Journal of Sustainability Science and Management
Volume 14 *Number* 5, October 2019: 135-147
ISSN: 1823-8556

PRELIMINARY REVIEW ON PREPARATIONS IN MALAYSIA TO IMPROVE STEM EDUCATION

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Abstract: Strengthening the knowledge of Science, Technology, Engineering, and Mathematics (STEM) in human populations is one of the key elements in the fourth sustainable development goals (SDG4). Many countries are facing challenges to implement STEM education. Findings from international benchmarking such as Trends in International Mathematics and Science Study (TIMMS) and Programme for International Student Assessment (PISA) revealed that students who originate from East Asia countries outperformed students from other countries consistently. This implies that the educators in East Asia countries are employing good strategies in the implementation of STEM education. This paper reviews the preparation of Malaysians in implementing STEM education and compares them with the preparations made by these East Asia countries. This is significant because it would help to benchmark Malaysians' effort in achieving SDG4. From this study, it was found that Malaysia has established necessary interventions suggested by the theory of change, but its effectiveness is yet to be known. The study allows educational researcher to identify the research opportunity related to educational research related to STEM education in Malaysia.

Keywords: Sustainable development goals (SDG), East Asia science education, theory of change.

Introduction

Strengthening the knowledge of Science, Technology, Engineering, and Mathematics (STEM) in human populations is one of the key elements in the fourth sustainable development goals (SDG 4). STEM education has been defined differently depending on regional needs (Council *et al*., 2011; Glancy & Moore, 2013; Kim, 2015; Kelley & Knowles, 2016). Integrated STEM education is defined by Moore *et al.* (2014) as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit or lesson that is based on connections between the subjects and real-world problems". Kelley and Knowles (2016) quoted the definition of integrated STEM education as "the approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning" and commented that there are limits to this approach. They have proposed a conceptual framework for secondary education as shown in Figure 1. The framework was constructed using learning theories such as situated cognition theory and pedagogies that will lead to achieving key learning outcome. In the framework, the four STEM disciplines are connected by block and tackle of four pulleys bounded by the rope of community of practice. The pulleys allow learning activities of STEM subjects to be implemented more efficiently. Educators who planned to employ this framework in guiding their teaching needs to have a strong understanding of the relationship that can be established across domains (Kelley & Knowles, 2016). In Malaysia, a conceptual framework to implement STEM education from pre-school level until undergraduate level appeared in BPK (2016) as shown in Figure 2. In this framework, it was suggested that STEM education. should begin through students exploring and investigating their surroundings

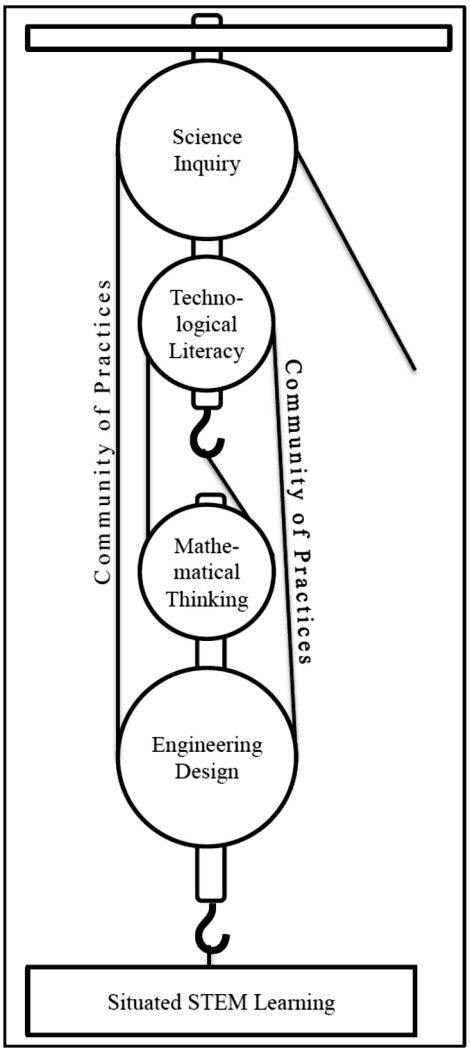

Figure 1: Conceptual Framework for STEM Learning at Secondary School Level (Kelley & Knowles, 2016)

to trigger interest and curiosity. The experiences gained though exploration and investigation will be used to relate with basic science knowledge that will assist in develop more advance STEM knowledge and STEM technical skill at higher level of education. At higher level of education, students will need more advance science knowledge that allows them to analyze global issues and develop solution to the issues. 21st century skills are only emphasized at tertiary level. At the end of the curriculum, students are expected to contribute to society by applying STEM knowledge and STEM skill in their work and continue to learn through experiences while working.

In Malaysia, the acronym STEM is used by stakeholders of basic education and higher education in three different contexts as illustrated in Figure 3 (Halim & Meerah, 2016). The terms STEM field and STEM stream are used to represent the field or stream related to science, technology, engineering and mathematics. STEM fields appear in curriculum at all level. At secondary school level, students are allowed to choose either STEM stream or art stream.

