STEM Education in Indonesia: Science Teachers' and Students' Perspectives

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Abstract: STEM education in Indonesia has become a commitment for all of stakeholders in the field of science education in the last several years. All education participants agree to increase the popularity of STEM education in various parties, especially teachers and students. The research has been conducted to see to what extent science teachers in the secondary school interpret and understand STEM education and how Students pertain toward STEM learning. The research was conducted with a descriptive method using a survey approach. A set of questionnaire which comprises open-ended and closed-ended questions about teachers' and students' perceptions and understanding regarding STEM education were developed and applied. Responses from science teachers as well as students were then analysed through interpretative methods in which the participants' own meanings and points of view were sought. The result indicated that STEM education is quite well understood by science teachers. Most of teachers show the same level of understanding toward STEM Education. Unfortunately, not many teachers have applied the STEM approach for science learning in the classroom. This is led to the weak understanding of STEM learning in students' side. Most of students did not familiar with "STEM learning" term. Based on the research, it is recommended that the science teachers' training and development should be reorientated and implemented through lesson analysis with various best practices on STEM learning systematically and continually.

Keywords: STEM education; science teachers' perception; students' perception on STEM

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INTRODUCTION

STEM education basically uses an interdisciplinary approach in which academic concepts are integrated together based on a real life context by applying science, technology, engineering and mathematics. In practice, the integrated learning can develop connections between schools, communities, jobs, and global companies that make it possible in the new economic world. (Tsupros, et al., 2009). Sanders (2009) stated that STEM learning involves all of approaches those explored two or more subjects of STEM fields. STEM learning, if it is packaged with the right way can produce a meaningful learning through the integration and application of mathematics, technology, and/or science (Moore & Smith, 2014).

Moreover, STEM learning can be used to focus an understanding integrated nature of the discipline of science, technology, engineering, and mathematics as well as their importance in the long-term academic success of children, economic well-being (Quigley & Herro, 2016), and development of communities (Han et al., 2015). STEM education is now being implemented by several countries and becomes one of the main trends in global education. Many countries started to prepare their citizen to understand STEM and have multidimensional capabilities to use in modern life (Pimthong & Williams, 2018).

STEM education has been recognized in the U.S as an important educational reform and described as an instructional approach to prepare children for the current century's global economy (Yakman & Lee, 2012). The idea of developing STEM learning models in U.S arises because results from the 2011 Trends in International Mathematics and Science Study (TIMSS) in mathematics revealed that fourth graders in the United States ranked 11th and eighth graders in the United States ranked ninth when compared to other nations (Mullis et al., 2012). In science, fourth graders in the United States ranked seventh when compared to other nations, and eighth graders in the United States ranked 10th, the relevance of STEM education in the United States is highlighted by the 5-Year Federal STEM Education Strategic Plan adopted in 2013 for preparation of 100,000 new STEM teachers by 2020 and provide effective support to the current contingent of teachers (Martin et al., 2012).

In Taiwan, learning curricula started from the STEM curriculum and made students the center of learning activities (Lou *et al.*, 2010). Malaysia Education Blueprint (2013) provides STEM-education reform which is started by improving the quality of STEM-education through the improvement of curriculum, teacher training, and use of integrated learning methods. Australia has adopted strategy for STEM-education for 2016-2026 (National STEM School Education Strategy). The curriculum defines 5 key objectives consisted of increase the abilities, involvement and interest of students in STEM, increase the capacity of teachers and quality of teaching of STEM subjects, support opportunities for STEM-education in schools, promote effective partnerships with universities, business and industry, establish a sound database (Education Council, 2015). In 2013, a three-year project "MASCIL" that entails the development and organization of training courses for teachers with the support of the industrial sector was launched, in which 11 countries took part: Austria, Bulgaria, Cyprus, Czech Republic, Greece, Lithuania, Netherlands, Norway, Spain, Turkey and Great Britain (European Commission, 2015). INSTEM project (2012-2015) is aimed in promoting research training with the purpose of gathering innovative teaching methods and improving the interest of students in science, as well as providing comprehensive information on careers in the field of STEM in Austria, Germany, Greece, Ireland, Italy, Norway, Romania, Turkey and Great Britain (Kezar, 2018).

