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TEACHERS' READINESS IN TEACHING STEM EDUCATION

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Science, Technology, Engineering and Mathematics education (STEM) is a curriculum that aims to educate students in four specific disciplines using an interdisciplinary and applied approach. Instead of teaching the four disciplines as separate subjects; STEM education integrates them into a cohesive learning based on real-world applications. The objective of this study was to examine teacher readiness towards teaching Science, Technology, Engineering and Mathematics education (STEM). This study is carried out through a case study based on open-ended question survey done by ten participants. This study also used content analysis as its data analysis. As a result, three out of ten participants agreed that they are ready to implement STEM education and seven out of ten participants agreed that they are not ready to implement STEM education because of few reasons: lack of confidence to teach subjects that are other than their expertise, lack of related teaching materials and poor condition of laboratory facilities to support STEM activities. Implication for science educators based on these results is discussed.

Keywords: STEM Education, Teacher Readiness, Science Teacher.

1. INTRODUCTION

Transformation of the education system is an urgent need to provide world-class education system for the next generation who is capable to compete globally and to generate economic sustainability of the country. Thus, the Malaysian Education Blueprint (2013-2025) was developed in order to produce intended workforce through the Science, Technology, Engineering and Mathematics education (STEM). STEM education is defined as an interdisciplinary approach that applies the concepts of science, technology, engineering and mathematics (White, 2014). STEM education began in the United States ever since the early 1990s (Ghaziah Mohd Ghazali *et al.*, 2013). Introduction of STEM education is important for overcoming high-tech industry economic challenges. Through STEM education, the integration of the four branches of knowledge to form a new knowledge can actually be implemented4. This integration is also known as a meta-discipline, or means the establishment of knowledge based on integration between other disciplines (Hernandez *et al.*, 2014).

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STEM brought a new approach from teaching science, technology, engineering and mathematics as a separate and discrete subject. STEM education integrates this four branches of knowledge into integrated learning based on real-world applications (Stohlmann *et al.*, 2012). Integration approach in education allows students to explore, collect and process information required without constraints of distinction disciplines (Robert and Cantu, 2013). Integration of learning encourages students to build the relationship between disciplines. The integrated approach in STEM education aims to remove the constraints between each discipline contained in STEM education and then teach them as a subject. Integrating science, technology, engineering and mathematics curriculum in STEM learning across the curriculum is an example that is fundamental to the curriculum of the 21st century (El-Deghaidy and Mansour, 2015). Skills needed by students in order to successfully meet the 21st century challenges can be applied effectively through this integrated curriculum of STEM education.

To develop a competitive scientific community through the implementation of STEM education, every teacher plays a very significant role in achieving the educational goals. The teacher's role is not only to transmit the knowledge to students but also to determine the success of the transformation of education.

The changing landscape of education in Malaysia is not limited to the adjustment of the syllabus or different pedagogical integration, but teachers' readiness's also need to be investigated so that the desired changes can be implemented better. Teachers are responsible in choosing the relevant knowledge required for their students. It shows that teachers are a medium of instruction that connects students with the knowledge. An effective teaching is contributed by teachers' abilities in processing and translating the selected knowledge to facilitate students' understanding (Sadler, 2013; Nor Hasniza *et al.*, 2015). To achieve effective teaching, teachers must have a broad knowledge and deeper understanding about what knowledge (Knoell, 2012). In order to promote STEM education, this study seeks to identify teachers' readiness in teaching STEM education and the factors that influence their readiness in teaching STEM. The research questions are shown below:

- Are science teacher ready to implement STEM education?
- What are the factors that hinder science teachers' readiness to practice STEM education?

2. METHODOLOGY

This study employed a qualitative instrument. The instrument was used consecutively to identify science teacher readiness to implement STEM education and factors that hinder science teacher readiness to practices STEM education.

The study used a focus group to discuss science teacher's readiness in teaching STEM education. The ten teachers were involved in the focus group.

2.1 Sample

Participants in this study were ten secondary school science teachers in local educational districts in Johor Bahru. They are voluntary science secondary school teachers with 1- 10 years of teaching experience.

