30 years based on their teaching experience. Even though eight teachers admitted that they tend to conduct STEM instruction without knowing the term of STEM education, but the implementation really depends on the teacher's interest and motivations, because of unprovided guidance, reference, or instruction from community as well as government. Moreover, this finding also shows that new teachers put more attention and interest in STEM education compared to experienced teachers based on the frequency of STEM implementation.

"I tend to conduct STEM education in my classes, but I did not know that it was called STEM education."
"It was not an integrated STEM, because I did not complete four subjects, sometimes I only combine two or three STEM subjects, and try to build the connection between the learning and students' daily life experiences."

Meanwhile, the second question, "*Have you ever heard about STEM education before the professional development program?*" in Table 3 shows almost the same number of teachers for the two categories. Half participants did not know about STEM education before PD program and the rest found out the term STEM education in the last two-year from various sources currently STEM was adopted by the government and delivered by supervisors through MGMP meetings.

"*Recently, our supervisors encouraged teachers to learn more about STEM education, we discuss about STEM education in each meeting and will conduct a one-day seminar to present about STEM education tomorrow*."

Table 3:
Science Teachers' knowledge about STEM Education before joining the professional development program.

Category	Participant
I know about STEM Education when I attend this PD program	Four experienced teachers; two new teachers
I have ever heard about STEM education before, and this is the second time or more	Five experienced teachers; three new teachers

Besides, the third question was mentioning about STEM education compared to the conventional learning method. It emerged that there is no difference between experienced and new teachers' perceptions. 14 teachers agreed that STEM education is more challenging compared to conventional instruction. Three categories are mentioned by the teachers: STEM is interesting; STEM provides hands-on activities; STEM is the most updated learning process. They believed that STEM education could give a chance for students to explore more based on real life and to balance the students' habits in and outside the classes.

"*Nowadays, students are different from 10 years ago. Students become more active and love playing. Frequently, students cannot be controlled using traditional learning. STEM education emerges as a new one with enjoyable activities that match the student's habits and of course the workplace demand. In addition, even though STEM education is appropriate with the physics learning process, all facilitators in education also have to realize the need for effort*."

Further, the fourth question revealed the toughest subject among four in STEM education. Based on the interview result shown in Table 4, engineering emerged as the most problematic subject to be implemented, followed by mathematics, technology, and science. This is because most teachers imagine the complexity of engineering and assume as a problem to be implemented in the primary and secondary levels.

Table 4:
Science Teachers believed for the most challenging subject among STEM subjects

Category	Participant
Engineering	Four experienced teachers; three new teachers
Mathematics	Three experienced teachers; one new teacher
Technology	Two experienced teachers, one new teacher

In the fifth question, teachers confirmed a huge advantages of STEM Education in improving students' quality of knowledge and skills. Otherwise, government, as well as all facilitators, including teachers, must give more awareness in supporting teachers' capabilities to prepare for STEM implementation.

Interestingly, one of the new teachers assumed that school goals and national examination goals become the most sensitive points in STEM implementation. These conditions have driven the teachers in the learning process.

"*In my school, most of the teachers including me, feel difficult to transfer from conventional learning to STEM education. We do believe STEM Education can help students to improve achievement, STEM Education emphasizes the learning process, so students can deeply understand the concept of phenomena, and problems, and have an interest in science, technology, engineering, and mathematics. However, the school goals and the national examination target do not match to STEM. The school goals underline the knowledge, answering the question which is not problem-solving. Hence, there is a gap between the expected learning process and the expected achievement of students. It causes teachers do not have any choice, except how to maximize the correct answer of the student in the national examination*."

"*In developing countries such as Indonesia, STEM education will be more appropriate in the urban area compared to rural. It is similar to what we have done in the previous curriculum development, it needs step-by-step implementation for a long-term benefit*."

To conclude, teachers pointed out some challenges and limitations as listed below:

1. Time limitations in the class and after class,
2. Teacher is careless about the effective teaching methods,
3. Lack of technology,
4. Content of national curriculum
5. The main goal of a national examination in Indonesia.

These are not all wholly new but particularly consequential for STEM implementation in developing countries, especially Indonesia. Both experienced and new teachers revealed that the time limit is one of the most frequent answers. It is not limited only in STEM class but also to STEM preparation. In the course, teachers only have three times 45 minutes in grade X and four times 45 minutes in grades XI and XII for one week. Teachers assume that the time will not be enough for STEM implementation.