STEM education in Indonesia has become the commitment of all stakeholders in the field of science education in the last several years. All education participants agree to increase the popularity of STEM education in various parties, especially teachers and students. In collaboration with USAID (United States Agency for International Development), Indonesia has been develop STEM-based learning model. Some research on STEM education have already established. Syukri, et al. (2013) have examined the integration of STEM education in science learning and teaching in elementary and secondary schools that was carried out by the Faculty of Education Universiti Kebangsaan Malaysia (UKM) in collaboration with the Teaching and Education Faculty of Syiah Kuala University (Unsyiah) Aceh. Wiguna (2018) have conducted STEM-based science learning research by asking students to design balloon-powered cars as learning media in understanding the concept of regular straight motion and the research found that students become motivated and directly involved in the manufacturing process. Some researches initiated an innovation strategy to build students' disaster literacy through STEM-D (Science, Technology, Engineering, Mathematics and Disaster) Education (Sampurno, et al., 2015), a partnership program between local schools in Riau province and Honeywell about science and technology (Honeywell, 2014) and an ongoing project between Columbia University and the Institute Pertanian Bogor to improve the teaching of STEM in Indonesian high schools (Columbia Global, 2014). In higher education, research development that focuses on STEM education established by Syiah Kuala University who build a STEM study center for research development that focuses on STEM education.

Research findings indicate that science and math teachers lack pedagogical knowledge and efficacy when it comes to STEM education (Stohlmann, et al., 2012). There are claims that the number of mathematics and science teachers with hands-on experience working in STEM education is limited and teachers may also lack educational background in STEM according to a finding by NSF that 30% of science middle school teachers lack in-field training (NRC, 2012). Nonetheless, introducing STEM education into schools should be taken into consideration because successful integration of science and mathematics depends largely on teachers' understanding (Pang & Good, 2000). In this way, teachers' perceptions of the STEM education are very important given that they can influence STEM education development in Indonesia. In order to promote STEM education, this study seeks to identify teachers' perceptions regarding STEM education in Indonesia including understanding of STEM definition. On the other hand, students' readiness to learn science with STEM learning is something interest to be learned, so we will get the more clear information about the perspectives from teachers and students sides about STEM learning.

METHODS

The research was conducted on using descriptive method with survey design. A survey was used in this present study to gather data at a particular point in time with the intention of describing the nature of existing conditions (Cohen, et al., 2017).

Participants

The participants in this study included 100 science teachers from various region in Indonesia. They came from both private and public schools all over the country, aged between 20 and 60 years old (38.5 %

aged between 20 and 29 years old, 17.1% aged between 30-35 years old, 17.9% aged between 36-40 years old and 26.5% aged above 40 years old).

Instrument

A set of questionnaire which comprises open-ended and closed-ended questions about teachers' perceptions and understanding regarding STEM education and 21st century skills preparation were developed and applied with a focus on the following statements:

1. I know about STEM education or STEM approach (S1)
2. I know that STEM learning can accommodate the competencies and skills that needed in the 21st century workforce (S2)
3. I believe that the implementation current learning approach such as STEM education learning approach could help students improved their ability to prepare their competencies in the 21st century (S3)
4. I believe that STEM learning can accelerate student to gain the HOT Skills (S4).
5. I implement learning approach such as STEM at least once in a semester (S5)
6. I implement STEM learning on using model (you can choose more than one item: (o) Project based learning; (o) Problem based Learning (o); others (name it) (S6)
7. I think government has done the best effort in preparing high quality teacher (S7)
8. The facilities and infrastructures at school where I teach are sufficient to implement STEM learning (S8)
9. STEM learning is one of issues that ever been discussed in the meeting of sciences' teacher council (S9)
10. The MGMP give a significance impact in enhancing teachers' understand toward STEM learning (S10)
11. The obstacles on STEM learning implementation (Describe in some sentences)

Responses from science teachers were analysed through interpretive methods ([Erickson, 1986](#)), in which the participants' own meanings and points of view were sought. For Student sides, the questioners are about how they understand learning science with STEM approach, they enjoyable, they opinion toward STEM learning. As many as 100 students involved in the survey, chosen on using random stratified sampling (50 students from secondary school and 50 students from senior high school)