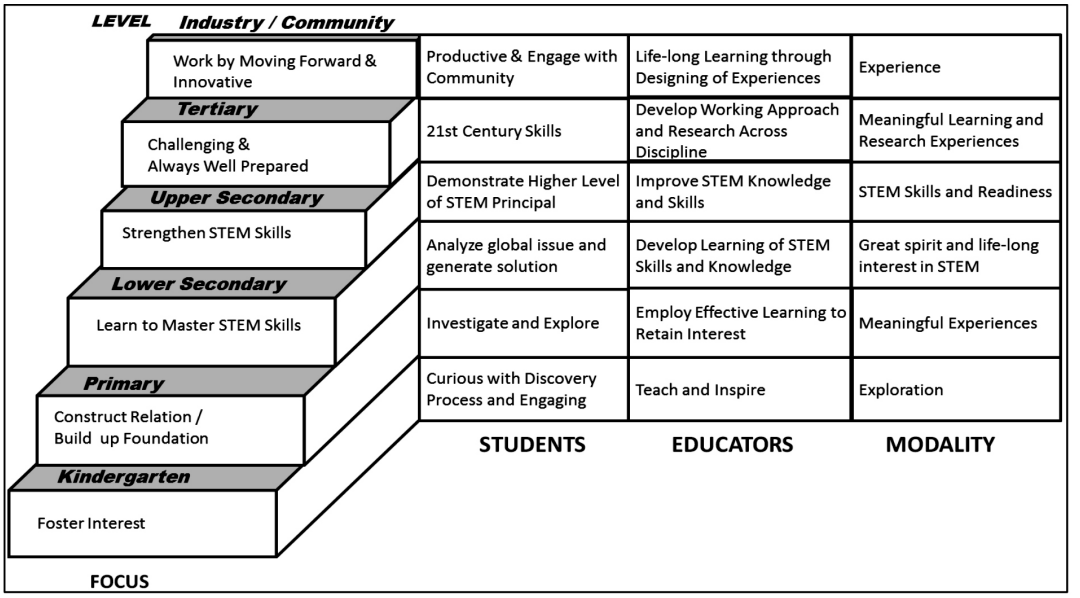

Figure 2: Conceptual framework for STEM Education in Malaysia (BPK, 2016)

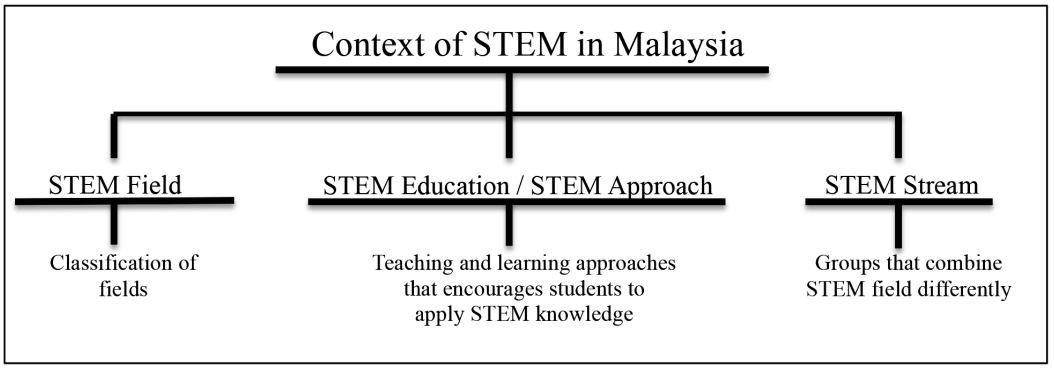

Figure 3: Components in concept of STEM in Malaysia (Halim & Meerah, 2016)

Students who choose STEM stream will learn advanced theoretical knowledge and technical skill in STEM fields.

The third term, STEM Education, refers to the STEM approach. This context is also used by Moore *et al.* (2014) and Kelley and Knowles (2016). STEM Education encourages students to apply STEM knowledge in solving real world problem (Ishikawa *et al*., 2013). It is one of the crucial educational strategies to ensure that the young generations are well prepared to face the industry revolution 4.0 (NIES, 2017). During the revolution period, it is expected that the robotics technology will replace labor work consisting repetitive tasks. The type of jobs that will be more available is the one that require high level thinking and creative solution (GAO, 2018). Therefore, students need to possess high level thinking skill in order to become more employable in the future.

Across the globe, STEM education continuously gained significant emphasize often at national level (Roehrig *et al*., 2012; Maltese *et al*., 2012; Marginson *et al*., 2013; Feinstein & Kirchgasler, 2015; Park *et al*., 2016; Tanenbaum, 2016; OECD, 2016; Wayne,

2017; Ledbetter, 2018). For developed country such as United State, ACT Inc. (2017) reported the needs for United States to improve STEM Education system and implementation policies. During Federal STEM Education Summit, it was addressed that United State will continue to support the implementation of STEM education as the government recognized the need to forge stronger connections or partnership between education and work through apprenticeships, internships, cooperative education, and mentorship. Such connection is able to create work-based learning for students (OSTP, 2018).

China, which is the world fastest developing country, also recognized that STEM Education is able to prepare students in facing the quick changing era. Despite the fact that students in China scored higher than average in Programme for International Student Assessment (PISA) in year 2015, STEM implementation policy continued to be refined. In China Education White Paper Year 2017, it has been reported that vulnerabilities still exist in their STEM system, mainly in the way of instruction and scientific spirit cultivation (NIES, 2017).