"We should finish much work, excluding teaching arrangement. STEM Education requires a lot of understanding and preparation, so many teachers choose conventional learning methods."

The implementation of the new curriculum depends on the teachers' attention. Some teachers believe that implementing a new thing is useless. Besides, these points are supported by the lack of facilities, for instance, technology. The other challenges came to our findings, the content of the national curriculum and the goals of the national exam in Indonesia. In Indonesia, there is no specific curriculum that manages STEM education. Recently, based on the interview, some teachers just used STEM. Otherwise, STEM implementation is limited in teachers' creativity to integrate one subject to the other subject, and there is a small number of integrated STEM education, most of the teachers only use two or three subject integrations. Furthermore, teachers also point out the national exam, which exclusively focuses on knowledge, not skills. These challenges become the last and the most significant fact that the government should find out before starting STEM implementation in the whole country.

DISCUSSION AND CONCLUSION

This paper aims to identify teachers' perceptions of STEM education and its implementation as well as the challenges in Indonesia that have not yet been studied comprehensively. Initially, all teachers revealed that STEM education has not existed in the university level in Indonesia for the last 30 years based on their teaching experience. Even though eight teachers admitted that they tend to conduct STEM instruction without knowing the term of STEM education, the implementation really depends on the

teacher's interest and motivations due to unprovided guidance, reference, or instruction from community as well as the government. Moreover, this finding also shows that new teachers put more attention and interest in STEM education compared to experienced teachers based on the frequency of STEM implementation.

Indeed, STEM has been around for decades, and no one realized its importance until teachers in 1957 broadly agreed on the value of STEM education for ensuring America's edge in the global economy (White, 2014) It indicates that STEM education has been existing around the world for a long ago, but it was just promoted lately in Indonesia with limited information sources such as friends, and/or the association. The previous study confirmed that the concept of STEM in Indonesia has become popular in recent years, especially in higher education levels. It is consistently developing in the education sector, and researchers, teachers, as well as events, were turned to it (Suprapto, 2016a). This study also shows that the three mentioned teachers only conducted two or three subjects and rarely conducted integrated STEM due to limited knowledge and understanding. The previous research presented that teachers' intention and understanding is depended on their participation in STEM-related coursework (Karisan, Macalalag, & Johnson, 2019). Thus, more STEM professional development programs are needed to improve both pre-service and in-service levels.

Meanwhile, based on the current experiences, most teachers in both groups have shown positive attitudes toward STEM education compared to the conventional method. Teachers believe that STEM education is fascinating, full of hands-on learning, hands-on activities, and the most updated instruction that can improve students' knowledge and skills. STEM education was confirmed more appropriate to the current student's characteristics, especially in high school students. The emergence of STEM in the public K-12 education system provides opportunities for all level learners to master skills and content necessary for 21st-century learning and through using a variety of activity-based learning models, students are provided opportunities to accelerate to a rigorous depth of knowledge (Meyrick, 2011). It involves problem-based and project-based learning that allows students to explore real-world problems while simultaneously developing cross-curriculum skills such as reasoning skills, thinking skills, creativity, collaboration, problem-solving, and research skills that could be useful for selecting careers in science. Students now expect real-world connections to what they are learning, or else they may completely disengage (El-Deghaidy & Mansour, 2015; Havice et al., 2018) that they potentially find in STEM education.

Further, both teachers' groups are agreeing that engineering is the most challenging subject in STEM education, followed by mathematics, technology, and science. Science can be concluded as the easiest subject

because this study was interviewing physics teachers who face science almost every day in their life. In addition, engineering voted as the most difficult subject in STEM. Teachers are unfamiliar with the work of engineers and have little experience in teaching engineering design (Hammack & Ivey, 2016; Smith et al., 2015). All educators need to realize that engineering is the situated context and the platform for STEM learning. Based on the previous study, engineering becomes the most challenging part because of critical challenges that should be considered in STEM education. These include 1) lack of widely accepted vision, 2) lack of formal engineering education programs, 3) lack of informal support to engineering education, 4) rough treatment of engineering key ideas, 5) gender gap, and 6) technical difficulties. Current engineering education curricula are designed without the strategic vision of what should be covered in K-12 engineering. Indeed, the "qualifications" for engineering educators at the K-12 level have not even been described, and most teachers do not have engineering degrees. It is generally true that engineering school graduates are trained to work as professionals in the industry and are not equipped nor certified to teach in K-12 schools. Usually, there is an intergenerational gap in education specifically in engineering education (Ayyash & Black, 2014). These items should be covered to fulfill the engineering domain in implemented STEM education around the world.

