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Can Education Institution Implement STEM? From Malaysian Teachers' View

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Abstract
STEM (Science, Technology, Engineering, Mathematics) has been implemented in schools beginning 2017. The main objective of the paper is to find out the views of science teachers regarding the implementation of STEM in schools. This study utilized a qualitative approach in which interviews were carried out among five secondary school teachers who teach science subjects (science, biology, chemistry or physics). The results showed that teachers' understanding in implementing STEM is insufficient. This was due to lack of information from the authorities. There are some barriers highlighted in this study which are motivation, syllabus, time constraints, lack of training, inadequate facilities, students' involvement and school community response. This study suggests the urgent need for authorities to disseminate understanding and provide sufficient training to the teachers as well as to overcome the barriers as they are going to implement STEM in schools.
Keywords: STEM, STEM implementation, STEM barriers, Malaysia

1.0 Introduction

STEM (Science, Technology, Engineering and Mathematics) is a hot global topic in education. STEM awareness begins with the creation of Sputnik by the Soviet Union in 1957(Banks & Barlex, 2014). The world has recognized the need for science, technology, engineering and mathematics to be combined. Since that day, other countries have started their mission to explore STEM as competition to the developed countries. The education sector plays a major part as it responsible to determine the success of labour production of related to STEM. Recently, on a mission to introduce STEM has started in Malaysia where it has been placed in the Malaysia Education Blueprint 2016-2020 (MOE, 2013, 2016).

An understanding of scientific and mathematical principles, a working knowledge of technology and engineering, and the problem-solving skills are the features hunted in the future workforce. For example, Malaysia experiences an urgent need to provide at least one

million workers for jobs in the fields related to Science and Technology by 2020 with half of them graduating with at least degrees and diplomas with related science fields (Academy of Sciences Malaysia, 2015). Thus, its importance in generating future skilled workers in this high demanding field has been the goal of STEM.

Although the demand for labour associated with STEM has increased, interest in science-related subjects continues to decline. According to Academy of Sciences (2015), the number of students pursuing education in the science stream decreased from 44% in 2011 to 21% in 2014. These statistics are alarming since it is far away from the Higher Education Planning Committee's set target to achieve their 60:40 Science: Art Policy (MOE, 2013). Lack of student's interest in science-related subjects also led to poor achievements in international tests such as TIMMS and PISA (MOE, 2013).

Lack of students' interest in STEM-related subjects that lead to poor achievement are due to many factors, such as encouragement from parents as well as teachers' and students' own anxiety. Students feel that STEM discipline subjects are difficult, unexciting and boring (Aschbacher, Li, & Roth, 2010; Christensen, Knezek, & Tyler-Wood, 2014; Yu, 2012). Teachers' attitudes and content knowledge are among the main factors that contribute to students' lack of interest (Jackson & Ash, 2012). Apart from that, qualified and more passionate teachers can also help increase students' interest in STEM related subjects (Christensen et al., 2014). Therefore, teachers play an important role in the formation of interest in STEM. STEM as the one of the new pillars embedded in the Secondary School Standard Curriculum will be used effectively by 2017 (Curriculum Development Division, 2016). Teachers' views on STEM implementation should be assessed so that appropriate actions can be taken by authorities and other related stakeholders such as administrator, parents, students and community.

Objective Of The Study

The main objective of the study is to determine the contribution of teachers towards strengthening STEM in schools. The point of view of science teachers as the implementer is important in improving the quality of STEM education. It can also be a guide to authorities to ensure the successful implementation of STEM in Malaysia.

The following research questions will guide the study:

1. How do secondary Science teachers define STEM?
2. How far has STEM been implemented in school?
3. What do teachers perceive as barriers to STEM implementation?

2.0 Literature Review

STEM is an effort to break the boundaries between Science, Technology, Engineering and Mathematics to ensure that students can use it to solve everyday problems and to increase students' interest in choosing STEM-related career as their first choice. Integrating STEM in lessons is the approach to teach STEM content with two or more disciplines within an authentic context for the purpose of connecting these subjects to enhance students learning (Kelley et al., 2016). While definition by Bryan et al., (2015) stated that STEM integration is teaching and learning of the content practices of disciplinary knowledge which include science and/or mathematics through the integration of the practices of engineering and engineering design of relevant technologies.

STEM approach involves the application of knowledge, skills and values of STEM to solve problems in daily life, society and the environment as shown in Figure 1.

