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Science, Technology, Engineering and Mathematic (STEM) Education in Malaysia: Preparing the Pre-service Science Teachers

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ABSTRACT
The aims of this paper is to discuss the importance of science, technology, engineering and mathematic (STEM) education in Malaysian educational system and how it has been implemented in teaching method course. The policy of STEM education started in the United States and has been expanded to all over the world including Malaysia. The policy of STEM education in Malaysia has its own understanding based on Malaysian Education policy. In ensuring the successful of STEM education, preservice teachers need to be trained. Hence, School of Educational Studies has taken this initiative to train these student teachers through Chemistry Teaching Methods course. In this course, student teachers need to plan a lesson plan using 5E instructional model. They also need to teach based on that lesson plan through simulated teaching in ensuring STEM elements are successfully implemented.

Keywords : *STEM, Education, Pre-service science*

INTRODUCTION

Whether we try to deny it or not, the world today is already in the 21st century and that includes its learning style. At the same time, science education has become a must and compulsory in developing nation. This is because science education is closely related to economic development for the country (Chesky & Wolfmeyer, 2015). Most of the countries have made science education compulsory in their educational system starting from pre-school until secondary or high school (OECD, 2011; Kammermeyer, 2016). Bybee (2013) claimed that science is highly focused in national development and largely driven by innovation that involves technology and engineering. Sublette (2013) notes that there is a need for a change in education, particularly highlighting the issues related to education and employment in science, technology, engineering and mathematics (STEM). This suggests that science, technology, engineering and mathematics education has gained considerable attention today, requiring high emphasis on the field for improvement in the curriculum and guidelines within and across the field(Honey, M., Pearson, G., & Schweingruber, H. (Eds.), 2014).

In today's competitive global economy, most countries need a knowledgeable and highly skilled workforce. This new workforce should have a critical foundation of problem solving, innovation, not dependent on others and think logically that can drive capacity innovation in the global marketplace. Therefore, according to Honey, Pearson, and Schweingruber, (Eds.) (2014), it is important for people to have qualification education related to science and technology literacy. This is because most employers and public

officials believe that science and technology can lead to a better life for the community (Honey, Pearson, & Schweingruber, (Eds.) 2014). Therefore, STEM Education can provide such services by providing scientific and technical workforce. As suggested by Carter (2013) the key to developing such skills is to reinforce the competence of each student's STEM at school level. An effective method of raising the STEM level of students is theIntegrationof STEM Education approach which is the best method for now (Elliot, Oty, McArthur & Clark, 2001). This is because STEM can help students to apply their knowledge, collaborate with friends and can identify their interests by learning through STEM (Vasquez, Sneider & Comer, 2013). According to Teo and Ke (2014), the United States alone has 100 STEM specialized schools in 30 states to make STEM education happens. Singapore also have two STEM schools. This shows that Singapore has undergone a paradigm change in the curriculum. Their curriculum offers specific talents and desires in the STEM domain to students.

STEM education becomes a global phenomenon due to several things. One of the main reasons behind is that STEM Education emphasizing the mastery of the four STEM disciplines which comprises of science, technology, engineering and mathematics as the core discipline for economic development (Bybee, 2010; NGSS, 2013). The Queensland Government (2016) also stated the same thing in the "Interim review of STEM education in Queensland state schools" where STEM have been an important part of society now to continue development and meet their needs. Development in a country today is not focused on just one aspect but involving more holistic involvement. This can be seen through Successful STEM Education (2011) statement stating that STEM is no longer solely involved in the production of scientists, STEM has act as an economic driver. This is because almost all occupations today require STEM skills and capabilities

METHODOLOGY

This research is literature research or literature study. the method used is qualitative method with content analysis. Data sources are taken from books and literatures related to science, technology, engineering and mathematics (STEM).

DISCUSSION

Science, Technology, Engineering and Mathematics (STEM) Education Background

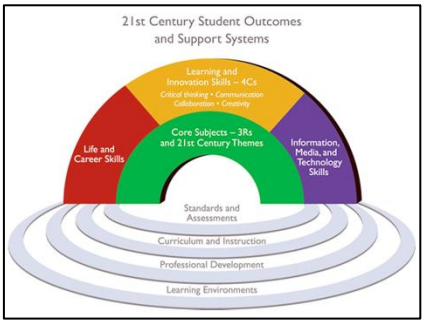
Ostler (2012) states that STEM is not a new concept, but it is otherwise. The practice of integrating subject matter like science and mathematics is not a new thing (Ostler, 2012). Integration between subjects has been started since the 19th by the Committee of Ten of Harvard (Eliot et al., 1892; Ostler, 2012) as a way to standardize the learning system at that time. STEM integration instruction in education was only introduced in the 21st century through the National Science Foundation (NSF) officially in the early 90s (Ostler, 2012). The use of the term STEM was introduced by NSF in 2001 by Judith Ramaley who was then NSF director (Breiner, Harkness, Johnson & Koehler, 2012; Heil, Pearson & Burger, 2013). Prior to that, STEM was known as 'SMET' which was later converted to the term now because of its lesser meaning (Bybee, 2013; Chesky & Wolfmeyer, 2015). Breiner et. al. (2012) noted that most parties are still unclear about STEM's intention but agree that STEM is an acronym for science, technology, engineering and mathematics. This has led to some skeptical views on the effectiveness of the STEM approach into the education system of the country (Ostler, 2012). Ostler (2012) states that most of the political figures, as well as educators and education reformers are part of the STEM initiative. Most of them have their own views on STEM, which are seen as fully