2.2 Data Collection

This study employed open-ended question surveys where all the participants were being asked the same question. An open-ended question was used because it encouraged meaningful answers based on participants' knowledge and feelings as they were free from restrictions (Stohlmann, 2012). Furthermore, the questions of the survey tend to be more objective and less leading (Mizzi, 2013). Through analysing the data descriptively, it enables the researcher to gain additional information to identify problems effectively with the current generalist practice of teaching and to assess what teachers feel should be done to improve the situation.

2.3 Data Analysis

In this study, data were analysed using content analysis method. This analysis method could help researchers to explain the data and information obtained from the study in more details (Bleuel, 2015). The analysis of qualitative data is divided into three parts, namely, the provision of data, data organization and data coding. The first part of the data analysis process is the provision of data. All of the data obtained during the data collection process will be transcript to text.

After the transcription, data were sorted and then be reused. Compilation of data was done by giving the numbers in each code and contextual data was collected through dividing the field notes to certain parts of the date. A nickname or a code number of participants was given as a reference to keep participants' real name confidential for the safety purpose (Haigh *et al.*, 2013).

Next, the main ideas generated from participant's answer were categorized. Researchers will shrink the size of the data gradually to smaller units according to similarities with the formation of several categories, sub-themes and themes. The coding process was implemented in three stages; open coding, axial coding and selective coding.

3. RESULT AND DISCUSSION

The analysis focused on understanding teachers' opinions on their readiness to teach STEM and their perceived barriers in teaching STEM. In this study, results showed that only 3 out of 10 participants were ready to teach STEM to their students

and 7 out of 10 participants were interested in STEM but they were not ready to teach. The main reason for participants who were ready to implement STEM education was because they thought that students needed to have STEM skills to deal with globalisation, challenges and changes.

> STEM education can provide exposure to the real world and not just the students learn to answer exams. (T8)

> STEM project are very helpful in developing cognitive skills of the student to facing real world problems nowadays. (T9)

> STEM education should be implemented as soon as possible because students not only compete with their classmates, but they (students) now compete student all over a world. Anyone who not skilled will be miss. (T10)

From those responses, researcher found that teachers are aware of the importance of STEM education in enabling their students to compete globally as stated in the introductory STEM education by Ministry of Education Malaysia in Malaysian Education Blueprint (2013-2025). The participants who responded that they were ready to implement STEM education also gave the reason that they could save teaching and learning time when implementing STEM education.

> STEM education is the integration of science, technology, mathematics and engineering. Therefore, STEM education can saves time that allocated for a study session. (T8)

> STEM is integrated subject where we teachers could combine/connect all subject and shorten learning time. The extra time that we have, we can do another learning activities. (T9)

This study also indicated that 7 out of 10 participants were interested in STEM but they were not ready to implement it. The results showed that those teachers who are interested in STEM would like to teach it, but they are not ready because they lack of confidence to teach subjects that are other than their expertise. Meanwhile, they lack of teaching materials and proper condition of laboratory facilities that support STEM application activities.

3.1 They Lack of Confidence to Teach Other Subject than their Expertise

Qualitative data analysis showed that seven participants had negatively responded on readiness in teaching STEM education. The teachers did not intend to teach STEM education because of lack confidence in STEM subjects as they are not familiar with STEM education. This result may be due to the teachers have limited knowledge on subjects that are not their expertise. STEM education does not focus on a subject but four different subjects. Most teachers only have knowledge and basic skills in teaching their own field only (Avery, 2013; Lee *et al.*, 2013).

> I'm still not able to teach student all subjects like mathematics, science, technology and engineering due to lack of knowledge on a particular subject. (T1)

> STEM education actually require teacher who expertise in four fields, but we (teacher) only have expertise in one field only. (T4)

> I'm still not ready to teach STEM because STEM have very broad scope and requires knowledge and skills in various fields, not science field only. (T6)

Based on the participants' responses, science teachers did not have any problem with teaching science subjects in different levels at secondary schools. However, they faced the challenge to teach other than science subjects. It is because these teachers are usually specialised in particular field at University level. Teaching other than their expertise is considered a challenge to them. They expressed their concern when dealing this situation. The teacher participants showed lacking of confidence when preparing lesson plans, selecting learning activities, answering questions from students and running experiments in the laboratory (Mizzi, 2013).