The second research question tried to figure out the possible challenges in STEM implementation. Teachers specify some challenges including time limitation, lack of teacher awareness, technology, limited content of the national curriculum for Integrated STEM, and unmatched curriculum with STEM education that are also mentioned in the previous literature review (Hasanah & Tsutaoka, 2019; Kanadh, 2019; Siew et al., 2015). It was found that STEM implementation will face time limitations, lack teacher awareness and technology. These difficulties were identified as the common challenges in STEM education (Shernoff et al., 2017). In this study, unmatched curriculum is narrowed down to the connection between national examination goals and STEM goals which become a boomerang for teachers in STEM implementation.

Based on the previous study, it was suggested to overcome some of these problems, teachers should be given STEM-based project preparation training, group activities, and accessible and recycled materials to replace modern technology should be preferred and STEM projects should be done outside of school hours (Hattie & Yates, 2013; Higgins, Xiao, & Katsipataki, 2012; Kanadh, 2019; Siew et al., 2015).

The last challenge is the gap between the Indonesian curriculum and STEM education. There are two points that teachers mentioned; the first is the content for integrated STEM, and the second is the national examination

target. The learning process in STEM Education emphasizes not only knowledge but also skills, especially 21-century expertise for students' benefit in the future workplace (Burrows & Slater, 2015). In the case of national examination target in Indonesia, it is believed that knowledge is the only intention that creates the probabilities for teachers to miss skills development in the class.

There are two ways to organize STEM: correlated curriculum and broad fields curriculum. McNeil (1990) in Herschbach (2011) defined the correlated curriculum pattern tends to be the most popular option because it retains the identity of each subject, and each may be offered as a separate course. With the broad fields' curriculum, a cluster of related but different subjects is organized into a single area of study (Herschbach, 2011). In the Indonesian case, the correlated curriculum is the possible way to implement STEM education, which is required the coordination and well planning among the different stand-alone subjects. Thus, to solve these challenges, teachers will acquire more preparation for themselves including deeply observed the contents and make connections for each content among subjects. More preparations are also need from other participants in the education sector, including government and administrators, they need to support teachers through providing facilities to create well-implemented STEM education in Indonesia.

This study provides an essential step towards STEM implementation in Indonesia, even though further research is needed. In the future, the researcher suggested conducting document observation to confirm teachers' perception in the first research question for additional data source and supporting the interview result. Besides, creating effective STEM professional development programs are needed for Indonesian teachers in both pre-service and in-service training to build an understanding of STEM education. Further, identifying students' respond after STEM instruction also should be done to complete this study.

REFERENCES

Akran, S. K., & Asiroglu, S. (2018). Perceptions of Teachers towards the STEM Education and the Constructivist Education Approach: Is the Constructivist Education Approach Preparatory to the STEM Education? *Universal Journal of Educational Research, 6*(10), 2175-2186. doi:10.13189/ujer.2018.061016

Awad, N. A., Salman, E., & Barak, M. (2019). Integrating Teachers to Teach an Interdisciplinary STEM-Focused Program about Sound, Waves and Communication Systems. *European Journal of STEM Education, 4*(1), 1-12. doi:http://doi.org/10.20897/ejsteme/5756

Ayyash, M., & Black, K. (2014). Preparing Teachers in Engineering for STEM Education. In *STEM Education*. New York: Nova Science Publishers.

Burghardt, M. D., & Hacker, M. (2004). Informed Design: A Contemporary Approach to Design Pedagogy as the Core Process in Technology. *The Technology Teacher, 64*(1), 6-8.

Burrows, A., & Slater, T. (2015). A Proposed Integrated STEM Framework for Contemporary Teacher Preparation. *Teacher Education and Practice, 28*(2/3), 318-330.

