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TEACHER READINESS TOWARDS INTEGRATING STEM EDUCATION INTO TEACHING AND LEARNING

Norazla Mustafa (a)*, Zaleha Ismail (b), Zaidatun Tasir (c), Mohd Nihra Haruzuan Mohamad Said (d)
*Corresponding author

(a) Department of Educational Sciences, Mathematics and Creative Multimedia, Faculty of Education, Universiti Teknologi Malaysia, Malaysia, norazla182@gmail.com
(b) Department of Educational Sciences, Mathematics and Creative Multimedia, Faculty of Education, Universiti Teknologi Malaysia, Malaysia, p-zaleha@utm.my
(c) Department of Educational Sciences, Mathematics and Creative Multimedia, Faculty of Education, Universiti Teknologi Malaysia, Malaysia, p-zaida@utm.my
(d) Department of Educational Sciences, Mathematics and Creative Multimedia, Faculty of Education, Universiti Teknologi Malaysia, Malaysia, nihra@utm.my

Abstract

Integrated STEM education is a combination of science, technology, engineering and mathematics into one lesson with connection of real-world problems that binds these four disciplines (Moore, Johnson, Peters-Burton, & Guzey, 2016). Despite its numerous benefit in teaching and learning, integrated STEM education is still not widely implemented in schools or practise by teachers. This study aims to identify teachers' readiness, knowledge and practices towards the integration of STEM education in teaching and learning. This survey was administered offline and online involving 107 teachers. The respondents were obtained through convenient random sampling. A 4 point likert scale based on adapted questionnaire which consisted of 5 constructs namely frequency, efficiency, benefits, awareness and attitudes (Samu, 2012; Siew, Amir, & Chong, 2015). Data was analysed descriptively. The results showed that teachers had moderate skills in integrating STEM in their teaching and learning activity and rarely integrate STEM education in preparing their lessons. However, they showed sign of positive attitude towards STEM implementation and well aware of the importance and benefit of STEM for students to attain 21st century skills. This study shared some insights of the teachers' perceptions in terms of the implementation of integrated STEM education in Malaysian secondary school.

Keywords: Readiness, STEM approach, integrating, teaching and learning. .

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1. Introduction

Integrated STEM emphasize on integrating other subjects (science social, arts and humanity) into mathematics and science pedagogy. Integrated STEM focuses on real-life situations to be implemented in meaningful student-centred learning activities to enhance students' creative and critically thinking as well as confidence in applying engineering design in their learning (Moore et al., 2016). It is believed that integrating content and process of science and/or mathematics with the content of technology and/or engineering is defined as Integrative STEM. In spite of continuing the conventional teaching practise that focused on learning the STEM subjects separately, teachers should be equipped with knowledge and teaching strategy that best support STEM education (Sanders, 2009). This is to ensure that mind set of teachers can be cultivated and apply the STEM pedagogical approaches in teaching. In spite of continuing the conventional teaching practise that focuses on learning the STEM subjects separately, teachers should be equipped with knowledge and teaching strategy that best support STEM education. This is to ensure that mind set of teachers can be cultivated and apply the STEM pedagogical approaches in their classroom.

Many countries in the world are very concerned about the integration of STEM in their education system as they believe that STEM skills are tremendously important for economic global. Hence, aligning with the need of 21st century skills, educational system in Malaysia is focusing on science, technology, engineering and mathematics (STEM) to generate innovative thinking citizens that capable to compete in the future global challenges (Ministry & Education, 2012). Hence, sharpening skills and abilities of teachers has become one of the initiative in Malaysian Blueprint 2013-2025.

Despite its numerous benefit in teaching and learning, integrated STEM education is still not widely implemented in schools or practised by teachers. Teachers in Malaysia were trained to ensure that students are able to grab and master the skills for each subject during their instructional lessons so that it can be applied in the exams. In their understanding, teaching approach that emphasis on quantity of factual knowledge or one true solution for every question in each STEM subject has been seen as an effective measure and proven to improve students' achievement. However, blaming solely on the teachers' instructional practices is unfair and inappropriate as they are inadequately expose to engineering design domain.