Methodology

Mohd Shahali *et al.* (2017) reported that Malaysia has been placing great commitment to align STEM initiatives to the objectives of the New Economic Model. Malaysia officially introduced the concept of STEM integrated education in Malaysia Education Blueprint (2013-2025) (Ministry of Education, 2013a). Findings from the international benchmarking tests on mathematics and science achievements such as the Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) shows that Malaysian students have improved in PISA assessment 2015 compare to PISA assessment in 2012. Malaysian student performance in the PISA assessment in 2015 showed an increase in all the three domains namely, Mathematics (421 score), Science (420 score) and reading literacy (398) (Bahrum *et al.*, 2017; OECD, 2018). Is the current educational preparation in the country sufficient to improve the ability of students to apply their STEM knowledge and STEM skill in solving real world problem?

Narrative review approach was used to review the educational preparations done in Malaysia which includes indexed journal, books and grey literatures. The literatures were found using Google Scholar by using the key search terms such as "successful STEM Education", "theoretical framework model describing preparation of a nation to improve the education outcome" and "STEM education Malaysia". The year of publication was not restricted. The review intends to provide the status quo of Malaysia's preparations to improve students' performance in TIMSS and PISA. The theory of change typology proposed by Masino and Niño-Zarazúa (2016) was used to classify the preparations and qualitatively evaluate the status quo. Good practices from other countries such as Singapore, China, and Korea were outlined in this study if the preparations in Malaysia were insufficient. These countries are high-achieving countries recognized by the international education community that consistently able to produce students that performed well in PISA and TIMSS (Khine, 2015). The study allows educational researcher to identify the research opportunity related to STEM education in Malaysia.

Theory of Change as Model

Theory of change has recently been used in educational literatures to establish strategies and interventions that drive changes to achieve long-term development goals (Masino & Niño-Zarazúa, 2016; Susan & Adrianna, 2017, Beth *et al.*, 2017; Cory *et al.*, 2017). Theory of change typology constructed by Masino and Niño-Zarazúa (2016) is as illustrated in Figure 4. The typology was constructed to determine the drivers of change for advancing education quality and student learning in developing countries. They identified three main drivers of change consisting: (i) interventions aiming to enhance the supply-side capabilities of educational institutions, (ii) interventions

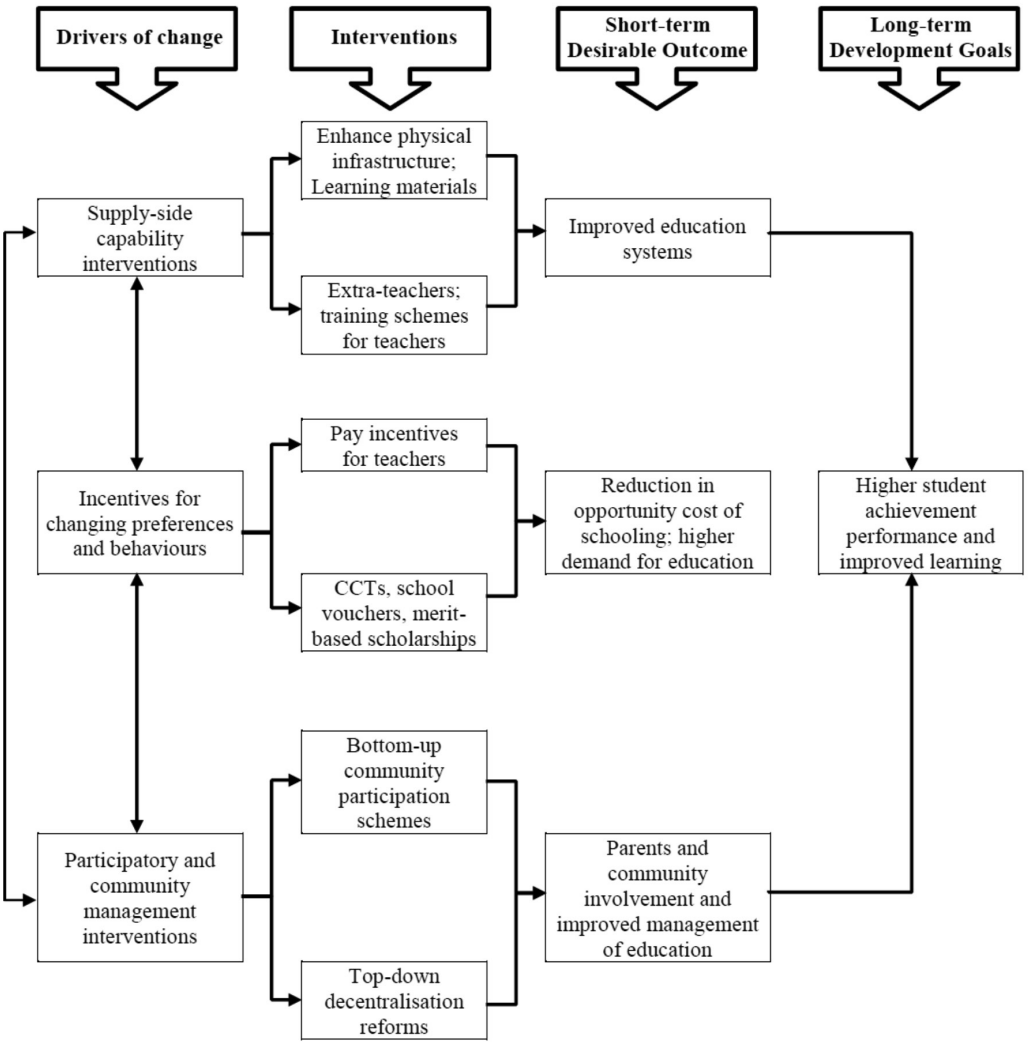

Figure 4: Theory of Change Flow Diagram (Masino & Niño-Zarazúa, 2016)

