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RESEARCH ARTICLE

STEAM TEACHING STRATEGIES IN RELATED SUBJECT

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ABSTRACT

A reform STEM (Science, Technology, Engineering, and Mathematics) education has become the guiding principle of science education in many countries and a focus of research efforts including Malaysia. Meanwhile, the STEAM (Science, Technology, Engineering, Arts and Mathematics) education is still new and lacking in literature search. In Malaysia, the government has not yet fully introduce in the STEAM education system but have suggested the features of STEAM education by combining an art skills in STEM education. The focus on the combination of arts in STEM education is one of the way to attract students to pursue or increase students' interest and motivation in science stream. It is also aimed to create a new generation of multi-skilled professionals that are capable in creatively integrating knowledge from different fields of study to solve problems effectively and create an innovation. Nevertheless, the STEAM education is new and has not enough empirical data regarding teachers' teaching strategies especially in the new curriculum, KSSM. An effective STEAM education requires teachers to have a correct method in enhancing student's ability. High school teaching strategies based upon 21st century teaching and learning have become the suitable methods for STEAM education. The development of various scientific models and theories play a central role in scientific inquiry and enhancing student's thinking ability. Model-based inquiry would be important in improving the learning of STEM subject. Thus, the role of teacher as an implementer of the new innovation in education should be taken seriously. This study aims to explore teacher's STEAM teaching strategies in new curriculum. This qualitative study was conducted using semi-structured interview questions to explore the practice and conception of secondary school teacher on STEAM teaching strategies especially in model based inquiry. The participants were selected using purposive sampling among teacher in Johor Bahru district that have experience in teaching the new KSSM curriculum in form 1 and form 2. The analysis was performed by using constant comparative method that was carried out simultaneously during data collection. Based on the findings, the participants carried-out the inquiry based learning as a teaching method selectively according to the topic. The participants also did not understand deeply about STEAM education. Thus, through the implementation of active teaching strategies, it was expected that students' interest in STEAM related field will be enhanced despite limited teachers' understanding about STEAM education.

KEYWORDS

STEAM Education, Teaching Strategies, Model-based inquiry, Students' Ability.

1. INTRODUCTION

Higher economic demands for today's science, technology, engineering and mathematics graduates make STEM (Science, Technology, Engineering, Math) education have more attention in education policies globally. Current economic conditions require human capital based on science, technology, engineering and mathematics with a growth rate of 16 out of 24 employment sectors make STEM education increasingly critical [1]. Concerns about improving STEM education among world countries are gradually in line with STEM's skill demand for challenging economic challenges [2,3]. Future economic growth is also seen as directly or indirectly dependant towards the advancement of science and technology [4]. STEM careers are intertwined with the world's economy and are expected to increase by 10.7% over the next decade, while the average increase of all other occupational areas is expected to be at 10.3% [5].

In Malaysia, the educational goals is aimed at creating a scientific, progressive, inventive and far-sighted society as well as utilizing the latest technologies purified with a new curriculum that has the vision of forming a critical, creative, innovative and skillful citizen that embraces Science, Technology, Engineering and Mathematics (STEM) [6]. The new curriculum, the Secondary Standard School Curriculum (KSSM) and the Lower School Standard Curriculum (KSSR) will replace the old curriculum, the Secondary Integrated Curriculum (KBSM) and the Primary School Integrated Curriculum (KBSR). This curriculum is parallel with the new policy under the Malaysia Education Blueprint 2013-2025 implemented in 2017. The KSSM is designed to provide STEM's basic knowledge and skills to enable students to become science literate and able to follow science at the level Higher.

However, there are many educational studies showing students' interest and motivation towards STEM learning decreased [7]. Among them, studies in America found that not only did the drop in student participation in the STEM field, students also had weak achievements in STEM. In Malaysia, Laporan Strategi Mencapai Dasar (2012) have stated that declining students' participation in the science stream to a worrisome state even at the higher education. Annual report of Malaysia Education Blueprint in 2013 showed that only 35 percent of students were enrolled in STEM field far beyond the 60 percent targeted by the government. Research by Buang, Lilia, Meerah and Osman (2010) found that the percentage of high school students who do not choose science even they are eligible to enroll in the stream after the Lower Secondary Assesment has increased by almost 15 percent. The international study, such as Trends in International Mathematics and Science Study (TIMSS), which assesses students' achievements in science and mathematics, shows deterioration year on year. Starting from 1999 until 2011, the science achievement especially in Form 2 students continues to have low achievement. These low performances in STEM subject may suggest deficiency in STEM instruction or training.

Educators, STEM professionals, and some lawmakers have begun to support integrating the arts into STEM (known by the acronym STEAM

with A standing for arts) and believe STEAM education can provide the creative piece missing from STEM [8,9]. A major premise driving arts reform and STEAM lies in the hope that creativity may deepen understanding of other subjects [10]. Many critics of art-based reforms argue the superfluous nature of aesthetics in the classroom [11]. It has long been accepted that arts are something extra, a task to explore after core subjects have been reviewed [12].

