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THE MOVEMENT OF STEM EDUCATION IN INDONESIA: SCIENCE TEACHERS' PERSPECTIVES

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ABSTRACT

Indonesia, as a large nation having a wealth of natural resources and abundant human resources, should be a nation which plays a great role in the development of science and technology. STEM education can be used in other scientific fields by utilizing the principles of science, technology, engineering, and mathematics as a basis for learning and developing potential students. This study is aimed at examining the teachers' perceptions on STEM education in Indonesia including the understanding of STEM definition more deeply. The subjects in this study consist of 117 science teachers from Indonesia. A set of questionnaire consisting of open- and closed-ended questions about teachers' perceptions and understanding regarding STEM education and the 21st century skills preparation were developed and implemented. Responses from the science teachers were analysed through interpretive methods in which the participants' meanings and points of view were sought. The results indicate that STEM education is quite well understood by the teachers. It is important that we focus on the teachers as they play a crucial role in the success of new reforms. The implication is that there is a considerable need for awareness raising at both government and teacher levels to embrace STEM education.

Keywords: science teachers, STEM approach, STEM education, 21st century skills

INTRODUCTION

The term STEM is used to emphasize an understanding of the integrated disciplines of science, technology, engineering, and mathematics as well as their importance in the long-term academic success of children, economic well-being (Herro& Quigley, 2016), and community development (Hanet al., 2015). STEM education is promoted in many countries to prepare their citizen to comprehend STEM and have multidimensional abilities to use in modern life (Radloff&Guzey, 2016). STEM education has been recognized in the U.S as an essential educational reform and described as an instructional approach to prepare children for the century's global economy (Yakman & Lee, 2012). The idea of developing STEM learning models in the U.S arose because results from the 2011 Trends in TIMSS (International Mathematics and Science Study) in mathematics unveiled that fourth graders in the United States ranked 11th and eighth graders in the U.S. ranked 9th when compared to other nations (Mullis et al., 2012). In science, the fourth graders in the United States ranked 7th 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 pre-

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paration of 100,000 new STEM teachers by 2020 and provides efficacious support to the current contingent of teachers (Martin et al., 2012).

STEM education is now being implemented by several countries and becomes one of the primary trends in global education. In Taiwan, the learning curricula began to be integrated with the STEM curriculum and made students the focus of learning activities (Louet al., 2011). Malaysia Education Blueprint (2013) provides for STEM education reform which is started by enhancing the STEM education quality through the enhancement of curriculum, teacher training, and the use of integrated learning methods. In 2015, Australia adopted a national strategy for STEM education development in schools in 2016-2026. The National STEM School Education Strategy defines 5 key goals consisting of increasing the abilities, involvement and interest of students in STEM, increasing the capacity of teachers and quality of teaching of STEM subjects, supporting chances for STEM-education in schools, promoting effective collaboration with universities, business and industry, and establishing a sound database (Education Council, 2015). In 2013, a three-year project "MASCIL" that demands the organization and development of training courses for teachers with the support of the industrial sector was launched, with 11 countries taking part: Austria, Bulgaria, Cyprus, Czech Republic, Greece, Great Britain, Lithuania, Netherlands, Norway, Turkey, and Spain (Hazelkorn et al., 2015). INSTEM project (2012-2015) intends to promote research training with the purpose of collecting innovative teaching methods and improve the interest of students in science, as well as provide comprehensive information on careers in the field of STEM in Austria, Germany, Greece, Great Britain, Italy, Ireland, Romania, Norway, and Turkey (Kezar, 2018).

The development of STEM in education in developed countries indicates that STEM needs to raise in education in Indonesia for STEM is a paradigm that creates inter-disciplinary learning and provides achievement results of science, mathematics, engineering, and technology while doing so. Indonesia, through collaboration with USAID (United States Agency for International Development), began to develop STEM-based learning model. Syukri et al. (2013) have examined the integration of STEM education in science learning and teaching in elementary and secondary schools 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 et al. (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. The research found that students become motivated and directly involved in the manufacturing process. Some researches show that an innovation strategy to construct students' disaster literacy through STEM-D (Science, Technology, Engineering, Mathematics and Disaster) Education (Sampurno et al., 2015) has been initiated, a partnership program between local schools in Riau province and Honeywell about science and technology (Honeywell, 2014) has been established, and an ongoing project between Columbia University and Bogor Agricultural Institute Institut Pertanian Bogor to escalate the teaching of STEM in Indonesian high schools has been conducted (Columbia Global, 2014). In higher education, Syiah Kuala University develops researches focusing on STEM education by establishing a STEM study center.

