STEM PEDAGOGICAL APPROACH FOR PRIMARY SCIENCE TEACHERS' THROUGH EARLY ENGINEERING TRAINING PROGRAM

Rose Amnah Abd Rauf

University of Malaya

Abstract

Strengthening STEM initiatives outlined in the Malaysian Blueprint 2013-20125 aims to ensure students are equipped with the necessary skills to meet the challenges of an increasingly industrialized world. Therefore, it is necessary for teachers to be equipped with knowledge and teaching approach for STEM education starting from primary school teachers. This is to ensure that the mindset towards STEM fields can be cultivated and sown from early schooling level. Teachers of primary and secondary schools in Malaysia is still new in STEM education to understand let alone to apply the STEM pedagogical approach in schools. Based on the Malaysia's STEM conceptual framework, primary science education is responsible for ensuring that students are able to make connections and build a foundation in science. Thus, the responsibility of a primary teacher is to ensure interest in science is applied and maintained using an effective STEM pedagogical approach so that students are more incline to investigate and explore matters related to science. Thus, this paper will share experiences of how the teacher of an early engineering training program was implemented and the impact obtained by the teacher in preparation to implement STEM education in primary schools.

Keywords; STEM pedagogical approach, STEM education, Early Engineering

Introduction

The challenge in this era of education is to teach students who have various capacities and different learning rates. Teachers are expected to teach an approach that allows students to master concepts of science and mathematics and at the same time acquire higher-order thinking skills. Various strategies have been encouraged in the teaching of science and mathematics classrooms, the teacher-centered approach to a student-centered approach.

Science and Mathematics Education was the focus in government, industry and the academic community (Ali, 2012). Science and Mathematics Education at the primary school level is an important factor in shaping the intellectual community. According to Ali, (2012) for an intensive economic future, human capital should be more scientific and technical. Reliance on science and engineering has increased in order to maintain competitive advantage.

The importance of maintaining the interest of students from the primary school level in science education is important because more primary school children should be given the opportunity to choose science in secondary education (Cleaves, 2005; Lindahl, 2003) in order to pursue in a science and engineering related career. Hamdan (2012) asserts that an effective action plan must be implemented to increase the number of students to take up science not only at the university level but also at the school level. Malaysia needs at least 500,000 students in 2020 who can think intellectually to continue its mission to become a developed country (Hamdan, 2012).

Science education is important in supporting the country's goal to achieve developed nation status by the year 2020 (Karpudewan, 2012). Various policies have been introduced in Malaysia including the National Science and Technology Policy (STP) and STP II by the Ministry of Science, Technology and Innovation (MOSTI). STP 1 is designed to make Malaysia a competent, independent and inventive in science and technology by 2020. In addition, this policy also aims to produce at least 60 researchers, scientists and engineers per 10,000 workers in Malaysia. Next STP II highlighted seven key areas and the main one of which is related to education, which states the need to use a 60:40 ratio of students pursuing science, technical and engineering in schools and universities than in the field of literature. Should formulate a strategy that is more creative and effective way to address the concerns of a larger group of Malaysians to be interested in science and technology (S & T). Deep knowledge in the field of science and technology will determine the survival of Malaysia in the era of science and technology (MOSTI, 2008).

Strengthening STEM initiatives outlined in the Malaysian Blueprint 2013-20125 aims to ensure students are equipped with the necessary skills to meet the challenges of an increasingly industrialized world. It is necessary for teachers to be equipped with knowledge and teaching approach for STEM education starting from primary school teachers. To ensure that the mind set towards STEM fields can be cultivated and sown from early schooling level. Teachers of primary and secondary schools in Malaysia is still new in STEM education to understand let alone to apply the STEM pedagogical approach in schools.

Why have we not achieved the 60:40 policy?