Teachers who teach other than their specialism are facing challenges in preparing their lessons. They need to understand the structure and learn that unfamiliar content knowledge. Then they need to transform and adapt the content knowledge into the suitable activities in order to help the student to learn. Inadequate background in subject knowledge is one of the main factors causes the teacher lack of self-confidence when teaching topics that are other than their expertise (Haigh *et al.*, 2013).

3.2 Lack of Reference Materials for Teachers

This study showed insufficient STEM reference materials influence teachers' readiness in implementing STEM education.

> I still not understand the things that need to be done to integrate all STEM subjects in one teaching session due to the lack of information and reference on STEM. (T3)

> ...there is no expert / reference that we (teachers) can refer if there are issues to implement STEM. (T4)

> ...teachers do not have a guide to implement STEM education and if there is no curriculum to implement, STEM objectives will not be achieved. (T5)

Most teachers are only expert in one or two subjects. It depends on their specialism in their tertiary levels, for example, if their major is Chemistry and their minor is Mathematics, they will not have much problems to teach chemistry and mathematics. However, they may face difficulties if they are being asked to teach engineering and technology which is one of STEM components. In such situation,

teachers need more and extra reference modules to help them in implementing STEM education. Unfortunately, there are insufficient references materials on STEM education (Amadio, 2015). As a result, teachers who teach STEM subjects also cannot teach and guide the students to apply the concept of integration of STEM education. Students cannot integrate the concept of science, technology, engineering and mathematics to solve serious problems (Lee *et al.*, 2013). The absence of complete reference on STEM could dampen the efforts of STEM education (Carlu *et al.*, 2014). Also, it makes teachers to implement the STEM knowledge based on their own understanding and yet reach the supposed level (Howard-Brown and Martinez, 2012).

3.3 Poor Condition of Laboratory Facilities

Based on this study, four out of seven participants who were not ready to teach STEM had mentioned that the poor condition of laboratory facilities caused them felt reluctant to implement STEM education.

> Lacks of infrastructure facilities such as science laboratories are poorly maintained and this becomes obstacles to teacher in implementing STEM education in schools. (T2)

> I was not ready because I find the schools' laboratory is still incomplete and inadequate to support me to teach STEM. (T3)

> Science laboratory facilities are incomplete and do not support the implementation of STEM education that requires science and technology tools. (T5)

> ...science laboratories in my schools are still not able to support STEM education for all student. (T7)

Based from participants' responses, science teachers emphasized the use of laboratories for practical training to enhance students' understanding of scientific concepts and theories learned. Laboratory is the most important area within STEM activities because STEM education involves a lot of hands-on activities that require a convenient space and many laboratory tools (Ejiwale, 2013; Valesco *et al.*, 2016). Therefore, a conducive laboratory should be made to support STEM learning.

4. CONCLUSION

From this study, we can conclude that teachers' readiness in implementing STEM education is still at a low level. There are an internal constraint such as teachers' self-confidence and few external constraints such as insufficient reference materials and poor infrastructure facilities. In order to achieve STEM education objectives, the addressing constraints to implement STEM education should be fixing as soon as possible. From this study, there is a need for professional development to increase teacher's confidence to teach STEM education. Teacher preparation programs must

also be considered for helping teachers to solve any challenge when implementing STEM education. This professional development is needed to train the teachers with new knowledge and the modern teaching trend so that the teachers can apply STEM education effectively to the students. Besides, this STEM education focuses on active learning that involves a lot of hands-on activities to effective problem solving. Due to this respect, laboratory and classroom need to be upgraded to support the STEM education needs. With all the support, it will foster teachers' readiness to teach STEM education.

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References

Nor Hasniza Ibrahim, Johari Surif, Dayana Farzeeha Ali, and Farhanawati Zuraimi (2015). Refleksi Terhadap Permasalahan Pedagogi Pengajaran. *Buletin Pendidikan Sains dan* Matematik Johor. 1: 63-69.

Amadio, M. (2015). STEM Education and the Curriculum: Issues, Tensions and Challenges. International STEM High-level Policy Forum in "Evidence-based Science Education in Developing Countries", Unesco International Bureau of Education.