under-conceptualized STEM and how this STEM education can help schools and universities (Narum, 2008).

The United States has placed high priority in promoting STEM enrollment and retention so that international competitive advantage can be enhanced (Augustine, 2005; Kuenzi, Matthews & Mangan, 2006). STEM is currently a major focus on education and industry in the United States. This is based on the Executive Report Prepare and Inspire K-12 Education in Science, Technology, Engineering and Math the President's Council of Advisors on Science and Math Education for America's Future under the administration of President Barack Obama stating that the education system in the United States should provide the foundation which is strong in STEM disciplines (President's Council of Advisors on Science and Technology, 2010). This issue was issued by the president as concerns among industry members and economists were due to the enrollment of students in STEM's major subjects (National Science Foundation, 2010). The identified sources are that most capable students do not follow the relevant courses (National Science Foundation, 2010).

There are reasons why STEM Education is important. The National Science Foundation have given their thought about it. "Education at all levels in science, technology, engineering, and mathematics—STEM—develops, preserves, and disseminates knowledge and skills that convey personal, economic, and social benefits. Higher education provides the advanced work skills needed in an increasingly knowledge-intensive, innovation-focused economy and society" The National Science Foundation, 2012. From this statement, we can conclude that STEM is a fundamental element for the personal, economic and social benefits. They also state that STEM is needed for advanced work skills in today's industries that compose of knowledge-intensive, innovation-focused economy. As we look upon the 21st century learning, STEM Education is really parallel to it. The Partnership for 21st Century Learning or P21 have developed the Framework for 21st Century Learning. Science is a core subject in the 21st century that must be mastered by every individual claimed by P21. The framework can be used in STEM education because the elements within the Framework of P21 which are development of cognitive, interpersonal and intrapersonal is part of the main goals STEM education (Johnson, Peters-Burton, and Moore (2015).

Furthermore, learning skills and innovation which consists of the 4Cfocussing on creativity, critical thinking, communication and collaboration also highlighted in theP21 Framework.Life and career skills in this framework also as important in STEM Education one of the purpose is for carrer and also life skills based on solving real world problems. Moreover, the framework also focused on the skills of information, technology and media. The technology part are also included in STEM education and consists of information literacy, media literacy, and literacy in media, information and technology. The picture below shows the framework.



STEM in Malaysia

STEM Education was first formally discussed in Malaysia in early 2012 when the Faculty of Education of the National University of Malaysia (UKM) conducted a "Engineering in Elementary" workshop (Muhammad Syukri, 2012). Several studies and surveys have been conducted at some previous levels internally to identify the need to implement the curriculum with STEM education (Muhammad Syukri, 2012) that later leads to the development of national blueprint. This workshop aims to increase knowledge and information on the application of engineering knowledge in science learning at primary and secondary level. During this workshop, the Dean of the Faculty of Education, UKM, Professor Dr. Lilia Halim stated that the importance of integrating STEM should be done immediately into teaching and learning. According to her, this integration cannot be implemented at the university level effectively, if it is still not run at primary and secondary level (Muhammad Syukri, 2012).

By the end of 2012, the then Deputy Prime Minister cum Minister of Education had launched the Malaysia Educational Blueprints 2013-2025. He stated that the aim for the blueprint is reform the educational system and a next step from the previous blueprints that ended in 2010. There are a lot of things discussed in the blueprint, and STEM education is one of the big things discussed in the blueprint. The deputy prime minister said: "Like other developed countries, Malaysia needs specialists in Engineering, Science, Medicine and other Technology sectors. Lack of interest in Science subjects will stave off efforts to improve technology innovation to make Malaysia a high-income nation" Deputy Prime Minister Tan Sri Muhyiddin Yassin (October 2012).