targeting supply-side and demand-side changes in preferences and behaviours that affect the utilisation of education services, and (iii) bottom-up and top-down participation and management interventions. In this work, we only focus on interventions (i) and (iii) as intervention (ii) is a complement for the other two. According to the evidences synthesized by Masino and Niño-Zarazúa (2016), effective interventions to enhance supply-side capability are typically the ones that: 1. do not limit policy strategies to the provision of supply-side capabilities, 2. able to overcome problems caused by demand-side factors, and 3. Introduce new teaching method. For participatory and community management interventions involving top-down approaches, the implementation is commonly carried out by government education agencies. The purpose of the interventions is to overcome the inefficiency of the management and operation in education systems. The strategies used are mostly decentralisation reform and the results of the intervention strategies show mixed results. This means that such intervention do not significantly improve the academic performance of students. For bottom-up policy strategies, community involvement successfully improved academic performance of students.

Interventions to Enhance the Supply-side Capabilities of Educational Institutions

Interventions such as enhancing teaching and learning material, improve curriculum, and providing training to teachers aim to enhance the supply-side capabilities of educational institution. These policies provide additional resources for schools and teachers (Masino & Niño-Zarazúa, 2016). Studies on the effectiveness of appointing School Improvement Specialists Coaches (SISC+) for Science subject was hardly found. For interventions that were studied, report from the literature shows that these interventions are not as effective as intended due to absent of complementary interventions.

Enhanced Learning Material and Curriculum

In conjunction with the STEM initiative launched in Malaysia, teaching and learning materials for STEM education have been enhanced. BPK (2016) wrote a few structured guidelines for educators to implement STEM in science classes. Educational videos, which either act as supplementary material to the guidelines or used as learning material, are accessible via http://btp.moe.gov.my/stem/video or http://www.eduwebtv.com/. These videos are collectively known as EduwebTV video (Ministry of Education, 2015). Even though the learning materials may have been enhanced, the materials will not be useful if the teacher or students fail to use it effectively. Abdullah *et al.* (2017) reported that teachers failed to create classroom environment that motivates students learning as they focused on following the procedure of implementing STEM education rigidly. This brings a negative impact towards the implementation of STEM education. Such a scenario is common in other countries. Several literatures reported that most teachers are unable to effectively use the engineering design desired by NGSS (New Generation Science Standards) or equivalent document drafted by relevant department in respective countries (Park *et al.*, 2016; Bahrum *et al.*, 2017; NIES, 2017). Complimentary interventions are needed to train teachers in using established guidelines.

Malaysia curriculum, namely 'Kurikulum Standard Sekolah Menengah (KSSM)' and 'Kurikulum Standard Sekolah Rendah (KSSR)', has only started to implement STEM integrated education in year 2017 for grade 1 (year 1 in primary school) and grade 7 (year 1 in secondary school). Teaching pedagogies recommended in the curriculum emphasizes the approach of teaching and learning that employs higher order thinking skills (HOTS). Focus has been given to inquiry-based learning, problem solving, contextual learning, collaborative learning, and project-based learning. These learning pedagogies have been studied by researchers of different region internationally and these positively reported as practically able to promote higher order thinking in students (Mustafa *et al.*, 2016). Policies that introduce new teaching method must be complement with suitable teacher training.

Calling for Complimentary Interventions

Ministry of Education Malaysia introduces several types of training for school teachers through the establishment of School Improvement Specialists Coaches (SISC+) for Science subject. It has been formed since year 2014 (Mahmud *et al.*, 2018). In the most recent *Panduan Pengurusan* published by Ministry of Education Malaysia (2017), it was indicated that the role of the coach is to enhance the teaching pedagogies and skills of in-service teachers to meet the needs of stakeholders from time to time. The teachers are trained to use creative and innovative pedagogy together with technology to attract and retain students' attention in classroom. The coaches themselves will also receive training on timely manner which serve as a part of continuous professionalism development. No studies were found regarding the effectiveness of SISC+. Perhaps intervention that provides incentives for in-service teacher or the coaches themselves to monitor new teaching method used from time to time either through financial incentives or through successful publication of active research could be established.