The investigation of the movement of STEM education in Indonesia is rarely found. Basically, researchers present their studies, meanwhile the improvement of STEM education which is suitable for characteristics in Indonesia should be published. Specifically, more journal analyses can enhance other researchers to broaden their knowledge about STEM education in Indonesia. Thus, the values for the improvement of STEM education will be investigated in this paper.

Indonesia as a large country with a wealth of natural resources and abundant human resources should be a nation that plays a great role in the development of science and technology. STEM education can be used in other scientific fields by utilizing the principles of STEM as a basis for learning and developing potential students. Education system in Indonesia is still overshadowed by a variety of classic problems, such as the chaotic determination of the curriculum for basic education, yet research findings revealed that science and math teachers lack pedagogical knowledge and efficacy when it comes to STEM education (Stohlmann, et al. 2012). There are asserts 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). In this way, teachers' insights of the STEM education are very crucial given that they could influence STEM education development in

Indonesia. In order to promote STEM education, this study seeks to identify the teachers' perceptions regarding STEM education in Indonesia including the understanding of STEM definition.

Many skilled workers in Indonesia come from other countries such as India, China, and numerous other nations. They enter Indonesia to compete for jobs. Many sources considered those countries a representation of developed countries. They have great inventions in STEM education. Actually, policy makers can recognize the changes. Unfortunately, Indonesia is at risk. It can be seen from the social and economic condition in some parts of Indonesia. The data show that PISA level is still low.

Recognizing the recent focus on STEM education is interesting and it emerges from STEM education in learning from an analysis. The research is conducted on STEM education from some conception and current condition in Indonesia. To increase the interest in STEM education in Indonesia, the researchers addressed the problem by exploring the following questions: How is STEM education movement implemented in Indonesia? How deep is the teachers' understanding about STEM? How often do the teachers' do their activities in STEM education?

METHODS

The researchers adopted a quantitative instrument. A survey research was conducted to examine the teachers' perceptions of STEM education and the 21st century skills preparation. The survey was used in this study to collect data at a particular point in time with the intention of describing the nature of existing conditions (Cohenet al., 2007). The population in this study is science teachers in Indonesia, separated in each island. The sampling technique was purposive sampling as the researchers might imply thus chose representative samples to suit the needs. The participants in this study consisted of 117 science teachers from various island in Indonesia, such as Sumatera, Java, Bali, Borneo, and Celebes. They were 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). A set of questionnaire consisting of open-ended and closed-ended questions about the teachers' perception and understanding of STEM education and the 21st century skills preparation was developed and applied with a focus on the following questionnaire. The instruments were developed by considering judgements form the experts. The experts were STEM researchers from UPI STEM center and from the governent. The questions can be shown below:

1. Do you know about STEM education or STEM approach (Q1)?
2. Do you know what competencies and skills needed in the 21st century workforce (Q2)?
3. As a teacher, do you know and implement learning approach such as STEM education approach to facilitate students facing the 21st century? If the answer is yes, how do you implement it (Q3)?
4. Do you believe that the implementation of the current learning approach such as STEM education learning could help students improve their ability to prepare their competencies in the 21st century (Q4)?
5. Do you think that the government has done the best effort in preparing high quality teachers? (Q5)
6. School facilities and infrastructures become one of the important factors for instructional process. Are the facilities and infrastructures in the school where you teach sufficient (Q6)?
7. Are you involved in the Secondary School Subject Teacher's Working Group (*Musyawarah Guru Mata Pelajaran/MGMP*) (Q7)?
8. Do you find significant impact of *Musyawarah Guru Mata Pelajaran/MGMP* towards the way you conduct instructional processes (Q8)?
9. Are you still developing an ideal teaching method to be implemented in the classroom? How do you develop the ideal teaching method (Q9)?
10. Do you know about Higher Order Thinking Skills/HOTS (Q10)?

Responses from the science teachers were analysed through interpretive methods (Erickson, 1986), in which the participants' meanings and points of view were sought. The terminology of survey research design can be described as statistical, explanatory, and cross sectional. As many as 117 respondents took the survey. Statistical method was used to analyse various factors and levels of engagement. The findings were documented by using descriptive methods.

