Introduction of STEM Teaching Approaches

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Abstract **- It is crucial for students to realize the importance of academic achievements in Science, Technology, Engineering and Mathematics (STEM) subjects in the 21st century. Some countries are facing a shortfall in providing highly-skilled workers in STEM industries. STEM concepts today are part of multidisciplinary and integrated educational systems which are desperately needed in any workforce. As the world becomes a technologically advanced society, countries that wish to stay competitive in the 21st century global economy, must have effective practices and skilled workers in the STEM fields. To remain competitive in this challenging world, there is an urgent need to enhance the quality and knowledge of STEM education. This paper will discuss teaching approaches that can be used in STEM teaching. A few activities suggested from previous research and base on concept of teaching also will be discussed. Through these STEM activities, students can benefit enhancing their academic, career and personal development.**

I. INTRODUCTION

STEM ideas have been applied centuries ago through the Industrial Revolution which focused more on engineering to generate technological revolution in automobiles, machines, instruments and others. People involved in these interventions, such as Thomas Edison etc., received only little education or under traineeship (White, 2014). However, although history has shown the importance and significance of STEM in our lives, it is still hard for students nowadays to maintain a high level of interest if STEM is simply introduced to them. Without a doubt, the school education system is still one of the ways students can gain STEM knowledge. STEM subjects are currently taught independently from each other even though in most of the workforce in developing countries, STEM disciplines overlap (El-Deghaidy & Mansour, 2015; Wang et al., 2011). Hence, it is important for educators to identify the various alternative teaching approaches in STEM curriculum and the barriers that must be overcome to make possible the integration of teaching STEM subjects.

STEM Teaching Approaches

It is important for teachers who wish to teach in STEM fields to equip themselves with profound knowledge in STEM (Ejiwale, 2013). Therefore, it is essential for teachers to be prepared with teaching approaches for STEM education. Various types of STEM teaching approaches are discussed below:

A. 5E Learning Cycle/ 5E Instructional Model

Liu, Peng, Wu, & Lin (2009), Aydin & Yilmaz (2010) and Abdi (2014) are some of the researchers who used the 5E Learning Cycle teaching method in their researches (STEM). 5E Learning Cycle is considered one of the constructivist approaches (Aydin & Yilmaz, 2010). According to Khalid & Azeem (2012), constructivism encourages learners to use their prior knowledge and experiences to construct information. At the same time, it encourages leaners to actively build their own new knowledge, test their hypotheses, rectify former information or justify existing knowledge. Constructivist learners are able to make connection about their world and construct new ideas by relating their present understanding with their past information (Kang, Brian, & Ricca, 2010). Sometimes, new experiences can be transferred to learners from their teachers instead of gained personally. These new experiences allow the learners to have better thinking and motivate them to make their own investigation (Martin, Jean-Sigur, & Schmidt, 2005).

The 5E Learning Cycle originated from Atkin and Karplus. They proposed the learning cycle of exploration, invention and discovery. These terms were later revised to the 5E Learning Cycle (also known as Instructional Model) which are Engagement, Exploration, Explanation, Elaboration and Evaluation. The discussion below summarises the different phases of the 5E Learning Cycle (Bybee et al., 2006):

1. Engagement

Teacher uses simple activities to engage students' prior knowledge with new ideas that could ignite students' curiosity. The activities should make a connection between past and existing knowledge, reveal old ideas, and help the students achieve learning outcomes.

2. Exploration

Teacher provides problem statements for the students to collect evidence and conduct investigation. This can be done through lab activities which help the students generate new concepts, and skills as well as identify any misconceptions that is different from their prior knowledge.

3. Explanation

This is the part where the teacher explains the concepts to students to bring them toward extensive understanding. A learner demonstrates scientific explanations based on their engagement and exploration journeys which at the same time enable them to express their understanding, demonstrating their processing skills or behaviors. A concept, process or skill can be introduce by the teacher directly throughout this phase.

4. Elaboration

In this phase, students are able to apply new conceptual understanding and skills to new problems or activities. Students use new experiences to gain deeper understanding, extensive knowledge, and sufficient skills.

5. Evaluation

Teachers have the chance to evaluate students' progress in achieving the educational purposes. In this phase, students are also able to evaluate their understanding and potentials.