For pre-service teachers, the education for secondary school teachers in Malaysia may consider training the pre-service teachers to have the ability to teach several science subjects. This could increase the success rate in integrating STEM in their classroom lessons. In Korea, elementary school teachers practiced STEM lessons during regular classes more frequently compared to secondary school teachers. Park *et al.* (2016) explained that elementary school teachers are trained to have ability to teach all school subjects, whereas most of the secondary school teachers are trained to teach one specialized school subject. Thus, elementary school teachers have higher level of confidence in implementing STEM lessons than secondary school teachers. In Singapore, pre-service teachers are provided with comprehensive trainings at National Institute of Education (NIE). Three out of twelve academic groups in the institute are related to STEM based education namely (i) Learning Sciences and Technologies, (ii) Natural Sciences and Sciences Education, and (iii) Mathematics Education. These groups actively engage in finding new and innovative ways of delivering STEM content and pedagogy courses in order to develop the best practices for STEM education in Singapore. In addition, there is a special research center known as Centre of Excellence in Learning Innovation. One of its functions and responsibilities is to look into areas to refine, adapt and evaluate Singapore's Mathematics and Science curricula in United States (Idris *et al.*, 2013). As for China, training workshops and peer group projects have been developed focusing on developing science teachers' content knowledge and pedagogical knowledge. Inquiry method is the most common theme in their teacher professional development. Even though the teachers resisted to use inquiry method initially, they eventually became accustomed to the new curricula after going through workshops for several years. Some of these teachers even become routinely using inquiry science teaching pedagogies (Gao, 2012). In Finland, LUMA center offers summer courses, workshops and science fair for in-service teacher to develop their professionalism from time to time (Dobson, 2012).

Since year 1999, school teachers have been encouraged to participate in conferences to have conversation with educational researcher in higher institution to draft out teaching and learning methods that suits Malaysian student (Mahmud *et al.*, 2018). Complementary intervention such as rewarding teachers who dedicated themselves in carrying out action research. Ng and Adnan (2018) have demonstrated good example of such collaboration. Ng is an excellent teacher of Mathematics in Penang. Together with Associate Professor Dr. Adnan, they have conducted a research to identify the effectiveness of using project-based inquiry learning in SJK (C) Kai Chee. They found out that project based learning approach is the dominant strategy in STEM education implementation as it is able to improve students' skills and their capability to compete with others in the highly knowledge-based society. Li and Arshad (2015) have collaborated with 23 chemistry teachers from 13 different secondary schools to find out the status of inquiry teaching practices carried out by them in the schools. They found out the inquiry teaching practices need to be further improved. Mustafa *et al.* (2016) have used meta-analysis method to uncovered effective strategies for integrating STEM education used worldwide. Such findings are important to identify good STEM education practices. Teachers from other schools or even lecturers will benefit from these educational research works.

Interventions Involving Bottom-up and Top-down Participation and Management

Intervention involving bottom-up and top-down involve efforts to raise awareness and increase participation by local communities, parent-teacher associations, and parent committees. Such interventions have been carried out by the local agencies and parents. The studies on the effectiveness were not studied in Malaysia but literatures that study the effectiveness of similar strategies carried out in other countries reported

that such interventions are able to improve students' interest in STEM subjects.

Mass media plays an important role in creating awareness (Idris *et al.*; Ishikawa *et al*., 2013). In Malaysia, the involvement of mass media is not as active as media in other countries. Media in China actively involved in creating documentaries and entertainment shows that successfully attract viewers. In China, entertainment shows such as "Is it for real?" ("是真的吗?"), and "I am the future" ("我是未来") featuring STEM have been rolled out and received great attention in the region (Sina Entertainment, 2017; CCTV.com, 2014). In Singapore, magazines and newspapers have highlighted the careers in STEM related fields and also provided avenues for STEM related companies to put advertisements on job opportunities (Idris *et al.*, 2013). For third phase of the education blueprint, Ministry of Education of Malaysia may involve media to prepare interesting show that could engage public with STEM knowledge.

Involvement of Local Agencies

National STEM Movement Malaysia, was formed in year 2017 through a group of individuals, agencies and institutions working together to advance their shared passion on STEM programmes for the country (National STEM Movement, 2017). The movement was led by Professor Dato' Dr. Noraini Idris, Deputy Vice Chanselor of Universiti Pendidikan Sultan Idris (UPSI), supported by fellow academicians, industry partners, teachers and parents. Currently, STEM Content Providers Network acts as a platform for individuals and organizations who have effective STEM educational programs to champion. Their main role is to promote the Enhancing STEM Education Initiative under the auspices of Performance And Delivery Unit (PADU), Education Policy, Planning and Research Division (EPRD), and Ministry of Education Malaysia. Its main objective is to assist in accelerating the implementation of Enhancing STEM Education Initiatives as outlined in the National Education Blueprint. Malaysian Association of Creativity & Innovation (MACRI), one of its main partners, plays an important role in gathering STEM related content providers in Malaysia to organize awareness activities or workshops such as coding, robotics, life sciences exhibitions, drones, and 3D printing. Universities or relevant institution mainly become organizer for STEM related competitions (Friends of STEM and STEM Content Providers Network, 2018). National STEM Movement also established network with *Persatuan Guru STEM Malaysia* in order to engage with teachers more effectively. Several carnivals have been organized at different states in Malaysia to engage not only the students but also public about the interesting aspect of science and technology in daily life (Mohd Shahali *et al.*, 2017). Some carnivals are held at big scale such as "N9 STEM @ Nilai" while some are small depending on the number of organizations that involve in organizing the carnival. Most of the carnivals encourage direct involvement of visitors and the admission fee is normally waived. During the direct involvement session in carnivals, visitors were prompted to conduct scientific experiments with the guidance of exhibitors. Students who joined the carnivals learned STEM concept actively (Friends of STEM and STEM Content Providers Network, 2018). Such engagement with students and public are potentially effective. Singapore is one of the countries that score more than average in PISA 2015 and scored higher marks compare to England and US (Idris *et al.*, 2013). Idris *et al.* (2013) reported that this is partly contributed by higher number of students in Singapore (26%) participating in a camp or extracurricular activity that focuses on mathematics compared to United States (11%) and England (7%). Also, there are more students in Singapore who exposed themselves to quality STEM content through joining at least one mathematics competition over the past few years compared to England (20%) and United States (9%). Through participation in carnivals, students' interest in STEM subjects was found improved.