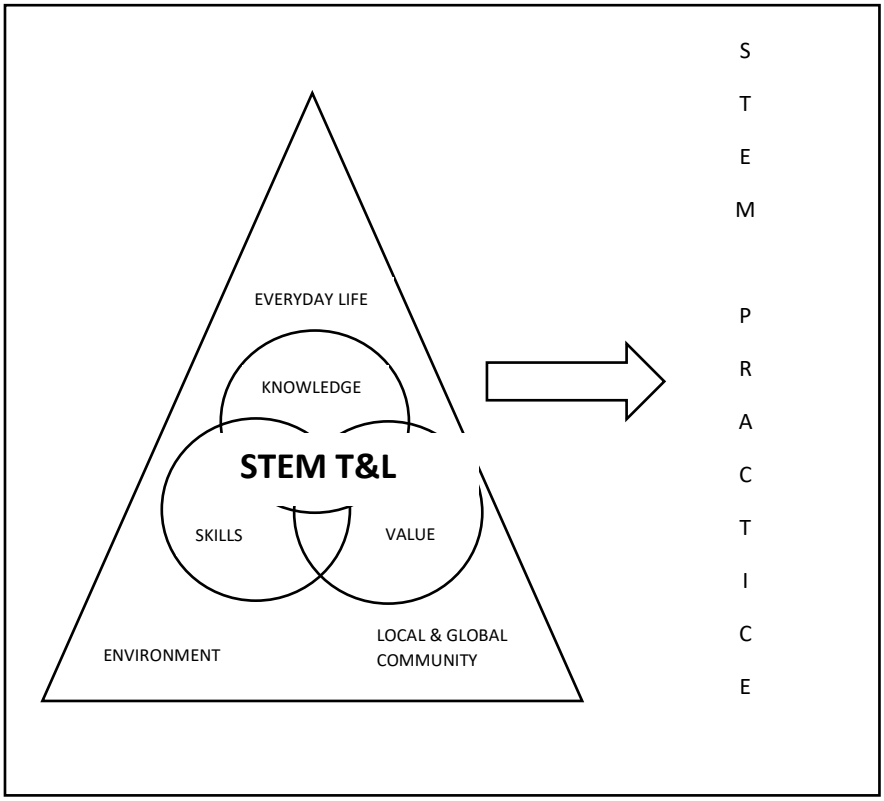

Figure 1 : STEM as Teaching and Learning Approach
(Curriculum Development Division, 2016)

STEM has been embedded in the Malaysian Curriculum starting 2017 in the Secondary School Standard Curriculum (Curriculum Development Division, 2016). As one of the pillars in the curriculum, STEM is expected to produce students with science literacy that can be fitted for the STEM related job demand. Teachers as the backbone in this process require knowledge of content, teaching skills and values in implementing STEM at schools (Alves et al., 2015; Hollins, 2011; Jackson & Ash, 2012; Stohlmann, Moore, & Roehrig, 2012).
STEM in teaching and learning requires that the borders between disciplines involved are abolished for the solution of proposed problems. Apart from having the disciplines basic knowledge, teachers also need to be competent in planning, implementation and measurement-evaluation (Altan, 2016). Professional development, briefing and training are courses provided to in-service teachers to ensure that their level of competency remains up-to-date with the changing trend of time (Niemi, 2015). Without it, teachers will find challenges to implement STEM in schools (Siew, Amir, & Chong, 2015).
The environment also plays a key role as support from authorities, administrators, teachers, staff members, parents, colleagues, community and most importantly, students themselves to ensure the successful implementation of STEM in schools so that there will be the continuity to use the STEM knowledge in everyday life (Aschbacher et al., 2010; Johnson, 2011; Lam, Cheng, & Choy, 2010). School environment consists of support in terms of competence, autonomy and collegial can increased teacher motivation. Indirectly, it will increase teacher willingness to perform better in their task. Conversely, the decrease of motivation among teachers can be a result of teacher burnout and also can effect student

interest and performance (Dodeen, Abdelfattah, Shumrani, & Hilal, 2012; Roslan, Sharifah, & Thirumalai, 2012).

3.0 Methodology

This study uses a qualitative approach with interviews carried out with five secondary school teachers who teach Science subjects (Science, Chemistry, Biology or Physics). All teachers involved were from a range of novice teachers to expert Science teachers.