The data were in the form of questionnaire and examination documents. In this study, the documents were the result of research papers related to STEM education. A qualitative document analysis is a qualitative content analysis which examines the relationship between the do-

cuments and the research results. With a qualitative document analysis framework, the coding of the research paper could be done. Each research paper was given a descriptive point of view and became the thematic structure for STEM education in Indonesia.

RESULTS AND DISCUSSION

The result of the survey administered to science teachers about their perception towards STEM education and the 21st century skills preparation is provided in Figure 1 below.

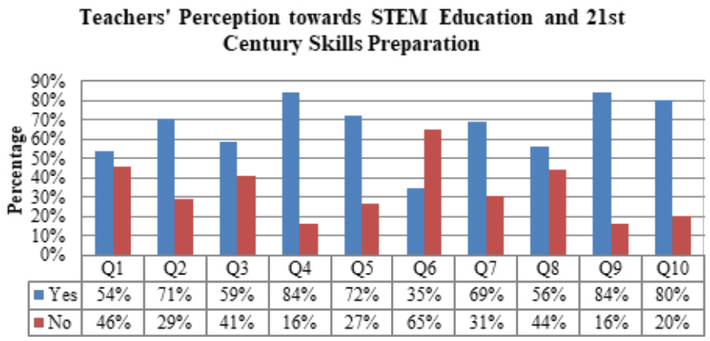

Figure 1. Teachers' Perception towards STEM Education and the 21st Century Skills Preparation

Figure 1 shows that most of the teachers are familiar with STEM education and the 21st century skills challenge. It can be seen from the percentage of the teachers who answered *Yes* that is bigger than that of the teachers who answered *No*s for each question. As for Question 6 (Q6), the percentage of the teachers who stated that school facilities and infrastructures were sufficient is only 35%.

The data revealed that among the participants who responded to question 1 (Q1) "Do you know about STEM education or STEM approach?" (N=117), 54% stated they know about STEM education and were able to adequately define it as education involving science, technology, engineering, and mathematics. The rest 46.8% did not have knowledge about STEM education. Many educators approach STEM education with precariousness because no single definition of STEM education exists, and many do not have an interdisciplinary understanding of STEM (Breineret al., 2012). This is not entirely surprising because there is no ordinary understanding or agreement on the nature of STEM education as an integrated or multidisciplinary endeavor, only few guidelines and models that 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 country in the world, needs to prepare teachers who have sufficient knowledge of STEM education.

Question 2 (Q2), question 3 (Q3), and question 4 (Q4) reveal the teachers' knowledge about the 21st century skills along with their effort in implementing STEM education as learning approach to facilitate students nurturing the 21st century skills. The data show that 71% of the teachers possessed knowledge about competencies needed in the 21st century workforce, 59% implemented STEM education as learning approach to foster the students' 21st century skills, and 84% believed that the implementation of the current learning approach such as STEM could help the students improve their ability to prepare their competencies in the 21st century. This result indirectly infers that the current educational system in Indonesia should not neglect STEM education, which is capable of fostering the 21st century skills and creating a society that is able to compete globally. Referring to Kay (2009) and Rotherham& Willingham (2009), the combination of the 21st century skills and content knowledge are impartially essential and this combination should be applied to students even in their lower secondary level. Furthermore, Senechal (2010) found out that countries with higher performance in PISA such as Australia, Canada, Finland, Hong Kong, Japan, Netherlands, New Zealand, SoutKorea, and Switzerland provide their students with a solid curriculum in terms of its content and practice of the 21st century skills. These countries are also well-advanced in the field of STEM. Halim (2013) concluded that STEM education is the perfect medium for the implementation of the 21st century skills. STEM education could aid in the improvement of problem-solving skills and critical and analytical thinking in students, which guide them to a better real-world connection in the curriculum (Brown et al., 2011). Most importantly, STEM education makes students ready to face the 21st century global economy challenges (Becker & Park, 2011).