Even though the teachers are aware that integrated STEM provide exposure to real-world problem solving normally involves engineering and technology domain to solve the problem, teachers find out that the STEM education is quite challenging to be implemented as provision of guidelines or modules is still scarce. Previous study agreed that STEM education provides meaningful situated and contextualized learning opportunities (Kezar & Elrod, 2012; Tseng, Chang, Lai, & Chen, 2013) and increased awareness among teachers to increase the quality of their instruction. Hence, it is necessary for the teachers to be the medium of change in implementing STEM education, help in fostering this essential skill to the upcoming generation. Teachers must be physically and mentally ready to help students to understand the relationship between the STEM skills with the real world issues such as natural disasters and epidemic diseases as it require professionals with good thinking skill to lay out a good contingency plan. Therefore, young generations should be trained to develop critical and creative thinking to enable them to face these kind of obstacle later in the future.

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In fact, countries like United States of America, Korea and Singapore has taken positive measures by providing trainings to their in-service teachers as an effort to integrate STEM education in school. Although Malaysia too has started to take serious action to implement STEM in teaching and learning, teachers still unaware about STEM due to insufficient exposure. Therefore, teachers education program should include elements that are geared towards scientific investigation, reasoning and mathematical thinking, engineering design and 21st century skills (Bunyamin & Finley, 2016). Research that reviewed of the students' science process skills shows an increase when teachers are adequately exposed to STEM integration in teaching and learning with the help of the EnsciT module (Lilia, Ahmad, Abdullah, & Meerah, 2012). With this point of view, this study aims to identify the readiness of teachers towards the integration of STEM education in teaching and learning.

2. Problem Statement

2.1. Implementation of Integrated STEM Education

Confusion on STEM arose as STEM education is defined in many ways as separated, disconnected and focused only on science and mathematics (Breiner, Harkness, Johnson, & Koehler, 2012; ; Wang, Moore, Roehrig, & Park, 2011 Sanders, 2009). It has been emphasized that STEM should refer to an integrative approach or instruction (Bybee, 2010) to enable~~s~~ the skills in STEM discipline to be taught as one (Morrison & Raymond Barlett, 2009) as *"STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy"* (Tsupros, 2009).

Teacher should be aware that implementing STEM in the lesson does not required them to include all the STEM discipline at once (Kelly & Knowles, 2016), the exposure towards the skills connections among the discipline of STEM is more important. These exposures help students to apply their knowledge and problem-solving skills to relate students learning experiences with the real life activities. Thus, promotes a higher order thinking skills that leads students to be more critical and innovative. In order to achieve this, teachers' should be more flexible in adapting their experiences with the new world paradigm skills and competencies. It is hoped that teacher manage to enhance their readiness in the implementation of STEM and to be prepared with precise knowledge and skills to avoid any technical failure that has occurred during the implementation of Teaching Mathematics and Science in English (PPSMI) in the previous years. The reasons behind the discontinuation of PPSMI is because teachers are more comfortable using their mother tongue language in delivering the instruction and low proficiency in English language skill (Asri, Ahmad, S., & Asliaty, 2011). Teachers as implementers were not allocated with sufficient time duration to familiarize and master themselves with the new approach proposed. As a result, the implementation process of the newly transformed teaching and learning practice was affected and loss its effectiveness along the line.

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2.2. STEM Education in Malaysia

Confusion on STEM arose as STEM education is defined in many ways as separated, disconnected and focused only on science and mathematics (Breiner et al., 2012; Sanders, 2009; Wang et al., 2011). STEM education is an interdisciplinary approach that focuses on relating academics skills with real-world problems especially when students apply science, technology, engineering and mathematics in solving problem involving school, community and global issues (Bybee, 2010; Morrison & Raymond Barlett, 2009; Tsupros, 2009).