Involvement of Parent

Parental involvement refers to the interaction of parent with their child and also the interaction with school in promoting educational success (Hill *et al.*, 2004). Parental involvement has been reported to be associated with higher academic performance in students (Kelley-Laine, 1998). Parents are capable to improve children's motivation in learning STEM related subject by at least monitor or provide good learning environment for their children. Studies in Philippines showed that parents of high-achieving students have high expectation in their children and cited to have more concrete teaching strategies whereas parents of underachieving students are more lenient with their children study. The level of intention in parents to teach or to facilitate their children's learning is important especially in school that has large class size and poor facilities and resources. When parents are effortful in teaching their children, it can help compensate the limitations of school and optimize children's learning experiences (Garcia, 2018).

If parents are knowledgeable in STEM related subject, their child will be more likely to venture themselves in STEM related career too. Sociocultural theory posits that a child's learning is strongly influenced by the interactions which take place in the child's social context. Effective parent-child conversations and interactions in everyday life can contribute to the enhancement of children learning experiences outside the school. Also, the theory emphasizes the importance of the "zone of proximal development" as shown in Figure 5. The theory suggests that meaningful learning is more likely to take place if the knowledgeable others could provide support structures to help learner achieve the next level of learning. Public amenities such as science museums, bird parks, botanical gardens or even supermarket could provide opportunities and useful resources for parents to engage their children in deep and meaningful learning outside formal science classroom (Lee & Nie, 2015).

In the guidebook released by Ministry of Education Malaysia (2013b) namely 'Pelibatan Ibu Bapa', there is a section devoted for enculturation STEM (as educational policy) in their children's learning:

I. Assist children in learning subject related to sciences, technology, engineering and mathematics. ('Membantu anak-anak dalam mempelajari bidang sains, teknologi, kejuruteraan dan matematik').

II. Create awareness to children that knowledge in STEM is able to improve academic achievement and open more career opportunities ('Kesedaran kepada anak-anak bahawa menerusi STEM ini dapat meningkatkan pencapaian akademik dan memberikan peluang kerjaya dalam bidang sains dan teknologi').

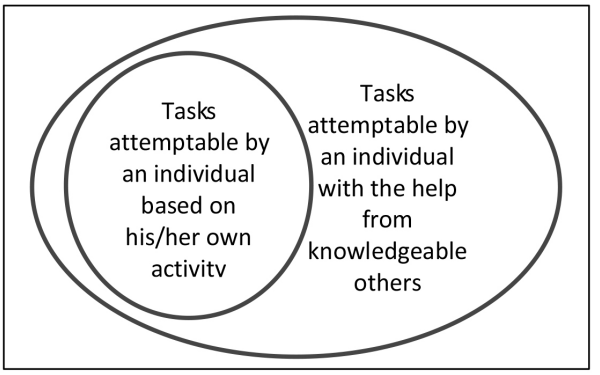

Figure 5: Zone of proximal development (Lee & Nie, 2015)

III. Increase motivation of children to venturing into the field of work in science and technology ('Meningkatkan minat anak-anak untuk menceburi bidang sains dan teknologi').

Recently, some of the schools in Malaysia have begun to employ a new type of parent involvement with school namely 'Sukarelawan dalam Kelas (SdK)'. This involvement allows parents and the community to become strategic partner that provide continuous support in their children learning activities. In SK Desa Pandan and SK Taman Kota Kulai 2, parents with relevant background joining this voluntary program will become teaching assistant or facilitator for teacher during a teaching session in classroom (Man, 2018). Their presence opens up more opportunity to conduct group activities or activities that involve movements of students to be well monitored. Based on the verbal feedback of the parents and teachers, this method is able to enhance students' learning experiences in classroom.

In Singapore, most of the parents have very positive attitude towards STEM related fields including those who belong to the middle-class category. About 30% of parents have a degree from public universities in the country. Students who excel in sciences and scoring higher score than average in Trends in International Mathematics and Science Study (TIMMS) are reported to be associated with both parents possessing high education qualification. These parents are aware that most of the high earning jobs require good knowledge in STEM subjects and the socio-economic status of the family could be improved. With this awareness, they are willing to send their children to undergo private tutorial sessions outside school hours to ensure their good achievement in STEM subjects. Good education background allows the parents to be in a better position to guide their children in joining workforce related to STEM fields. Studies carried out through TIMSS had consistently shown that students with more reading resources at home performed well in mathematics and science (Mullis *et al.*, 2012, p.158). Students with more literacy resources have higher achievement on average in mathematics and science compared to students with less literacy resources (TIMSS, 2003; 2007). Singapore is one of the countries with 30% of the students reporting having more than 100 books at home (Idris *et al.*, 2013).