Students' performance have deteriorate because of the difficulty of the science subjects and they could not relate what they have learnt to real life scenario. There is high expectation for careers in STEM lead but due to fear and lack of confidence to proceed in STEM fields resulted in the decline of participation in STEM careers. The Implementation problems starts from the ground, whereby teacher used ineffective teaching strategies or approaches. Moreover there is evidence for lack of learning by doing approach in teaching, thus resulting in the lack in 21st century skills – computational thinking, problem solving, and critical thinking. Low English language proficiency also could add on the problem because most STEM resources are in English. The support from the school administration is most important. That is why there is a need to change the mindset of school heads in supporting teachers when it comes to hands-on activities, and also the mindset of the science teachers to wait until they get good students then only they can proceed in the STEM field. These are the findings from a round table discussions between Ministry Of Education policy makers with experts in the STEM field. They also revealed that there is a lack of passion and scientific skills among STEM teachers, teachers are not ready to teach beyond the textbooks. There is a need for continuous capacity building for STEM teachers. Teacher professional development must focus on equipping teachers with skills and knowledge on differentiated learning, active learning, project-based learning. Program in school are not systematically organized, teachers need to plan for program in a more structured manner such as putting STEM activities in school calendars. Although it is beneficial for schools to engage industries in bringing more meaningful and context to teaching and learning in school, there is too much of administrative procedure for industry to approach school, while school personnel might not have direct contact with people from the industries. It would be good to bring STEM role model, professional back to school to share experience and profession. Provide sufficient funding for implementation of programs and policies.

Looking at teachers' teaching much has been talked about. In order to achieve effective science teaching, there is a need to embrace knowledge and science processes and practice, as well as provide multiple opportunities for students to use these processes and apply them across many experiences. Teachers need to know how to use investigations and the data they generate to promote thinking about how and why phenomena are happening. It is widely known that cognitive stimulation in the early years is critical for brain development that young children have cognitive capacities far beyond what was previous believed. Many teachers are unprepared to promote science inquiry and learning in their classrooms. The way science was presented to them as students- a static collection of facts to b transmitted by the teacher and memorized by students- does not translate to young children.

THE PROGRAM

The program was developed according to the Malaysia's STEM Conceptual Framework (figure 1). In the framework it distinguished the need for STEM education for every level of education in Malaysia in order to achieve the goal of increasing and preparing for the STEM workforce and STEM literate society. This program was developed especially for primary. There are 3 modules based on 3 principles :

- Integration with the school science curriculum
- Continuous involvement with the community and institution
- Connection with secondary education

The program module was developed based on 3 themes a) life science (energy) ; b) Physical science (urbanisation); c) technology and sustainability (transportation). Every module have 4 main construct ; a) theory and concept; b) activity; c) engineering Design process; and showcase