Teacher should be aware that implementing STEM in the lesson does not required them to include all the STEM discipline at once (Kelly & Knowles, 2016), the exposure towards the skills connections among the discipline of STEM is more important. These exposures help students to apply their knowledge and problem-solving skills to relate students learning experiences with the real life activities. Thus, promotes a higher order thinking skills that leads students to be more critical and innovative. In order to achieve this, teachers' should be more flexible in adapting their experiences with the new world paradigm skills and competencies. It is hoped that teachers manage to enhance their readiness towards the implementation of STEM by gaining more information on teaching aids and activities that is suitable for integrating STEM. Teacher should be prepared with precise knowledge and skills to avoid any technical failure that has occurred during the implementation of Teaching Mathematics and Science in English (PPSMI) in the previous years. The reasons behind the discontinuation of PPSMI is because teachers are more comfortable using their mother tongue language in delivering the instruction and low proficiency in English language skill (Asri et al., 2011). Teachers as implementers were not allocated with sufficient time duration to familiarize and master themselves with the new approach proposed. As a result, the implementation process of the newly transformed teaching and learning practice was affected and loss its effectiveness along the line.

3. Research Questions

The readiness of teachers was very important to ensure they were well equipped with knowledge on effective ways to engage their students in STEM literacy. Therefore, this study explore the readiness of teachers in terms of frequency, efficiency, benefits, awareness and attitudes towards the implementing of integrated STEM into their teaching practice. The research questions that lead this study are as follows:

(a) How frequent teachers implement STEM education in teaching and learning?
(b) How effective is the implementation of STEM education in teaching and learning?
(c) How the implementation of STEM education in teaching and learning benefit the teachers?
(d) How is the awareness of teachers on the implementation of STEM education in teaching and learning?
(e) How are the attitudes of teachers on the implementing of STEM education in teaching and learning?

4. Purpose of the Study

The purpose of the study was to investigate teachers' perspectives in terms of readiness, knowledge and practices towards the integration of STEM education in teaching and learning. The findings in this

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study will give some insights to the researcher in developing an appropriate learning module using STEM approach.

5. Research Methods

5.1. Research Design

The research design of this study was a quantitative descriptive survey in which the readiness of teachers towards integrating STEM education in their teaching and learning were investigated. An adapted 4-Likert scale based questionnaire (Samu, 2012; Siew et al., 2015) were used to gather the data from the teachers. The questionnaires were disseminated through online via Google Form and paper-based survey form. The link of the online form was posted in social media and sent through email. An online survey form was designed for teachers who preferred to respond using Internet access. The online surveys save the cost, easier in terms of reachable and a popular platform. The paper-based questionnaire was distributed to teachers using convenient sampling. Both questionnaires were given time frame to be answered and returned.

5.2. Sample

The sample of this study consisted of 107 teachers from public secondary schools in Malaysia through convenient sampling. Any teachers that meet the criteria outlined were accepted as sample due factors of availability, easily accessible and willingness of the respondent. The sample comprised of 58 females (54.2%) and 49 males (45.8%) teacher that teaches science, mathematics and or technical subjects in secondary schools in Malaysia. About 38.9% of the respondents are teaching mathematics, 27.8% are science teachers, and 15.4% taught both mathematics and science subjects while the others are technical teachers who taught Engineering Drawing or Accounting. They have at least 5 years teaching experience. About 53.2% of them are bachelor degree holders, 44.9% holding a master degrees and 1.9% are teachers with doctorate degree.