Conclusion

Science education aims to develop learner's science literacy through the acquisition of scientific knowledge and scientific reasoning skills so that they can gain a better understanding of how things work in the natural world. With competent knowledge, they would be able to contribute to the sustainability of the natural environment and improve the quality of human life. From this study, it was found that the effectiveness of teaching and learning method in Malaysia need to be determined on a regular basis. Further research work may focus on studying the effectiveness of each interventions using quantitative method.

Acknowledgements

The author would like to acknowledge Research Innovation & Enterprise Centre of Universiti Malaysia Sarawak, Associate Professor Ramlah Zainudin, and Madam Noor Azie Azura Mohd Arif for their supports and encouragements during the completion this work.

References

Abdullah, A. H., Hamzah, M. H., Hussin, R. H. S. R., Kohar, U. H. A., Rahman, S. N. S. A., & Junaidi, J. (2017). Teachers' readiness in implementing science, technology, engineering and mathematics (STEM) education from the cognitive, affective and behavioural aspects. In *Teaching, Assessment, and Learning for Engineering (TALE), 2017 IEEE 6th International Conference on* (pp. 6-12).

ACT Inc., U. (2017). *STEM Education in the U.S.: Where We Are and What We Can Do (2017)*.

BPK, Bahagian Pembangunan Kurikulum Malaysia (2016). 'Panduan Perlaksanaan Sains, Teknologi, Kejuruteraan dan Matematik (STEM) dalam Pengajaran dan Pembelajaran'.

Bahrum, S., Wahid, N., & Ibrahim, N. (2017). Integration of STEM education in Malaysian and why to STEAM. *International Journal of Academic Research in Business and Social Sciences*, *7*(6), 645-654.

Beth C. G., Alina M., & Laurie B. (2017). Calling STEM experts: how can experts contribute to students' increased STEM engagement? *International Journal of Science Education, Part B*, *7*(1), 31-59.

Cory B., Susan H., Yolanda D. P., & Martha A. (2017). Using the Sociology of Associations to Rethink STEM Education, *Educational Studies*, *53*(6), 587-600.

CCTV.com. (2014). Ratings of shows broadcasted on channel CCTV-2 in year 2013. http://1118.cctv.com/20140117/105063.shtml, [*2013 CCTV-2*].

OECD, Organization for Economic Cooperation and Development. (2016). *Education in China, A Snapshot*.

OECD, Organization for Economic Cooperation and Development. (2018). Data-PISA. http://www.oecd.org/pisa/data/.

Council, N. R., & others. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*. National Academies Press.

Dobson, I. R. (2012). *Consultant Report Securing Australia's Future STEM: Country Comparisons*.

Feinstein, N. W., & Kirchgasler, K. L. (2015). Sustainability in science education? How the next generation science standards approach sustainability, and why it matters. *Science Education*, *99*(1), 121-144.

Friends of STEM and STEM Content Providers Network (2018). *STEM Content Provider Network*. http://www.stem-malaysia.com/.

Gao, Y. (2012). *Consultant Report Securing Australia's Future STEM: Country Comparisons*.

Garcia, A. (2018). *Parental Involvement Among Low-Income Filipinos: A Phenomenological Inquiry*. Thesis of Doctor of Philosophy, University of Nebraska.

Glancy, A. W., & Moore, T. J. (2013). Theoretical foundations for effective STEM learning environments. *School of Engineering Education Working Papers*. Paper 1. https://docs.lib.purdue.edu/enewp/1/

GAO, Government Accountability Office, U. S. (2018). *Trends Affecting Government and Society*.

Halim, L., & Meerah, T. S. M. (2016). Science education research and practice in Malaysia. In *Science Education Research and Practice in Asia*. Springer. pp. 71-93.

Hill, N. E., Castellino, D. R., Lansford, J. E., Nowlin, P., Dodge, K. A., Bates, J. E., & Pettit, G. S. (2004). Parent academic involvement as related to school behavior, achievement, and aspirations: Demographic variations across adolescence. *Child Development*, *75*(5), 1491-1509. Idris, N., Daud, M. F., Meng, C. C. & Eu, L. K. (2013). Country report Singapore STEM.

Ishikawa, M., Fujii, S., & Moehle, A. (2013). Consultant Report Securing Australia's Future STEM: Country Comparisons.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, *3*(1), 11.

Kelley-Laine, K. (1998). Overview of 9 OECD Nations: Parents as Partners in Schooling: The Current State of Affairs. *Childhood Education*, *74*(6), 342-345.

Khine, M. S. (2015). *Science Education in East Asia: Pedagogical Innovations and Research-informed Practices*. Springer, 3 pp.

Kim, Y., Chu, H., & Lim, G. (2015) Science Curriculum Changes and STEM Education in East Asia. In: Khine M. (eds.) *Science Education in East Asia*. Springer, Cham.

Ledbetter, N. L. (2018). STEM Shift Action Plan. *Transformations*, *4*(1), 28-44.