1. I have ever studied science with STEM learning based on teacher explanation (ST-1)
2. Learning by doing science projects is lot of fun (ST-2)
3. I love learning science with having projects (ST-3)
4. Learning science with STEM make me understand science more than usual (ST-4)
5. I do the STEM project at school (ST-5)
6. I do STEM Project at home (ST-6)
7. I do STEM Project at both of school and home (ST-7)
8. I do STEM project in a group (ST-8)
9. Learning with project made me thinking about ideas (ST-9)
10. Learning with STEM make me more tired than usual (ST-10)

Data Collection

All of data come from questioner were than triangulated with data come from learning observation (two learning situations with STEM approach). There are eleven statements to reveal teacher's perceptions and understanding about STEM education and skill preparation in the 21st century. In this study, there are also ten survey items to reveal students' opinions.

Data Analysis

Teachers' perceptions about STEM education were analyzed by determining teachers' understanding level. Data of students' perceptions were analyzed to determine students' perception levels to STEM learning. This study also analyzed students' responses to STEM learning based on their scores at school.

RESULTS AND DISCUSSION

The survey result that was administered to science teacher about teachers' perception towards STEM education and 21st century skills preparation is provided on [Figure 1](#).

Figure 1. Teachers' Perception towards STEM Education

Figure 1 showed that most of science teachers have a good understanding of STEM learning. They are all realized that STEM learning can accommodate the competencies and skills that needed in the 21st century workforce. Most of them are also believe that implementation current learning approach such as STEM education learning approach could help students improved their ability to prepare their competencies in the 21st century as well as it can accelerate student to gain the HOT Skills. By the interview, they stated that all knowledge about STEM was also come from the training activities they participate in. Several teachers added that despite from training, they gained an understanding of STEM from google searching, both from journal articles and blogs. In addition, as many as 5 science teachers stated that they got more understanding about STEM from the communities' service activities of academic staffs of the educational colleges nearby.

As many as 79 teachers stated that government has done the best effort in preparing high quality teacher (S-7). Based on the interview it is revealed that when they entered to the workshop on STEM learning arranged by government, the first meeting discussed was about policy of government to introduce and train STEM learning to all of science teachers in secondary and vocational school. By the interview it was also revealed that at least all respondent had attended one STEM learning training. Based on in-dept interview it was also revealed that some of teachers obtained the information from the Ministry of Education and Culture's website. In the interview, they were also asked how the role of P4TK Science (Center for Development and Empowerment of Science Educators and Education Personel). A small portion of them stated that they received training on STEM from that agent. They stated that P4TK provided training and professional development to science teacher representatives in each region. Usually, the representative disseminates the result of training to other science teachers within the scope of the MGMP-Science (Science teacher council). STEM learning is one of issues that ever been discussed in the meeting of sciences' teacher council. The MGMP give a significance impact in enhancing teachers'understand toward STEM learning (S-10)

From 10 statements, 2 statement related to number S5 (I implement learning approach such as STEM at least once in a semester) dan S8 (The facilities and infrastructures at school where I teach are sufficient to implement STEM learning). By the interview, most of them said that they had never tried to implement STEM learning. They knew about project based learning, problem based learning and discovery learning, and they had implemented those in learning science several times. However, they have never tried using it in STEM learning. They reasoned that they did not have the confidence to implement STEM learning. They are also arguing that they still not quite sure about the steps of STEM learning. They also argued that STEM learning took a lot of time, meanwhile the materials had to be completed on time.

Almost of 50% teachers applied STEM learning embedded with model Project based learning; Problem based Learning; others (EDP). This is relevant to several studies that using model of PjBL, PBL, Inquiry, IBL, embedded with STEM gave positive impact to the quality of learning science. Through those models includes introduction to engineering design cycle Sejati (2017) achieved to develop workbook on lever system to enhance students STEM competencies. Jauhariyyah (2016) has been developed STEM-PjBL in science learning can improve scientific literacy, motivation and creativity. In line with Jauhariyyah (2016) develop learning material using 6L learning by Design TM and Nurlaely (2017) was using casuistic problems to improve scientific literacy. Another research has been developed by Prima (2018) by using Arduino-Phet to enlarge meaningfull of STEM education. Arduino-Phet as a technology literacy embedded with content of science, mathematic and engineering process to design the project.