5.3. Instruments

The instrument consists of five sections; Part A: Demographic data for participants, Part B: Frequency of implementing Integrated STEM Education, Part C: Efficiency in Implementing STEM, Part D: Benefits of Integrated STEM education, Part E: Awareness of STEM Implementation and Part F: Attitudes towards Integrated STEM. Part B to F was four constructs used to identify the readiness of integrating STEM education in teaching and learning among Malaysian secondary school teachers. The 32-item in this questionnaire using responses ranging from 1 to 4 as shown in Table 1. Pilot study was conducted to ensure the reliability of the questionnaire. The reliability index for each construct were anlayzed and shown in Table 1. Any Cronbach's Alpha value ranged from 0.70 to 0.93 were considered "respectable" to "excellent" (DeVillis, 1991) hence, the Cronbach's Alpha for each constructs in the questionnaire are very consistent (Cronbach, 1951) and has high reliability

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Table 01. Likert Scale for Five Constructs

Constructs	1	2	3	4	Cronbach Alpha
Frequency	Never	Rarely	Very Often	Always	.932
Efficiency	Ineffective	Moderately Effective	Effective	Very Effective	.835
Benefits	Strongly Disagree	Disagree	Agree	Strongly Agree	.856
Awareness	Strongly Disagree	Disagree	Agree	Strongly Agree	.857
Attitudes	Strongly Disagree	Disagree	Agree	Strongly Agree	.714

5.4. Data Analysis

The collected data was analysed descriptively, using Statistical Program for Science Social (SPSS) specifically for frequency, percentage and median. The higher median values for each of the constructs reflect that these elements are important from the point of view and readiness of respondents.

6. Findings

Results of the study indicate that 36% of the teachers had exposed to STEM course during their study in university, while 64% had never attend any professional development for integrating STEM education in their teaching and learning. Figure 1 shows additional information on demographic part.

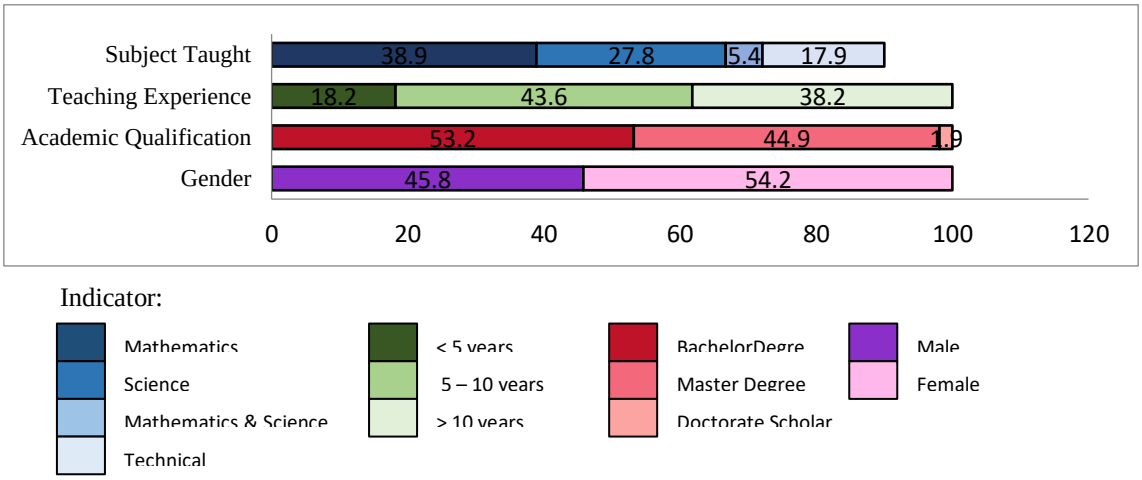

Figure 01: Demographic Data

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6.1. Teachers' Readiness on Frequency of Integrating STEM Education in Teaching and Learning

Table 02. Summary of percentage and median for efficiency of teachers implementing integrated STEM education in their instructions