The result of question 5 (Q5) shows that 72% of the teachers thought that the government has done the best effort in preparing high quality teachers. Most of the teachers stated that teacher training and professional development program including the STEM teacher training workshop held by the government was effective to improve the quality of science teachers in Indonesia. Meanwhile, 28% argued that the teacher training and professional development programs were usually unrelated from everyday practice of teaching, too generic, and unrelated to the curriculum or to the particular instructional problems teachers face, and they were infrequent and implemented as a one-shot event or led by an outside consultant who drops in to carry out a workshop and never returns to the school or district. These problems are in line with some previous researches demonstrating that the professional development has no effect on the students' learning. A frequently-cited analysis of 1,300 studies unveiled that only nine of the studies show lucid, empirical evidence of the effect of professional development on the students' achievements (Harris & Sass, 2011). Despite the challenges, there is a meticulous research on professional learning showing that it can, indeed, change the way teachers teach and how much students learn. There is also another study that investigated the relationship between several professional development activities and specific teaching practices related to early-reading instruction. The study found out a relationship between what teachers learned and how they later taught (Walpole et al., 2010). This result indicates that our government is still learning how to make sure that professional development delivers the results we wish. Another obstacle is whether designing and implementing professional-learning activities at the local level are able to reveal what programs give evidence of demonstrated effectiveness. What further complicates the work of selecting professional-learning activities is that there aren't any 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.

The result of question 6 (Q6) shows that 65% of the teachers in Indonesia stated that education infrastructure was still inadequate. This result coincidentally links with the the performance of Indonesian students in PISA results that are still low. Question 7 (Q7) and question 8 (Q8) explain the teachers' involvement in the Secondary School Subject Teacher's Working Group (*Musyawarah Guru Mata Pelajaran/MGMP*) and the impact of MGMP towards teaching the 21st century skills in the classroom. The result shows that 69% were involved in MGMP and 56% stated that MGMP helped them to teach the 21st century skills in the classroom. MGMP is expected to be a forum for information exchange and information delivery related to education that specialises in certain subject. The head of the LP4TK program explains the steps as follows:

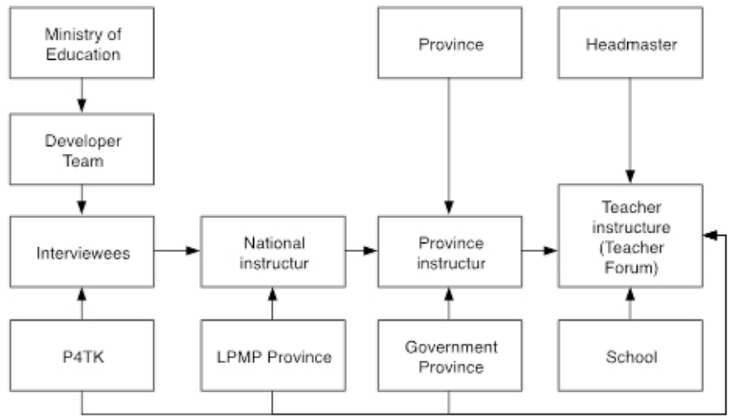

Figure 2. The Flowchart of the Structure and Function of MGMP Sector

Based on the diagram above, the role of each related element now has its own duties and functions. It is expected that a clear system can improve the teacher's understanding and equitable information related to the government's programs. However, it is unfortunate that there are still many teachers who are not involved in MGMP. There should be special attention to the role of the government and schools for paying more attention to the tasks and functions of MGMP as the leading sector in the distribution of information. Dr. Eneng Susilawati, M.Pd. (the head of the program) stated that the success of education lies in the teacher's ability in implementing learning approaches and methods. She said that until now teacher trainings have been carried out in every province in Indonesia and were expected to be continued by those who participated in the training. The comparison of teachers in the mainland of Java and the eastern regions of Indonesia shows other unique things. Teachers who are in the eastern part of Indonesia have a high level of creativity. This was reviewed from the results of the tests administered by P4TK when conducting teacher training in Eastern Indonesia. According to the researchers, it is necessary to re-examine the motivation of teachers in the mainland of Java towards the advancement of educational technology.

The results of from question 9 (Q9) and question 10 (Q10) indicate that 84% of the teachers was still developing the ideal teaching method to be implemented in the classroom and 80% have knowledge about Higher Order Thinking Skills/HOTS. These results indicate that most of the teachers in Indonesia are concerned on the development of education system in Indonesia. Higher Order Thinking Skills (HOTS) is the highest level in the hierarchy of cognitive processes and students who are coached to think demonstrate a positive impact on the development of their education (Heong et al.,2012). Studies indicate that engagement in technology and engineering learning experiences encourages creativity and higher order thinking skills, facilitates integration across STEM disciplines, and contextualises learning resulting in improved motivation and achievement (Cunningham &Lachapelle, 2014; English& King, 2015).

Firman (2015) developed STEM education in postgraduate studies. The urgencies of postgraduate are to break the barriers of STEM education implementation and how to prepare STEM implementation in the curriculum. It takes a long time to prepare the curriculum which covers some steps to achieve.