Actually, it is a shame that there are still many teachers who have not tried to implement STEM in learning. Even though, according to the questionnaire results from students it was found that most of students who had participated in STEM learning were very happy along the learning (ST-2= 85%). A pleasant finding was the fact that most of students felt that STEM learning with the project make them learn with fun (ST-3), and leads them to think about ideas (ST-9). It is also shown that learning science with STEM make me understand science more than usual (ST-4). Only 4% of 70 students who studied with STEM stated that learning STEM made them more tired than usual learning (ST-10). Another interesting from this study is that the teacher implemented STEM learning with various strategies. Some teachers ask students to do their STEM projects at home, some at school, but most of teachers ask students to do it at school as well as at home.

Figure 2. Students' perception toward STEM learning

Inline with data derived from teachers' perception, some students admitted that they had never heard and learned with the STEM approach. Based on the data obtained, the number of students who have never known STEM learning is 30% (ST-1). The interesting data come from the questioners No ST-1, ST-2, ST-9 and ST-10 as it is shown by Figure 3.

Figure 3. Students' responses toward STEM learning based on school's grade

Compare to student from Senior High School (SHS), Junior High School (JHS) students have less experience in STEM learning. Although a small percentage of them had studied with STEM, they did not show a positive impression toward STEM learning, even 4 out of 20 JHS students said they were tired of STEM learning. Most of student from SHS claimed that learning STEM made them understand science more than usual. This statement is strengthened by their claimed that learning by doing projects is lot of fun. The fact indicates that STEM is more popular to SHS students than JHS. JHS students do not seem fully ready for

STEM learning. This is consistent with data from teachers questionnaires, only 14 JHS teachers have implemented STEM learning, out of a total number of 55 teachers who answered "yes" to this point.

The result of research above indicate the need to look at several things so the STEM learning is more socialized and can be implemented properly. Many science teachers stated that implementing STEM learning is very draining and mindful because they have to really master science related to engineering and technology that should be chosen as a context, meanwhile they have not mastered in depth. This is in line with Breiner *et al.*, 2012, that many teachers do not have an interdisciplinary understanding of STEM. This is not entirely surprising because there is no common understanding or agreement on the nature of STEM education as an integrated or multidisciplinary endeavor, only few guidelines and models exist for teachers to follow regarding how to teach using STEM integration approaches (Roehrig *et al.*, 2012). Based on this data, Indonesia as one of the largest countries in the world, needs to prepare teachers who have sufficient knowledge regarding STEM education. The needs to STEM learning is because of this approach is very potential to enhance the Higher Order Thinking Skills (HOTS). HOTS is the highest level in the hierarchy of cognitive processes and students who are trained to think demonstrate a positive impact on the development of their education (Yee *et al.*, 2012). Studies indicated engagement in technology and engineering learning experiences fosters creativity and higher order thinking skills, facilitates integration across the STEM disciplines, and contextualises learning resulting in improved motivation and achievement (Cunningham & Lachapelle, 2014; English, 2015; Moundridou & Kaniglonou, 2008).

This result indirectly implies that the current Indonesia educational system should not neglect STEM education, which is capable of fostering 21st century skills and creating a society that is able to compete globally. According to Kay (2009) and Rotherham and Willingham (2009), the combination of 21st century skills and content knowledge are equally important and this combination should be applied to students even during their lower secondary level. Moreover, Senechal (2010) found out those countries with higher performance in PISA such as Australia, Canada, Finland, Hong Kong, Japan, Netherlands, New Zealand, South Korea and Switzerland each provides their students with a solid curriculum in terms of its content and the practice of 21st century skills and these countries are well-advanced in the field of STEM. Halim (2013) concluded that STEM education is the perfect medium for the implementation of 21st century skills. STEM education can aid in the improvement of problem-solving skills, critical and analytical thinking in students, which lead them to a better real-world connection in the curriculum (Brophy *et al.*, 2008; Brown *et al.*, 2011) and most importantly STEM education prepares students to face 21st century global economy challenges (Becker & Park, 2011; Khaeroningtyas, *et al.*, 2016; Nurlaely, *et al.*, 2017).