	I used Integrated STEM education to	N	Never	Rarely	Very Often	Always	Median
F1.	prepared lesson materials	107	11.2	40.2	36.4	12.1	2.00
F2.	diversifying teaching approaches	107	23.4	40.2	26.2	10.3	2.00
F3.	carried out enrichment activities	107	14.0	51.4	27.1	7.5	2.00
F4.	guide students to master the skills	107	15.9	51.4	32.7	-	2.00
F5.	guide the students to relate the skills learned with daily life situations	107	13.1	58.9	26.2	1.9	2.00
F6.	increase students' understanding	107	12.1	51.4	33.6	2.8	2.00
F7.	improve students' achievement	107	12.1	54.2	27.1	6.5	2.00
F8.	monitor student learning progress	107	18.7	55.1	24.3	1.9	2.00
F9.	guide student to find new information and ideas	107	21.5	49.5	25.2	3.7	2.00
F10.	help students to relate the skills between STEM subjects	107	6.5	48.6	34.6	10.3	2.00

Based on the findings in Table 1, most of the teachers have moderate skills in integrated STEM education implementation in their teaching and learning as they rarely used it. The survey revealed that teachers that used STEM when they prepared lesson material would also help the students to relate the skills between STEM subjects. They guide their students to master the skills so that it willincrease students' understanding and achievement. On the other hand, teachers that never use STEM in their lesson would also never guide the students to find new information and ideas. They also never help the students to relate the skills between STEM subjects as they realize that there is no point to emphasize on it because they concern more on the students' ability to obtain good grades.

6.2. Teachers' Readiness on Effectiveness of Integrating STEM Education in Teaching and Learning

Table 03. Summary of percentage and median for efficiency of teachers implementing integrated STEM education in their instructions

	I used Integrated STEM education to	N	In effective	Moderately Effective	Effective	Very Effective	Median
E11.	prepared lesson materials	107	18.7	48.6	25.2	7.5	2.00
E12.	diversifying teaching approaches	107	15.0	57.0	23.4	4.7	2.00
E13.	carried out enrichment activities	107	16.8	49.5	33.6	-	2.00
E14.	guide students to master the skills	107	15.9	52.3	29.0	2.8	2.00
E15.	guide the students to relate the skills learned with daily life situations	107	9.3	50.5	32.7	7.5	2.00

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As expected, the average median for efficiency constructs proved that teacher were not efficient in implementing the STEM approach. None of the teachers were very effective in using STEM approach for preparing the enrichment activities but their effort in preparing lesson materials and diversifying their teaching approaches could be classified as moderately effective. The teachers also guide their students to relate the skills they have learned with the problem in their daily life. However, this study also revealed that almost 30% of the teachers quite effective in preparing and implementing STEM approach in their classroom. They tried to diversify the teaching approaches to help the students in mastering the skills they have learned.

6.3. Benefits of Integrating STEM Education in Teaching and Learning

Table 04. Summary of percentage and median for benefits of teachers implementing integrated STEM education in their instructions

	STEM Education in teaching and learning will	N	Strongly Disagree	Disagree	Agree	Strongly Agree	Median
B16	improve student problem solving skills	107	-	15.9	53.3	30.8	3.00
B17	provide equal learning opportunities to all students who have a variety of capabilities	107	1.9	32.7	59.8	6.0	3.00
B18	increase students' motivation to think critically	107	-	31.8	57.0	11.2	3.00
B19	create a learning environment that is fun and challenging	107	1.9	23.4	56.1	18.7	3.00
B20	allow students to access and relate the skills in each STEM field	107	-	17.8	61.7	20.6	3.00
B21	encourage creativity and innovation	107	-	12.1	60.7	27.1	3.00
B22	build up confidence in making a decision	107	-	23.4	55.1	21.5	3.00
B23	produce future workforce that is competitive with the 21st century	107	-	12.1	58.9	29.0	3.00

Implementation of STEM approach in the teaching and learning process had big potential to improve students' problem solving skills. They believe that these approaches allow students to access and relate the skills between STEM subjects to overcome the different level of achievement among students. Overall, they acknowledged the important of STEM approach in their instruction to encourage the critical thinking and innovative future workforce that is competitive with the 21st century and have high confidence in making big decision in certain situation. Even though some researcher believe that STEM approaches provide better understanding in scientific and engineering fields, 1.9% claim that these approaches failed to provide an equal learning opportunities and created uncomfortable learning environment especially for low achievers' students as they cannot build up their own knowledge and understanding.