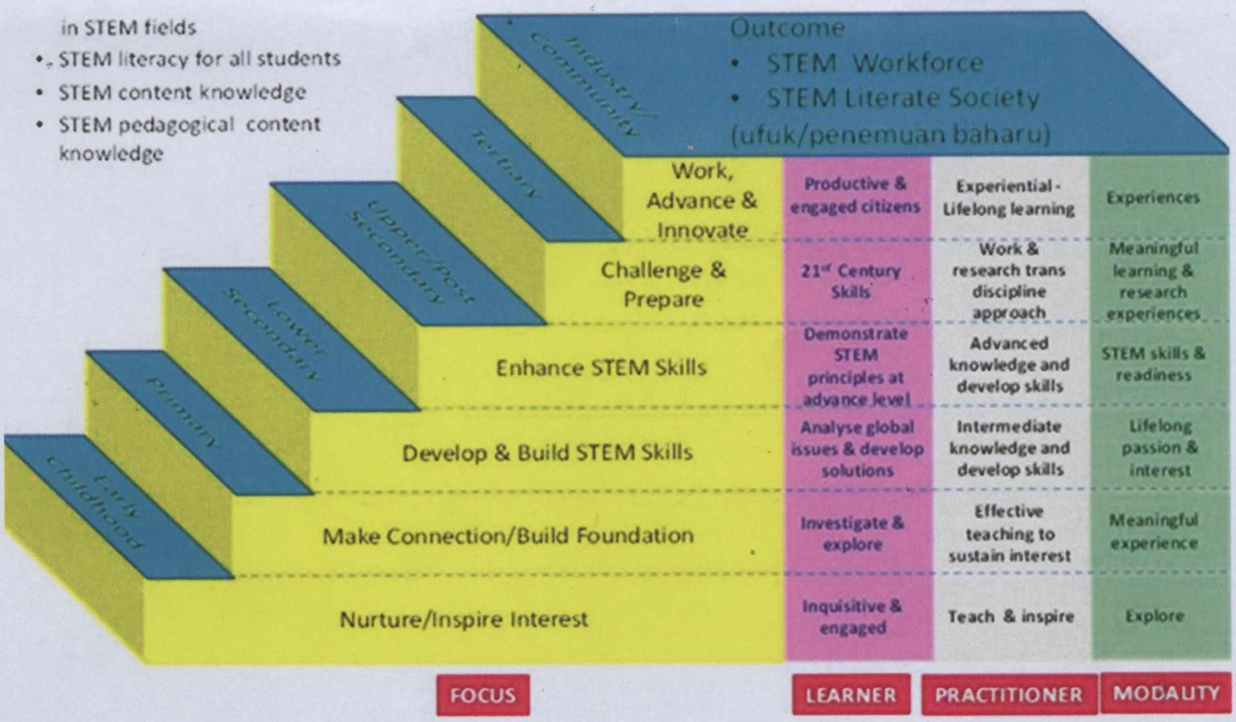

Figure 1 : Malaysia's STEM Conceptual Framework

The main feature in the module is the instructional design which follows the 'engineering design process' (figure 2). We might asked **'Why enginneering design?'.** Most STEM educators have different approaches to implement STEM in schools but the underpinning theories behind STEM education is 'constructivism' by Piaget and 'constructionism' by Pappert. Piaget and Papert are both **constructivists** . they view children as the builders of their own cognitive tools, as well as of their external realities. For them, knowledge and the world are both constructed and constantly reconstructed through personal experience. Each gains existence and form through the construction of the other. Knowledge is not merely a commodity to be transmitted, encoded, retained, and re-applied, but a personal experience to be constructed. STEM integration should involve **"engineering design" as a basic for creating connections to concepts from mathematics or science** (or both) (Sanders 2009). Engineering design process through STEM integration can act **as a connector for meaningful learning** the content of mathematics & science (Moore et al. 2013). can provide a gateway to turn the abstract science and mathematic concepts into concrete real-life applications.

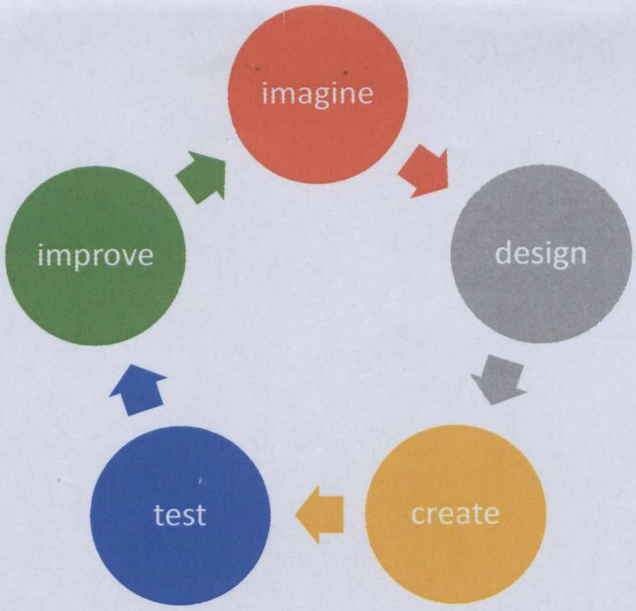

Figure 2: Engineering Design Process

PROGRAM IMPLEMENTATION

The program was carried out in four phases (Figure 3). The first phase is the knowledge transfer phase; two modules were given to 35 teachers in a training of trainers program. These teachers came from 35 different schools. This training involved theory and hands-on activities in the first part and teachers were then instructed to carry out the activities in their schools and are being monitored by their district education department and from University of Malaya(UM) as the training provider. During the monitoring phase, the program team from UM will observe and give consultation to the teachers. Then these teachers will be called back to be given one more training on module 3 and end with a STEM Camp. These teachers will be the facilitators in the STEM Camp to carry out the STEM activities on 80 students. In this camp the teachers are expected to deliver and apply all they have learnt through the training. The ensure sustainability of the program the program team (UM) will have a close relation with these schools and provide consultation and advise. These teachers are now only in the first two phases.