In chapter 4 titled Student Learning, there is a section focusing STEM (page 4-1). The MOE states that the implementation of this plan will ensure that students acquire the necessary knowledge and skills in meeting the 21st century, in line with the spirit of lifelong learning (MOE, 2012). Science, technology, engineering and mathematics science is very important today (MOE, 2012). Therefore, it is important for the country to have qualified and sufficient STEM graduates to meet the industry's workforce which will further enhance the country's economy (MOE, 2012). To achieve this goal, the country needs a thorough student preparation from the point of their knowledge and skills.Therefore, MOE outlines somethings to betaken of which wasenhancing student's interest through a new learning approach and strengthening of the curriculum, improving teacher skills and abilities and improving student and public awareness. These three targets are only for the first out of three waves that MOE had guide.

The three waves are strengthening learning basis (First wave, 2013-2015), build on the basis provided (Second wave, 2016-2020) and making innovation at the next level (Third wave, 2021-2025)

Preservice Teacher Preparation

Skilled teachers need a neat preparation before conducting teaching and learning sessions in the classroom. This includes the pre-service teachers because they will be posted to school in the future. Hibpshman (2007) conducted a study, A Brief Review of The Preparation of Kentucky Mathematics and Science Teachers on assessing teacher training and its impact on student achievement. There are three things that are assessed as the relationship between teacher training in science and mathematics with student achievement (part 1), the exploration of common Kentucky teacher prevalence in science and mathematics at both the primary and secondary level (part 2), and suggestions for improvement in STEM disciplines (part 3) based on the findings from sections 1 and 2.In the first part, the findings indicate that teachers' readiness in instructional content is

important to student achievement. They need a sustained readiness for teaching in the classroom in improving student achievement. The second part shows some findings on pre-service teachers' pre-service science subjects. Pre-service teachers who teach science subjects especially physics subjects at the secondary level have problems in teaching because their level of science knowledge is low. Teachers of mathematical service have their own understanding of the subject but do not have pedagogical knowledge appropriate to the students.

Hence, pre-service science teachers' preparation is a key part of teaching STEM subjects in schools. Hibpshman (2007) provides some recommendations in the third part of the study. The recommendation is that pre-service science teachers should be given training based on the curriculum set by the authorities such as the ministry or university teacher programs. This curriculum also includes pedagogical methods that are appropriate to the pupils' targets.

The Implementation of STEM education using 5E Instructional Model

The 5E instructional model will be used in assisting studentteachers to structure their lesson plan. This instructional model was chosen since it is based on constructivism theory which allowed students to work together, ask questions, investigate new concepts, observe, analyze and draw conclusion. This model will help student teachers to produce active and meaningful learning process. This model consisted five stage: engage, explore, explain, elaboration and evaluation. Table 1.1 explain each stage in 5E.

Table 1.1 The 5E stages

Stage	Explain
Engage	To foster students' interest and ready to learn new concepts. Besides, this stage also important to understand students' pre-knowledge.
Explore	Students actively explore the concepts through hands-on and minds-on activity. In here, students will get concrete experience through
Explain	Students will explain their ideas what they have learned during exploration stage. This stage is a teacher-led phase which helps students ask questions if they need further clarification.
Elaboration	This stage helps students to develop a deeper and broader understanding about concepts. Teachers should encourage students to apply their understandings into a new situation and reinforcing new skills. This stage allows students to strengthen their knowledge.
Evaluation	Teachers will evaluate their students using formal or non-formal assessment. It can be self-assessment, peer-assessment, writing assignments, or exams.

Here is the example of lesson plan where STEM has been integrated in this lesson. The first learning objective, at the end of this lesson, students will be taught to analyse the

energy changes in chemical reactions. The second learning outcomes, at the end of the lesson, students will be able to : (1) Define exothermic and endothermic reactions, (2) Classifying exothermic or endothermic reactions based on the sign of ΔH, (3) Classifying examples of daily life chemical reactions into exothermic and endothermic reactions, (4) Determine the ΔH and type of reaction from the given Hproducts and Hreactants in a chemical reaction.

STEM-GT element are science (thermochemistry), technology (concept maps), engineering (Creating hot packs and cold packs), mathematics (calculating ΔH from Hproducts - Hreactants of a chemical reaction). Green Technology use of salts instead of acids and bases to show exothermic and endothermic reaction. HOTS element: (1) Determine from 4 choices of salt (NaCl, NaHCO3, CaCl2, NH4Cl), which salt is the most suitable to produce hot pack and cold pack? (2) What do you think is an alternative way to treat the athlete's legs if you do not have cold pack during that time?. (3) Identify and explain the type of reactions for the following daily life chemical reactions are: melting of ice, a candle flame, melting solid salts and making ice-creams. (4) Determine the ΔH and the type of reaction for chemical reaction with Hproducts - Hreactants provided.

Conclusion

The implementation of STEM education using the 5E Instructional Model helps student teachers create a creative chemistry lesson that illustrate constructivist and active learning process.

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