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6.4. Awareness of Integrating STEM Education in Teaching and Learning

Table 05. Summary of percentage and median on teachers' awareness of using integrated STEM education

		N	Strongly Disagree	Disagree	Agree	Strongly Agree	Median
A24.	I am aware of the implementation of STEM	107	2.8	15.9	59.8	21.5	3.00
A25.	I incorporate STEM education in some of my lesson	107	3.7	31.8	62.6	1.9	3.00
A26.	I think that my students will be interested in learning using STEM education	107	0.9	18.7	55.1	25.2	3.00
A27.	I know that STEM education will motivate my students	107	0.9	15.9	69.2	14.0	3.00
A28.	I would like to adapt the STEM education based on my students' capability	107	0.9	8.4	53.3	37.4	3.00
A29.	I realize that some of the topics can be taught using STEM education	107	-	24.3	28.6	27.1	3.00
A30.	I think that my students will be motivated to learn when they can see a link between STEM subjects	107	0.9	11.2	48.6	39.3	3.00

The result from Table 5 indicated that only 0.9% strongly disagrees that integrated STEM education would trigger students' motivation in learning. They believe that the students' interest does not depend on whether the STEM subjects are related to the real-world situation or not. Therefore, teachers showed less interest in adopting integrated STEM education in their classroom. On the other hand, 1.9 % strongly agrees and 62.6% agree to incorporate STEM in their instruction although only 28.6% of them realized that some of the topics could be taught using STEM education. However, more than 50% showed positive perception towards STEM, therefore they are aware about the implementation of STEM. The higher median value for each construct shows positive sign of teacher's awareness about STEM implementation.

6.5. Attitude of Integrating STEM Education in Teaching and Learning

Table 06. Teachers' attitude towards using STEM approach in their teaching

		N	Strongly Disagree	Disagree	Agree	Strongly Agree	Median
S31.	STEM approach is easy to be implemented	107	-	9.3	66.4	24.3	3.00
S32.	Teachers need to know how to integrate STEM in their lesson	107	-	0.9	15.9	83.2	3.00
S33.	STEM education is important	107	-	7.5	43.0	49.5	3.00
S34.	Learning is more effective with the integration of STEM	107	-	6.5	51.4	42.1	3.00
S35.	The role of teachers will change with the implementation of STEM	107	-	8.4	72.9	18.7	3.00
S36.	I am comfortable using STEM approach in my lesson	107	-	8.4	77.6	14.0	3.00

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Despite of low mean value for frequency and efficiency constructs, none of the teacher shows negative attitudes towards integrated STEM education. Table 6 indicated less than 10% of the teachers disagreed about the importance of knowledge in implementing STEM. Yet, more than 70% agreed that teacher's role in the classroom will be change from traditional role to an effective facilitator. Thus, they are flexible and comfortable with the implementation of integrated STEM education.

7. Conclusion

The research findings support the conclusion that teacher shows a positive sign of perception towards STEM education but lack of knowledge and skills towards implementation of STEM in teaching and learning (Breiner et al., 2012; Brown, Brown, Reardon, & Merril, 2011). This findings proved that teacher were ineffective in handling integrated STEM education in teaching and learning because they still below adequate proficiency levels in STEM. Therefore, teachers need to develop deep understanding on integrated STEM education to help them overcome some issues prevailed during the implementation and improve the quality of teaching practice to compete with more technology literacy students. Students nowadays needs to embrace an interesting and active learning to enable them to transfer and apply their reasoning and understanding towards real-world application and the skills that they have learnt in school. The aim to improve the teachers' ability and STEM skills are one of the initiatives outlined in the Malaysian Blueprint 2013 – 2025. Enhancing content knowledge and pedagogical content knowledge will provide teachers with diverse strategies to engage students' in problem solving activities and guide them to think critically and innovatively.