Table 1. Teachers' demographic information

Teacher	T1	T2	T3	T4	T5
Teaching Experience	7	7	15	15	8
Subject Teaching	Science Math	Science Physics	Science	Science Biology	Science Chemistry

The purpose of this interview was to explore views on the implementation of STEM in schools. Semi-structure interviews were used for standard purposes, but with a deeper elaboration responses. Questions were prepared in advance based on the themes studied. Interviews conducted were in the national language, Bahasa Malaysia as requested by the participants. Each interview took place for about 20 – 30 minutes. Interviews were audio taped and transcribed. Examples of translated interview questions prepared for Science teachers are as follows:

1. Define STEM in 3 to 5 sentences
2. Explain how STEM implementation has been carried out in your school
3. List three major barriers in implementing STEM in your school

4.0 Findings And Disscussion

Participants were randomly selected from five secondary schools. Two of them were male and the rest were female teachers. The range of teaching experience was 7 years to 15 years with different science subject content expertise.

STEM Definition

The most basic thing in implementing STEM is to understand what STEM is. Three of the participants were able to define the basic discipline subject in STEM but with no further explanation.

> *"STEM is Science, Technology, Engineering and Mathematics" (T1) (T4) (T5)*

T2 could elaborate more on STEM by stating the elective subjects in STEM and the reasons for its implementation by saying that

> *"STEM subjects such as Chemistry, Physics, Biology and Computer Science, help to stimulate students to be independent learners and prepare them for the workforce demand"* (T2)'

However, T3 never heard about STEM before and reversed the question to the researcher

> *"What is that?"* (T3)

Based on the answers given, participants have shown lack of understanding about STEM. STEM is not just about the discipline subjects that have been thought, it is more than that. STEM is an idea to break the boundaries among the discipline. In addition, the STEM learning environment should consist of strong curriculum, instruction and assessment (Alves et al.,

2015; Hollins, 2011; Jackson & Ash, 2012; Sondergeld, Koskey, Stone, & Peters-Burton, 2015; Stohlmann et al., 2012). If teachers do not have the basic understanding about STEM, it is expected that teachers will find it very challenging in implementing it (Siew et al., 2015).

STEM Implementation at school

Despite participants' uncertainty about STEM implementation, the science projects that had been conducted at schools showed contrary results. Here are some examples of science projects that had been done in schools:

> "*For topic related to water, I asked my students to make a water filter. They used recycled materials such as bottles, rags and rocks. I used the same approach (using the recycled materials) with another Science project like the solar cooker" (T1)*
>
> *"In reference to Archimedes principle, I gave students a task to build a floating car based on situations given to them" (T2)*
>
> *"…solar car, solar boat, rocket and cooking with nature" (T3)*,
>
> *"Building a model of an animal cell and plant cell with polystyrene" (T4)*
>
> *"In an experiment to find the empirical formula, students will conduct experiments. From their observation and weighing, students will calculate the empirical mol. Students also use their own pocket money to build the lungs model" (T5)*.

Projects like water filter, floating boat, solar car, building cell and lungs model somehow show that they are implementing STEM disciplines in it. They are using science facts, calculating it with mathematics formula, finding information using technology, designing and building the model. For example, solar car will use energy facts from science and build it with mathematics with engineering expertise. It must be understood by the teachers when implementing STEM that it is not compulsory to include all STEM disciplines in a lesson (Kelley et al., 2016). However, teachers need to make use of all the characteristics in STEM integration to show the connections among the disciplines (Bryan, Moore, Johnson, & Roehrig, 2015).

Barriers to STEM Implementation

There were six major barriers appointed by the participants which are motivation, syllabus, skill (training), inadequate facilities, student involvement and responsive environment.

First barriers that participants see in implementing STEM is motivation. To be competent in implementing STEM in schools, teachers need the motivation, skills and responsive environment. Motivation is the willingness of someone in doing something. It need support from three dimensions such as competence support, participants show willingness to implement STEM but under duress as they feel that they are not ready in addition to the existing workload based on teachers' responses:

> *"Teacher ready or not, they have to face it. Eventhough we are not ready, we have to accept and implement it" (T2)*
>
> *"To fully guide students with the project, it involves time. I don't have time. Teacher workloads are severe, but I can still handle it" (T3)*

Without deeper understanding of STEM, teachers are not able to set their personal goals and ignite enthusiasm in teaching. Decrease in motivation will lead to teacher burnout (Roslan et al., 2012). Significantly teacher burnout, student motivation and performance will be also negatively affected (Shen et al., 2015). Teachers' motivation in implementing STEM should be taken seriously by the authorities. Emotional and physical support need to be given to the

teachers to increase their motivation so that they can enjoy their task without feeling any force.