The flow STEM education research in Indonesia can be shown below. Universities which concern on researching and developing STEM education among others are Indonesia University of Education (*Universitas Pendidikan Indonesia*), Syiah Kuala University, and Yogyakarta State University. Syiah Kuala University already built a STEM Center by collaborating with a Malaysian university, meanwhile Indonesia University of Education collaborates with the government through P4TK and SAMEO QTEP as a partner. Indonesia University of Education contributed as an expert in developing STEM workbook, project, etc. Some researches have already been conducted and have a big impact (summarized from Permanasari, 2016) in increasing students' literacy in STEM, creativity, critical thinking, causal reasoning, engineering literacy, technology literacy, etc.

Several studies found the positive impact of using models of PjBL, PBL, Inquiry, IBL, etc. embedded with STEM. Those models include introduction to engineering design cycle. Sejati et al. (2017) developed a workbook on lever system to enhance students' STEM competencies. Jauhariyyah et al. (2018) developed STEM-PjBL in science learning that can improve scienctific literacy, motivation, and creativity. In line with Jauhariyah, Nurlaely et al. (2017) used casuistic problems to improve scienctific literacy. Another research was developed by Prima et al. (2018) by usingArduino-Phet to enhance the meaning of STEM education. Arduino-Phet is a literacy technology embedded with contents of science, mathematic, and engineering process to design the project.

The government also concerns on how to develop researches on STEM education and delivers the model of STEM education to teachers all over Indonesia. P4TK as the leading sector collaborates with Indonesia University of Education aims to improve in-service teachers by conducting training for trainers in every province in Indonesia. Some researches on STEM education based on this training have been already published. Ismayani (2016) as a teacher of vocational school implemented STEM-PjBL to increase creativity. Meanwhile, Reeve (2013) used STEM approach to enhance the students' awareness of Industry 4.0 which can be seen in ASEAN community. Based on Aring (2015), the implication of ASEAN community requires human resources to have work skills. The quality of human resources sustains the nation's competitiveness not only in Indonesia but also around the ASEAN community.

In line with the next generation science standard whose vision is "intertwining knowledge and practice in learning experiences", in the next year, the implementation of science learning should have a strong correlation with learning experiences.

Triangulation

In order to describe the findings, the details of the survey can be used in the triangulation process of the research. The documentation data aim to improve the quantitative findings and the interpretation of data. Multi-methods were used to converge the data. The artifact shows the relation between the results and the theory. The data were explained to uncover any unexpected results of the level of understanding of STEM. The research is in line with the theory that said that STEM literacy in Indonesia is still low and needs to be improved in order to gain the teachers' capability in enhancing the students' skills in the 21st century. The teachers' forum (MGMP) aims to enhance and improve the teachers' understanding about the 21st century skills, but the flow of structural activities can not answer the problems. Those problems can be seen from a deep conversation with the government sectors and the teachers' understanding.

The relationship between the teachers' perception and theory involvement and success was not found. It means the teachers lack of knowledge of STEM education. The teachers' perception that STEM can enhance the students' 21st century skill is lower than the other models. The level of engagement of the teachers' success in implementing STEM education was unseen. In most respects, the patterns of understanding of STEM education in some areas of Java island is higher than the other parts.

CONCLUSION

This study examined the teachers' perceptions of STEM education and the skills to face the 21st century. STEM education gains proliferated attention in educational reforms worldwide. The first conclusion is that STEM education is quite well understood by teachers. It is essential that we pay attention to the teachers as they play a critical role in the success of the new reforms. The suggestion is that there is a substantial need to raise the awareness of both the government and the teachers to embrace STEM education. Guidance and activities should also provide opportunities for the enhancement of STEM understandings. Structural organization has been created by the government. In addition, the agenda requires a forum group discussion between the government and the teachers to increase the teachers' perception of STEM. This article has discussed the factors why the teachers need attention in order to overcome the problems. This research recommends significant supporting persistence, retention, and access to support the teachers in understanding STEM education. This implies that there is not only a need for awareness raising, but also for discussion on how STEM education would be implemented. Schools that agree to embrace STEM education may have different ideas of what it should look like, who should be involved (in terms of students and teachers), and how it should be implemented. Future researches could focus on the development of instructional models and curricula materials for STEM integration, connections between teacher education programs for integration and teachers' subsequent classroom teaching practices, and ways in which teachers view STEM integration.

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