Teachers' responses indicated that they are concerned about STEM but the time constraint and the heavy workloads are the major problem for the STEM implementation in teaching and learning. They faced obstacles to prepare STEM materials, to deliver STEM instruction and to carry out STEM learning as only 200 minutes per week were allocated to cover the syllabus required for each subject. Within the time frame given, teachers need to transmit knowledge and information to students due to the content-heavy curriculum. Examination-oriented system itself forced teachers to imply drilling strategies in order to ensure the students get good grades. Hence, the traditional approaches suits the need to produce a lot of A's in students with less focus on the learning process itself. Apart from teaching, teachers need to cope with co-curricular activities and non-teaching tasks too. Teacher workload should be reduced to ensure that they have enough time to prepare for STEM lesson and provide an appropriate strategies to increase students' understanding that STEM are interrelated skills to solve problem (Ejiwale, 2013). Since STEM sources for classroom lesson in Malaysian context are limited, teachers need a clear guideline to prepare instructional materials or enrichment activities related-STEM. After all, the differences in level of students' ability might be the main factor causing them rarely used integrated STEM education in their instruction (Myers & Washburn, 2008; Stubbs & Myers, 2016). Teachers need more time to enhance the understanding the function of skills in STEM subjects to the real-world situation for lower achievement students.

Teachers Professional Development might be a good start for in-service teachers to encourage them in implementing STEM as previous research indicated that science and mathematics teachers lack on pedagogical content of STEM education (Nadelson et al., 2013). This is happening because most of the teacher were trained in one subject only and has no background in STEM education (El-Deghaidy &

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Mansour, 2015). Therefore, they find that implementing STEM approach in their classroom would be challenging and time constraint. Based on the demographic data, most teachers had been teaching for more than five years with a qualification of degree in science, mathematics or technical. That means they have less basic knowledge towards STEM education and only a few of them had an opportunity to attend professional development courses related to STEM. Some teachers do not run in-house training to colleagues upon completion of the course so the knowledge of STEM are not dispersed among teachers. Therefore, ongoing professional development training in STEM subjects should be extended in order to improve the pedagogical content of knowledge and skills among teachers (Hibpshman, 2007). The failure to provide the teachers professional developments will decrease the chance of success in STEM implementation (Ejiwale, 2013). Hence, they need a proper training on preparing STEM material such as module, lesson plan or hands-on activity that can be used in the classroom. It was stated that Mathematics and Science teacher are lack of knowledge with hands on activity in STEM education. Teachers also pay less attention to engineering design and this risks the successfulness of implementation of STEM education (Coppola & Malyn-Smith, 2010).

Even though teachers are experienced with an average of teaching experience for more than five years, the teaching qualification that they had obtained were limited to one subject. Thus, they learnt science, mathematics, engineering and technology as an isolated subjects causing them to face the difficulties to integrate STEM education in the teaching and learning. Teachers play a crucial role in designing 21st century learning by implementing integrated STEM education in their lesson instead of just planning for traditional instruction. Teacher's attitude and willingness to incorporate technology and engineering into science and mathematics lesson were required to encourage students' engagement (Levin & Wadmany, 2008). Instead of using traditional approach for all students, an effective teacher must be able to design an instruction that provide experiential and authentic learning and expose students to innovation and critical thinking.

Overall, the quality of teachers' training and in-service teachers program should be enhanced with more exposure on STEM integration and STEM-based learning materials to develop the 21st century skills among students. Teachers' competence in implementation of STEM approach in their teaching and learning depends on their understanding of STEM definition, awareness on the importance of STEM education and their attitudes on relating academic skills to real-world situation. Hence, teachers need to be equipped with STEM content knowledge and pedagogical skills to ensure the successfulness of STEM integration. Otherwise, our target to develop understanding and increase high achievement in science and mathematics throughout the engineering design approach and technology design will be hard to achieve within the time frame allocated in the national education blueprint.

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