Secondly, participants show concern about syllabus. It is a compact syllabus to complete and students have to rely on it for their examinations. Their responses :

"In school, we have to complete the syllabus, especially for exam class" (T3)

"Compact syllabus. Teachers are unable to do many projects because we are focusing more on completing the syllabus" (T5)

It normally involves yearly planning and students need to master all the topics for their examination preparation. One respondent expressed his doubt on the necessity of the STEM project because it would not be tested in the final examination. This is his response:

"If we do projects, when we are going to complete the syllabus? Moreover, there are no questions related to project in exam" (T4)

Arguably, both teachers and students still trapped and bound by the examination-oriented system as they are need to complete and master the syllabus. Teacher and student need to change their paradigm of STEM. STEM implementation is not the addition of a subject. STEM implementation in curriculum is to help build science literate citizens that can use it in solving daily life problems.

Other than time constraints in relation to syllabus issues, participants also found that they needed more time to do projects :

"If we want to implement STEM, we need more time allocation for the project" (T1)

"Students have to stay back in school to finish the project" (T3).

In order, not to burden the teachers and students, a planning needs to be done in implementing STEM in schools. Suggestion from Siew et al (2015) is to do STEM project after school.

Third concern about the barriers is about training. There are mixed responses based on the training given to implement STEM at schools. Three of the participants did not receive any related training regarding STEM while the other two participants were given training.

"So far we didn't receive any training yet" (T1) (T3) (T5).

Meanwhile, the other two participants who had been in the training said:

"I participated in the STEM training organized by the Districts Education Office. But I think it is not enough. It only involves two experiments. Other Science teachers were also involved with experimenting skill training" (T2)

"I only went for laboratory training this year but I am not sure if *it is for STEM courses" (T4).*

However, there are also teachers who take the initiative to seek information about STEM on their own. With knowledge that she has gained, the teacher showed confidence and attempted to apply it in her teaching.

"Students make water filters from rocks, rags and recycled bottles. Students can produce various types of filters creatively. It's a STEM Practice, I think. I read about it, and I implement it in class" (T1).

Teachers' skills also play a crucial part in determining the teachers' competency in implementing STEM in schools. Subjects such as Physics, Chemistry, Biology, Additional

Mathematics, Agriculture, Computer Science, Design, Sport Science, Basic Conservation, Additional Science, Home Science Economics, Graphic Communication Technical will be taught as STEM elective subjects in secondary school standard curriculum. Basic knowledge in Science and Mathematics is not enough for a teacher to execute STEM lessons in the classroom. Most participants did not get proper STEM training and it may cause a problem in implementing it in the lesson. This challenge has also been highlighted in Siew et al (2015) where teachers face challenges in adopting STEM lessons in class without sufficient training. Equally important, teacher professional development training are also reported to be able to predict the level of student achievement in STEM disciplines (Dodeen et al., 2012; Lumpe, Czerniak, Haney, & Beltyukova, 2012).

Fourthly, inadequate facilities is also one of the barriers in implementing STEM in schools. Their reactions are:

"The school has to improve ICT facilities. There is only one computer lab for the usage of all students. We don't have LCD in the science laboratory" (T1)

"We need the best facilities to implement STEM" (T2)

"Our lab is so poor. We don't have complete sets of apparatus. Some of the chemicals have expired" (T4)

"Teachers use their own computers. Lab computers and LCDs are unsatisfactory" (T5).

Teaching aids like computers and LCD projectors to support technology discipline are one of the needs in STEM. Students use it to find information and as presentation tools in 21st century learning classroom. Apart from this, laboratory also plays an important role in STEM implementation. From the participants' perspectives, with the expired chemical and incomplete science apparatus, it may bring difficulties in implementing STEM. In order to implement STEM, the resources must keep up with teachers' and students' needs (Weber, Fox, Levings, & Bouwma-gearhart, 2013). Laboratory hands-on experience did play a role for sustaining students interest in STEM (VanMeter-Adams, Frankenfeld, Bases, Espina, & Liotta, 2014). It is authority's responsibility to provide all the facilities, however Siew et al (2015) suggested that students and other stakeholders may share the responsibilities to prepare the necessities for the project with their own initiatives to make STEM implementation successful.

The next barrier is students' involvement. Students' interest in STEM can be expressed through their involvement in STEM projects. Some responses indicate high students' interest in STEM projects, based on the following responses:

"Students are able to produce various types of filters creatively" (T1)

"I asked my students to explore any activity related to gas pressure. They explored it by themselves and managed to present it well to the class" (T2)

"Students have to stay back at school to finish the project" (T3)

"Student use their own pocket money" (T3)

"Students also use their own pocket money to build lungs model" (T5).