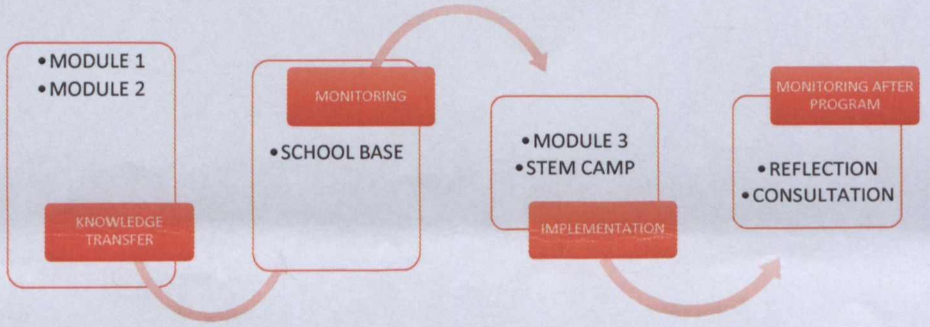

Figure 3: the implementation process of the program

Through out the implementation and training of the program several indicators to outcome of the program will be collected. In this paper I will only report on one assessment done on primary science teachers involved. The instruments used are :

- To determine attitudes on the nature of and the teaching of STEM, the *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science* (McGinnis, Watanabe & Shama, 1997) was modified. Modifications to some of the original items were made to reflect a more general focus on STEM and develop the rest of them.

- To assess the teachers' STEM teaching efficacy, the *Science Teaching Efficacy Beliefs Instrument* (STEBI) (Riggs & Enochs, 1990) was modified. These 25 item instruments assess teachers' perception of their efficacy for teaching science. 10 items out of the 25 items were selected to develop the questionnaire used in this study. Participants rate their beliefs on five Likert scale ranging from "1" representing "Strongly Disagree" to "5" representing "Strongly Agree". Modifications were also made to the STEBI items to reflect a more general focus on STEM.

- To determine the teacher knowledge of STEM approach, a five-point Likert-type scale, ranging from 1 (strongly disagree) to 3 (neutral) to 5 (strongly agree) was developed. These 11 item instruments assess teachers' knowledge of integrated STEM teaching. The instrument was used to collect data that would allow us to establish how the participants defined STEM teaching .

Table 1 shows the primary science teachers' knowledge, attitudes and perceptions of STEM Teaching Efficacy.

Means, standard deviations, t-test, and level of significance for primary science teachers' knowledge, attitudes and perceptions of STEM teaching efficacy (N=35).

	pre		post		Paired t-test
	M	S.D	M	S.D	T
Knowledge of STEM Approach	3.6045	0.54690	4.2024	0.54738	5.555
Attitudes towards STEM Approach	4.1450	0.42335	4.3874	0.39228	3.887
STEM Teaching Efficacy	3.9620	0.48280	4.2900	0.46233	3.911

The analysis revealed that the mean scores increases in value, and this increase is significant for knowledge of STEM approach ($p<0.05$), attitudes towards STEM approach ($p<0.05$), and STEM teaching efficacy ($p<0.05$).

CONNCLUSION

- The result revealed that knowledge of STEM approaches of teaching is related to perceptions of efficacy for teaching STEM. In other words, as teachers learn more about STEM instructional strategies and STEM concepts, they feel more comfortable in teaching STEM (Nadelson et al., 2013).
- This finding reinforces the notion that a lack of knowledge could make a teacher feel unsure about his/her abilities, which would be manifested in a reduced confidence in teaching STEM, a reduction in efficacy, and an overall feeling of being uncomfortable teach- ing STEM concepts (Nadelson et al., 2013).
- Educators, who feel deficient in their content knowledge, are less likely to believe they can teach the material effectively (Peterson et al., 1989). According to Nadelson et al. (2013), the teachers' perceptions of efficacy will then influence their comfort of contentment with teaching STEM during the implementation process.
- expressed a positive shift in their attitude toward STEM teaching during the training
- the teachers attitudes towards STEM approaches and initiatives also increases towards the positive side.
- Professional development is particularly important for elementary teachers involved in STEM education, as research shows that these teachers typically do not receive enough undergraduate education in mathematics and science. Furthermore, professional development for STEM teachers must be provided over an extended period of time

Observation of the implementation in schools showed that the teachers manage to carry out the activities following the engineering design process but needs more training and practice on the role of facilitator to encourage students to think, design and be innovative by strengthening their skills asking questions. There is also the need for these teachers to strengthen their knowledge and concepts in science related to the activities at hand. Mean while the students that participated in the program gave positive remarks on the activities saying that it was interesting, challenging and through the observation also revealed that it gives them confidence in communicating with each other and presenting.

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