Avery, Z. K. (2013). Developing Effective STEM Professional Development Programs, Journal of Technology Education, 25(1): 55-69.

Becker, K. and Kyungsuk, P. (2014). Effects of integrative approaches among Science, Technology, Engineering and Mathematics (STEM) subject on students' learning: a preliminary meta-analysis, Journal of STEM Education: Innovations and Research, 12(5): 23-37.

Bleuel, W. (2015). Information differences between closed-ended and open-ended survey question for high-technology products, Journal of Technology Research, 6: 1-10.

Chua, Y. P. (2014). Kaedah Penyelidikan (3rd Ed). Kuala Lumpur: McGraw Hill Education.

Corlu, M. S., Capraro, R. M. and Capraro, M. M. (2014). Introducing STEM Education: Implication for Educating Our Teacher for the Age of Innovation, Education and Science, 39(171): 74-85.

Ejiwale, J. (2013). Barriers to successful implementation of STEM education, Journal of Education and Learning, 7(2): 63-74.

El-Deghaidy, H. and Mansour, N. (2015). Science teachers' Perception of STEM Education: Possibilities and Challenges, International Journal of Learning and Teaching, 1(1): 51-54.

Ghaziah Mohd Ghazali, Nabilah Abdullah, Shireena Basree Abdul Rahman, Rohaya Abdul Wahab, and Norshidah Nordin. (2013). Pemerhatian dan Temubual, in Noraini Idris, Penyelidikan Dalam Pendidikan (2nd Ed), pp. 315-351. Kuala Lumpur: Mc Graw Hill Education.

Haigh, M., Ell, F and Mackisack, V. (2013). Judging Teacher Candidates' Readiness to Teach, Teaching and Teacher Education, 34: 1-11.

Hernandez, P. R. Bodin, R., Elliott, J. W., Baharuddin Ibrahim, Rambo-Hernandez, K. E., Chen, T.W. and de Miranda, M. A. (2014). Connecting the STEM dots: measuring the effect of an integrated engineering design intervention, International Journal Technology Education, 24: 107-120.

Howard-Brown, B. and Martinez, D. (2012). Engaging Diverse Learners trough the Provision of STEM Education Opportunities. Southeast Comprehensive Centre.

Knoell M. C. (2012). The Role of the Student-Teacher Relationship in the Lives of Fifth Grades: A Mixed Methods Analysis, Doctoral dissertation. University of Nebraska.

Lee, J. H., Fatin Aliah Phang Abdullah and Muhammad Abd Hadi Bunyamin. (2013). Aplikasi Konsep Fizik Dalam Menyelesaikan Masalah Yang Berasaskan STEM Bagi Pelajar Tingkatan Enam Atas, 2nd International Seminar on Quality and Affordable Education, 470-481.

Mizzi, D. (2013). The Challenges Faced by Science Teacher When Teaching Outside Their Specific Science Specialism, Acta Didactica Napocensia, 6(4): 1-6.

Robert, A and Cantu, D. (2013). Applying STEM Instruction Strategies to Design and Technology Curriculum. Department of STEM Education and Professional Studies. Old Dominion University. USA.

Sadler, P. M., Sonnert, G., Coyle, H. P., Cook-Smith, N. and Miller, J. L. (2013). The influence of teachers' knowledge on student learning in middle school physical science classrooms, American Educational Research Journal, 50(5): 1020-1049.

Scott, C. (2012). An investigation of science, technology, engineering, and math (STEM) focused high schools in the US, Journal of STEM education: Innovations and Research, 13(5): 30-39.

Stohlmann, M., Moore, T. J. and Roehrig, G. H. (2012). Considerations for Teaching Integrated STEM Education, Journal of Pre-College Engineering Education Research, 2(1): 28-34.

Velasco, J. B., Knedeisen, A., Xue, D., Vickrey, T. L., Abebe, M. and Stains, M. (2016). Characterizing Instructional Practices in the Laboratory: The Laboratory Observation Protocol for Undergrad STEM, Journal of Chemical Education, 93: 1191"1203.

White, D. W. (2014). What is STEM education and why is it important? Florida Association of Teacher Educators Journal, 1(14): 1-8.