Based on the answers from the participants, students interest can be seen from their voluntarily stay after school to finish the project, use of their own money and used their creativity to build and design the project. However, what is worrying is that the participation is only for certain students based on the answers:

"Only a certain number of students, not all. Only for those who are interested to take part in Science and Mathematics Week" (T4)

"Those students who are interested in it, they will do but only for 'front' classes" students (T3).

STEM should involve all students regardless what grade they are. The objective of implementing STEM is to increase students' interest in the subject matter. Teachers need to arouse students' interest creatively by getting them involved in the meaningful STEM projects with the help of stakeholders. Various ways can be undertaken to increase students' interest in STEM such as effective approaches (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Lou, Shih, Diez, & Tseng, 2011) and related STEM extracurricular activity (Dabney et al., 2012; Dilivan & Dilivan, 2014; VanMeter-Adams et al., 2014).
Finally, environmental response is also contributing to STEM implementation success. Being a teacher, they are being surrounded by administrators, colleagues, students, parents and community. Participants said that they received moral and financial support from the authority and stakeholders:

"Administrator encourages teachers to do action research on STEM" (T1),
"Our school will open one more Science stream class for STEM implementation" (T2)
"Administrator helps in terms of finance. They also provide materials like solar plat" (T3).

Participants also expressed their feelings that there was a lack of understanding of STEM implementation from their administrators and among their colleagues. The responses are as follows:

"From my point of view, administrators still don't understand STEM. We still don't see how STEM is going to be integrated in all discipline subjects" (T1)
"Only Science and Mathematics teachers understand STEM" (T2)
"Administrators did mention about STEM but it is only on definition of STEM as Science, Technology, Engineering and Mathematics "(T4)
"At this moment, administrators still don't get enough information (about STEM). As for Science teachers, they have been given a little bit of exposure of STEM in Secondary School Standard Curriculum "(T5).

This findings are similar with (Brown, Brown, Reardon, & Merrill, 2011) that found that STEM integration is not well understood by the administrator. It is difficult to get support from the administrators if they do not understand the integration of STEM. In addition to own efforts to understand what is STEM, authority also need to be responsible in disseminating the understanding of STEM among administrator, school community, parents and outside of school community so that the idea of implementing STEM in schools will receive good response from the environment.

Suggestions to Improve STEM implementation

Based on STEM implementation barriers being appointed by the participants, there were few suggestions to help it successfully implement at school. Firstly, authorities need to create awareness among STEM teachers. With the awareness of the importance of STEM, teacher would feel motivated and indirectly effect on student motivation and their involvement in the STEM activity (Shen et al., 2015). Teachers involved should also strive to seek knowledge about this STEM.

Besides that, authorities with the help of other stakes holder need to provide sufficient training and facilities that can help boost up STEM implementation at school. To ensure the success of STEM implementation, schools need to be equipped with the appropriate equipment to support student learning. Basic technology, for example computers, LCD projectors and internet, is a must to support "T' in STEM. Laboratory facilities also is important to ensure success in implementing STEM (VanMeter-Adams et al., 2014).
Financial responsibility is known to be the authorities' concern. However, parents and community can also play their parts to help schools with some source of income.

5.0 Conclusion

This paper presents the finding of teachers' views on STEM implementation in schools from in-depth interviews with five secondary Science teachers. The objective of this exploratory study is to find teachers' view about STEM, what have been done for STEM implementation at schools, the barriers and suggestions.
The result shows that teachers' understanding about implementing STEM is insufficient. It may be due to lack of information from authorities. There are some barriers highlighted in this research which are motivation, long syllabus, time constraint, lack of training, inadequate facilities, students' involvement and school community response. Teachers suggest that schools need to upgrade their facilities such as computer lab and laboratory. They also suggest the vital need of teacher training on STEM. More financial support has also been suggested by the teachers as the STEM project is expected to be quite costly.
Although the findings of this study are not generalised to all science teacher, the concern need to be taken seriously. Further research and studies have to be conducted in implementing STEM in schools. The understanding of STEM is the vital part of it, since it may change the view of STEM teachers. We also need to stress that STEM is not a new thing to teachers. They have done it before and it can be seen from the projects that they mentioned in their responses. The authorities play an important role to disseminate understanding and provide training to teachers as they are going to execute the STEM implementation in schools.

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