Some teachers argued that teacher training and professional development program was usually disconnected from the everyday practice of teaching, too generic and unrelated to the curriculum or to the specific instructional problems teachers face, and it was infrequent and implemented as a one-shot event or led by an outside consultant who drops in to conduct a workshop and never returns to the school or district. These problems aligned with some previous research that shows that the professional development that takes place does not have an effect on student learning, an often-cited analysis of 1,300 studies found that only nine of the studies showed clear, empirical evidence of the effect of professional development on student achievement (Harris & Sass, 2011). Despite the challenges, there is rigorous research on professional learning that shows that it can indeed change the way teachers teach and how much students learn. There are other studies too: An investigation into the relationship between several professional-development activities and specific teaching practices related to early-reading instruction found a relationship between what teachers learned and how they later taught (Walpole, 2010). This result indicated that our government still learning how to ensure that professional development delivers the results we desire. Another obstacle was designing and implementing professional-learning activities at the local level is being able to know what programs have evidence of demonstrated effectiveness. What further complicates the work of selecting professional-learning activities is that there are no features or programs that always work in every setting. Rather, professional development is as complex as teaching. To put it another way, professional development is about teaching teachers.

Infrastructure is still a problem in STEM learning implementation. This result coincidentally linked with not many science teachers who have implemented STEM learning, even though they have attended a long training. Previous research stated that there is a strong link between the school building/capacities and the learning process (Blair, 2003). Keller (2003) have pointed out that students surrounded by a safe, modern and environmentally controlled environment experience a positive effect on their learning. However, studies are needed to draw a clear comparison between the quality of our school buildings and academic outcomes.

Based on the description above, it cannot be denied that STEM learning is a learning approach that needs to be developed widely and comprehensively in Indonesia to face globalization. Various weaknesses

that arise both from the teachers' and students' perceptions, it is necessary to think about the best way to overcome. One can be recommended is to change the training and development program that have been carried out by the government. The training that has been carried out so far tends to be boring and does not provide STEM learning modelling. The uneven selection of trainee also needs to be concern. The involvement of MGMP and relevant Professional associations can be an alternative so that more science teachers can be reached by this STEM training.

Figure 4. The Network should be established among four parties for the successful of science teachers' training and development

The collaboration among parties is strongly recommended to overcome the problem. The weakness of science teachers in finding examples of relevant technology contexts with science concepts can be overcome by collaborating with relevant industry practitioners or polytechnics or engineering teachers as a third party. The government together with professional associations can work together to strengthen the science concept, while the collaboration with third party is needed to provide thoughts on the engineering context related to science. The sequence of the STEM learning Training program is shown in Figure 5.

Figure 5. Professional Training and Development for Science teachers on STEM Learning

The first step in developing learning materials, includes: Science concepts, technological and engineering contexts related to concepts, some examples of lesson plan on STEM learning. The next step is conducting the professional training on STEM learning. The training can only involve P4TK Science or it can also collaborate with professional Association and/or third parties. MGMP can be involved in the next step of training through the implementation STEM Lesson plan in real classroom situation. Along this step, teachers can arrange a kind of lesson analysis. They observe a lesson of the teacher model, and then make a selection to find for strength and improvement. In this step, an expert (come from university) can also be involved. To ensure the effectiveness of the training program, the monitoring and evaluation should be carried out. The

fact that STEM is less popular at the JHS student level because most of teachers have not implemented STEM learning needs to be anticipated by providing a larger portion of STEM training opportunities.

CONCLUSION

STEM education is currently an alternative approach in science learning that is highly recommended. The learning process that involves both the inquiry and engineering design processes is believed to be able to build the 21st century skills and readiness to face globalization. In Indoensia context, STEM learning has become the government's attention. In general, science teachers have understood STEM learning. They realized that STEM learning is a powerful approach to enhance HOTS. However, the lack of teachers implementing STEM learning indicates the need for more comprehensive efforts from various parties. Redesigning the training and development program is needed by involving the collaboration among government (P4TK Science), professional associations, MGMP, and other parties such as technical teachers and industry/polytechnics practitioners.

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