Calisici, H., & Sumen, O. O. (2018). Metaphorical Perceptions of Prospective Teachers for STEM Education. *Universal Journal of Educational Research, 6*(5), 871-880. doi:10.13189/ujer.2018.060509

Cronbach, L. J., & Snow, R. E. (1981). *Aptitudes and Instructional Methods*. New York: Ardent Media.

Depdiknas. (2016). *Peraturan Menteri Nasional Nomor 22 Tahun 2016*. Jakarta: Depdiknas

Driel, J. H. V., Beijard, D., & Verloop, N. (2001). Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge. *Journal of Research in Science Teaching, 38*(2), 137-158.

Driel, J. H. V., Bulte, A. M. W., & Verloop, N. (2005). The Conceptions of Chemistry Teachers about Teaching and Learning in the Context of a Curriculum Innovation. *International Journal of Science Education, 27*(3), 303-322. doi:10.1080/09500690412331314487

El-Deghaidy, H., & Mansour, N. (2015). Science Teachers' Perceptions of STEM Education: Possibilities and Challenges. *International Journal of Learning and Teaching, 1*(1), 51-54. doi:10.18178/ijlt.1.1.51-54

Elliott, J. (1994). The Teacher's Role in Curriculum Development: An Unresolved Issue in English Attempts at Curriculum Reform. *Curriculum Studies, 2*(2), 43-69. doi:10.10.80/095975940020103

Erdogan, I., & Ciftci, A. (2017). Investigating the Views of Pre-service Science Teachers on STEM Education Practices. *International Journal of Environmental & Science Education, 12*(5), 1055-1065.

Fan, S. C., & Yu, K. C. (2016). Core Value and Implementation of the Science, Technology, Engineering, and Mathematics Curriculum in Technology Education. *Journal of Research in Education Sciences, 61*(1), 183-2016. doi:https://doi.org/10.6209/JORIES.2016.61(2).06

Hammack, R., & Ivey, T. (2016). Elementary Teachers' Perceptions of Engineering and Engineering Design. *Journal of Research in STEM Education, 2*(2), 126-146.

Hasanah, U., & Tsutaoka, T. (2019). An Outline of Worldwide Barriers in Science, Technology, Engineering, and Mathematics (STEM) Education. *Indonesian Journal of Science Education, 8*(2), 193-200. doi:10.15294/jpii.v8i2.18350

Hattie, J., & Yates, G. (2013). *Visible Learning and the Science of How We Learn*. New York: Routledge.

Havice, W., Havice, P., Waugaman, C., & Walker, K. (2018). Evaluating the Effectiveness of Integrative STEM Education: Teacher and Administrator Professional Development. *Journal of Technology Education, 29*(2), 73-89.

Herschbach, D. R. (2011). The STEM Initiative: Constraints and Challenges. *Journal of STem Teacher Education, 48*(1), 96-122.

Higgins, S., Xiao, Z., & Katsipataki, M. (2012). *The Impact of Digital Technology on Learning: A Summary for the Education Endowment Foundation*. Retrieved from https://pdfs.semanticscholar.org/d26b/b59f2536107b57f242b8289b1eb6f51d8765.pdf?_ga=2.91616410.1278884721.1560260780-1494548299.1560260780

Kanadh, S. (2019). A Meta-Summary of Qualitative Findings about STEM Education. *International Journal of Instruction, 12*(1), 959-976. Retrieved from https://files.eric.ed.gov/fulltext/EJ1201183.pdf

Karisan, D., Macalalag, A., & Johnson, J. (2019). The Effect of Methods Course on Pre-service Teachers' Awarness and Intentions of Teaching Science, Technology, Engineering, and Mathematics (STEM) Subjects. *International Journal of Research in Education and Science, 5*(1), 22-35.

Kelley, T. R., & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education, 3*(11), 1-11. doi:10.1186/s40594-016-0046-z

Konokman, G. Y., Yelken, T. Y., Karasolak, K., & Cesur, E. (2017). Teachers' Perception: Competent or Not in Curricullum Development. *Malaysian Online Journal of Educational Sciences, 5*(4), 56-73. Retrieved from https://files.eric.ed.gov/fulltext/EJ1156771.pdf

Leedy, P. D., & Ormrod, J. E. (2015). *Practical Research* (Eleventh Edition ed.). England: Pearson Education.