Several researches have applied the 5E Learning Cycle and showed promising outcomes. For examples, in their study of fourth-grade students, Liu et al. (2009) compared the effectiveness of the 5E Learning Cycle before and after students experienced it. According to the researchers' findings, the learning activities increased their knowledge level (recall and recognition) of the subject (aquatic plant) they had learned. The activities also enhanced students' level of understanding of the (aquatic plants) content. The level of understanding included discussions, explanations, and restatements. In addition, the 5E learning activities improved students' engagement in mobile learning activities (scientific inquiry), which at the same time enhanced students' learning motivation toward natural science.

B. Inquiry-based learning

Inquiry-based learning may considered as well as the constructivist model of thought that aims to motivate students to do more investigation in scientific finding from very complicated procedures to logical and scientific (critical) thinking (Pedaste et al., 2015). According to the *National Science Education Standards*, science education should provide students with the fundamentals and concepts of science, skills of reasoning, scientific skills, and connections with the nature of science. Hence teaching science through inquiry enables students to create a new problem statement and look for alternative explanations or solutions that answers that problem statement (National Research Council, 2000).

There are four levels of inquiry-based learning namely Confirmation inquiry, Structured inquiry, Guided inquiry and Open inquiry. How a teacher decides to use one of the inquiry levels would depend on how much students rely on the teachers' guidance or how much the teacher provides information or resources to the students (Gautreau & Binns, 2012; Trna, Trnova, & Sibor, 2012). Teachers can either let students experience various levels of inquiry during a single lesson or just one inquiry phase in a single lesson, depending on the content of a subject (Lee, Kamarudin, Tablib, & Hassan, 2017). Below are the descriptions of the four levels of inquiry-based learning (Buck, Bretz, & Towns, 2008; Kamarudin, Phang, & Lee, 2017; Martin-Hansen, 2002; Raychowdhury & Sterling, 2013):

1. Confirmation inquiry-based learning

This phase is considered as the lowest level of inquiry. Students are provided with problem statements, background, step-by-step procedures, methods, results analysis, and means of results communication. Students only need to confirm scientific principles and results of the investigation can be foreseen by the students. Confirmation inquiry is suitable for students who have newly experienced laboratory techniques. It can build up their scientific concepts and give better comprehension of scientific skills. Confirmation inquiry activities are referred to 'cookbooks' which can served as fundamentals for the development of students' inquiry before proceeding on to higher phases.

2. Structured inquiry-based learning

At this level, problem statements, step-by-step procedures and methods are still provided to students; however, students need to conduct the investigation and collect evidence for the problem statement. Students are required to carry out the laboratory activities based on the procedures provided by the teacher and discover any possible outcomes. Students are not told the investigation results ahead of time. Teachers are encouraged to carry out a classroom discussion at the end of the inquiry activities in order to share scientific explanation or interpretations based on the evidences collected by the students during the investigation (Lee et al., 2017). Structured inquiry acts as the basis for more open-ended inquiry.

3. Guided inquiry-based learning

Students only receive research questions. Students will create the procedures to answer their research questions and come up with explanations based on evidences they have collected. Basically, the teacher will ask the students to form groups and collaborate in designing the procedures required. Guided inquiry gives more opportunities for students to design methods and increase their level of curiosity. This type of inquiry is very suitable for students to learn and design their experiments in different ways as well as practise data recording. Even though students are the one who design the procedures, the teacher still can give advice and play an active role to make the research plans successful.

4. Open inquiry-based learning

Students focus on a phenomenon which they wish to investigate; in other words, they have full authority to choose a problem statement to investigate. In open inquiry, students formulate a problem statement, generate a hypothesis and create their own procedures or design. Students who use this type of inquiry need to have higher-order thinking and they directly deal with the concept, resources, apparatus and other aspects. The teacher's role becomes critical in this phase as they need to guide and motivate students to be involve and to enjoy the open inquiry activity (Zion, Cohen, & Amir, 2007).

Avsec & Kocijancic's (2014) studied inquiry based learning (IBL) on 91 technology education students. It was a three-day quantitative research. The results showed that students who received inquiry based learning approach had better technological knowledge, problem solving skills, critical thinking, and decision-making skills. The researchers suggested that this IBL education model is equally suitable for males and females for enhancing their learning skills. Thus, teachers who wish to use the IBL approach are encouraged to do more inquiry teaching and come up with their own instructional design which can engage students in inquiry learning (Duncan, Pilitsis, & Piegaro, 2009).

II. CONCLUSION

Today, it is not only teachers who are responsible for students' learning but also students themselves. STEM education requires innovative teaching to engage students in developing their critical thinking and constructing their own understanding. The challenges that educators face today is making STEM subjects interesting and enjoyable to learn, which also reduced the chances of students dropping out from STEM fields.

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