Lee, A.N., & Nie Y. (2015). The 'Why' and 'How' of Engaging Parents in Their Children's Science Learning in Informal Contexts: Theoretical Perspectives and Applications. In: Khine M. (eds.) *Science Education in East Asia*. Springer, Cham.

Li, W. S. S., & Arshad, M. Y. (2015). Inquiry Practices in Malaysian Secondary Classroom and Model of Inquiry Teaching Based on Verbal Interaction. *Malaysian Journal of Learning and Instruction*, *12*, 151-175.

Mahmud, S. N. D., Nasri, N. M., Samsudin, M. A., & Halim, L. (2018). Science teacher education in Malaysia: challenges and way forward. *Asia-Pacific Science Education*, *4*(1), 8.

Maltese, A. V., Lung, F. D., Potvin, G., & Hochbein, C. D. (2012). *Consultant Report Securing Australia's Future STEM: Country Comparisons*.

Man, S. H. (2018). Kolaboratif Kreatif Sekolah dan Komuniti: Merangkai Titik-titik Fokus Sekolah TS 25. In *Seminar Nasional Pengurusan dan Kepimpinan Pendidikan ke-25*.

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). STEM: country comparisons: international comparisons of science, technology, engineering and mathematics (STEM) education. Final report.

Masino, S., & Niño-Zarazúa, M. (2016). What works to improve the quality of student learning in developing countries? *International Journal of Educational Development*, 48, 53-65.

Ministry of Education Malaysia (2013a). STEM Education: Policies and prospects towards achieving international standard and meeting national development needs. *https://www.akademisains.gov.my/download/STEM%20Education_Dr%20Azian.pdf*.

Ministry of Education Malaysia (2013b). *Pelibatan Ibu Bapa*. *https://www.moe.gov.my/images/KPM/UKK/2018/01%20Jan/BahanPelibatanIbuBapaSarana2.pdf*,

Ministry of Education Malaysia (2015). eduwebtv videos. http://www.eduwebtv.com/

Ministry of Education Malaysia (2017). *Panduan Pengurusan Program Transformasi Daerah*. *https://www.moe.gov.my/index.php/my/arkib/pemberitahuan/2017/3425-panduan-pengurusan-program-transformasi-daerah-dtp-3-0*,

Ministry of Education Malaysia (2017). *Sarana Penglibatan Ibu Bapa Penjaga Dengan Pembelajaran Anak. https://moe.gov.my/index.php/my/sumber/muat-turun/garis-panduan/item/sarana-ibu-bapa,*

Mohd Shahali, E. H., Ismail, I., & Halim, L. (2017). STEM education in Malaysia: Policy, trajectories and initiatives. *Asian Research Policy*, *8*(2), 122-133.

Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K-12 STEM education. In *Engineering in pre-college settings: Synthesizing Research, Policy, and Practices*. Purdue University Press.

Mullis, I. V., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics.* ERIC.

Mustafa, N., Ismail, Z., Tasir, Z., Said, M., & Haruzuan, M. N. (2016). A meta-analysis on effective strategies for integrated STEM education. *Advanced Science Letters*, *22*(12), 4225-4228.

NIES, National Institute of Education Sciences China (2017). *China STEM Education White Paper /*中国 *STEM* 教育白皮书*/*.

Ng, C. H., & Adnan, M. (2018). Integrating STEM education through Project-Based Inquiry Learning (PIL) in topic space among year one pupils. In *IOP Conference Series: Materials Science and Engineering* (Vol. 296, p. 012020).

National STEM Movement (2017). STEM content provider network. *http://www.stem-malaysia.com/*,

OSTP, Office of Science and Technology Policy, W. H. (2018). *Summary of the 2018 White House State – Federal STEM Education Summit*.

Park, H., Byun, S., Sim, J., Han, H., & Baek, Y. S. (2016). Teachers' Perceptions and Practices of STEAM Education in South Korea. *Eurasia Journal of Mathematics, Science \& Technology Education*, *12*(7).

Riihimäki, S. (2018). Education export at its best: LUMA Centre opens in China. *http://www.tut.fi/en/about-tut/news-and-events/archive/X228232C2*.

Roehrig, G. H., Moore, T. J., Wang, H.-H., & Park, M. S. (2012). Is adding the E enough? Investigating the impact of K-12 engineering standards on the implementation of STEM integration. *School Science and Mathematics*, *112*(1), 31-44.

Sina Entertainment (2017). "I am the future" received high attention and praise: People's daily newspaper acknowledge. *http://ent.sina.com.cn/tv/zy/2017-08-01/doc-ifyinvwu4260598.shtml*

Susan, E., & Adrianna, K. (2017). Increasing student success in STEM: Summary of a guide to systemic institutional change, *Change: The Magazine of Higher Learning*, *49*(4), 26-34.

Tanenbaum, C. (2016). *STEM 2026: A Vision for Innovation in STEM Education*.

Wayne, N. (2017). Implementing the ASEAN Work Plan on Education, 2016-2020 through a Collaborative Social and Sustainability Sciences Assessment Contributing to SDGs and COP 21 Action. In *Symposium: ASEAN Way Forward for SDGs and COP21 Social and Sustainability Sciences*.