Margot, K. C., & Kettler, T. (2019). Teachers' Perception of STEM Integration and Education: A Systematic Literature. *International Journal of STEM Education, 6*(2), 1-16. doi:https://doi.org/10.1186/s40594-018-0151-1

Meyrick, K. M. (2011). How STEM Education Improves Student Learning. *Meridian K-12 School Computer Technologies Journal, 14*(1), 1-5. Retrieved from https://pdfs.semanticscholar.org/7cab/b5223aa526d2f85ad4c1e675c089cb581895.pdf

Moore, T. J., Stohlmann, M. S., Wang, H.-H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and Integration of Engineering in K-12 STEM Education. In *Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices* (pp. 35-60): Purdue University Press.

Oliver, A. I. (1965). *Curriculum Development*. New-York: Dodd Mead and Company.

Oyana, T. J., Garcia, S. J., Haegele, J. A., Hawthorne, T. L., Morgan, J., & Young, N. J. (2015). Nurturing Diversity in STEM Fields through Geography: The Past, the Present, and the Future. *Journal of STEM Education, 16*(2), 20-29.

Pimthong, P., & Williams, J. (2018). Preservice Teachers' Understanding of STEM Education. *Kasetsart Journal of Social Science*, 1-7. doi:http://doi.org/10.1016/j.kjss.2018.07.017

Pitiporntapin, S., Chantara, P., Srikoom, W., Nuangchalerm, P., & Hines, L. M. (2018). Enhancing Thai In-service Teachers' Perceptions of STEM Education with Tablet-Based Professional Development. *Canadian Center of Science and Education, 14*(10), 13-20. doi:10.5539/ass.v14n10p13

Sallee, C. W., Edgar, D. W., & Johnson, D. M. (2013). Student Perceptions of Instructional Methods towards Alternative Energy Education. *Journal of Agricultural Education, 54*(2), 130-142. doi:10.5032/jae.2013.02130

Sanders, M. (2009). *STEM, STEM Education, STEM Mania*. Retrieved from https://www.teachmeteamwork.com/files/sanders.istem.ed.ttt.istem.ed.def.pdf

Sari, U., Alici, M., & Sen, O. F. (2017). The Effect of STEM Instruction on Attitude, Career Perception and Career Interest in a Problem-Based Learning Environment and Student Opinions. *Electronic Journal of Science Education, 22*(1), 1-21. Retrieved from http://ejse.southwestern.edu/

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing Teacher Education and Professional Development Needs for The Implementation of integrated approaches to STEM education. *International Journal of STEM Education, 13*(4), 1-16. doi:10.1186/s40594-017-0068-1

Shumow, L., & Schmidt, J. A. (2013). Academic Grades and Motivation in High School Science Classrooms Among Male and Female Students: Associations with Teachers' Characteristics, Beliefs and Practices. *Journal of Education Research, 7*(1), 53-71.

Siew, N. M., Amir, N., & Chong, C. L. (2015). The Perceptions of Pre-service and In-service Teachers Regarding a Project-Based STEM Approach to Teaching Science. *SpringerPlus, 4*(8), 1-20.

Smith, K. L., Rayfield, J., & McKim, B. R. (2015). Effective Practices in STEM Integration: Describing Teacher Perceptions and Instructional Method Use. *Journal of Agricultural Education, 56*(4), 182-201. doi:10.5032/jae.2015.04183

Srikoom, W., Hanuscin, D. L., & Faikhamta, C. (2017). Perceptions of In-service Teachers Toward Teaching STEM in Thailand. *Asia-Pacific Forum on Science Learning and Teaching, 18*(2), 1-23.

Suprapto, N. (2016a). Students' Attitudes towards STEM Education: Voices from Indonesian Junior High Schools. *Journal of Turkish Science Education, 13*(Spesial Issue). doi:10.12973/tused.10172a

Suprapto, N. (2016b). What Should Educational Reform in Indonesia Look Like?-Learning From the PISA Science Scores of East-Asian Countries and Singapore. *Asia-Pacific Forum on Science Learning and Teaching, 17*(2), 1-21.

White, D. W. (2014). What is STEM Education and Why Is It Important? *Florida Association of Teacher Educators Journal 1*(14), 1-9. Retrieved from http://www.fate1.org/journals/2014/white.pdf