In the US, STEAM education programs, STEAM education centers, and STEAM initiatives have emerged all over the country including STEAM being taught in a reoccurring segment on the 43rd season of Sesame Street, in which music was used to discuss mathematical concepts and included links to a STEAM curriculum page for parents [13,14]. Unlike in Malaysia, the STEAM education still new and not yet fully introduce in education system but have suggested the features of STEAM education focus on combining an art skills in STEM education. Therefore, this study aims at exploring the conception of secondary school teacher on their knowledge of teaching strategies with art skills in STEM fields.

2. TEACHING STRATEGIES

According to Shulman (1987), teaching strategies are the most critical aspect of pedagogy that influences the process of organizing and managing the classroom [15]. Seaman and Fellenz (1989) claim there are four basic factors that influence teachers' selection of teaching strategies; (a) learners, (b) teachers, (c) organizations and (d) content [16]. Thus, the teaching process selected by teacher must be according to learners' capacity to have an authentic learning. For STEM education, active teaching practice based on student-centered approach is the most effective way teaching process happened in learning environment. The approach is aligned with the new syllabus (KSSM) that have been introduced by the Malaysia government that teachers need to use active teaching practice in the classroom. Project based learning, problem based learning and inquiry based learning are teaching strategies based on students-centered approach, believes by many educators that can promote creative thinking and problem solving skills in STEM education.

Creativity is often said to be related with the art. To gain creativity, one must have an art skills. Going beyond the cognitive power of the arts, it is believed that participating in art, music, dance, poetry, etc. may provide more creative outlets for STEM students, serve as a viable recruiting tool for future students into technical fields, and derive joy from the learning experience [17]. Art and its creative processes may allow students to explore and unlock multiple intelligences. Thus, creativity through active teaching practice become the main tools to enhance student's skills.

Project based learning (PjBL) is an instructional approach that stressed on the practical experience in learning. Project based learning is broader and often composed of several problems students will need to solve. PjBL also provides the authentic experiences with science, technology, engineering and mathematics concepts to be applied. Problem based learning (PBL) is a teaching methodology which uses problems as starting point for the development of students' new knowledge [18]. The problem based learning (PBL) focus on the problems of the "real world" in the educational process in order to facilitate the development of critical thinking and problem solving abilities among students and assimilate the essential concepts for the various study of disciplines [19]. Problem based learning is also a teaching strategy based on experience (experiential instructional strategy) that encourage students to be active learners by engaging them in problems that are not very structured (loosely structured problems) that need situations which they may encounter in their lives and where various solutions are possible [20]. This procedure will encourage students to think critically in order to solve the problem. Inquiry based learning defined by Curriculum Development Centre, Ministry of Education Malaysia (2014) acts as an approach to look for solutions to questions which involved investigation, exploration, collecting data and making conclusion. It is also a form of constructivist learning. Inquiry based learning has been giving priority by the Minister of Education (MOE) for science education since 2005. Inquiry based learning in science teaching and learning is an inquiry exploring where a learner actively involved in the class as they look for information, questioning and exploring their surroundings.

3. CONCEPTUAL FRAMEWORK

The conceptual framework used for this study is from the Theory of Fullan Education Transformation (2001). The conceptual framework were modified in parallel with the research questions in this study. From figure 1, the teacher's teaching strategies from the aspect of art is combine with the STEM education has been studied. According to Theory of Fullan Education transformation, the implementation process of putting the conceptual transformation as a practice refers to teachers as practitioner [21]. Therefore, the practice is teaching strategies. Teaching strategies are focus in this study refer to constructivist theory in art and STEM education. It involved problem based learning, project based learning and inquiry based learning.

The student's capability to build a new knowledge from what they have understood before is the main ingredient in constructivist theory. This theory placed students as the main learner because student interact with the material and teacher as a guidance to them. Moreover, teacher may act as a designer of teaching material that is appropriate to students' existing knowledge in order to provide an opportunity for students' to build a new knowledge [22]. Constructivist theory in this study is a key to measure the effectiveness of teaching strategies among teachers. This post-modern perspective helps educators understand STEM education as an integrated entity. Therefore this conceptual framework is the best to be use in this research.

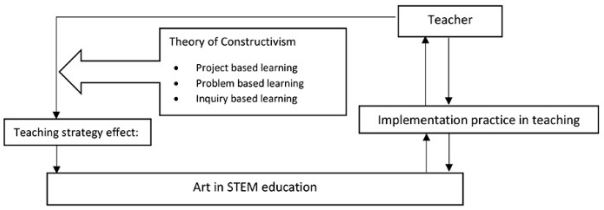

Figure 1: Conceptual Framework

4. METHODOLOGY

This study used a qualitative methodology to explore in depth conception of secondary school teacher in lower form about integration of Art in STEM education. A case study is suitable to use in this research because to explore a process of exploration phenomenon through an in depth collection and data analysis using various methods [23]. In this study, the researches wants to examine, explore and understands thoroughly on how arts is integrate in STEM fields based on teaching strategies were implemented in the teaching and learning in school. Teacher practices when teaching investigations were determined through semi-structured teacher interviews, and analysis of curriculum materials that is teaching plans. The use of mixed methods to triangulate and corroborate findings has been recommended by several researchers [24]. Therefore, the results from the study will be more reliable and convincing because it based on various sources of information.

4.1 Respondents

The process to determine the participants was based on the objectives of the research. In this study, the participants involved are selected purposively. The purposive sampling was utilized to ensure that participants chosen follow the criteria and suit the objective of the study [25]. According to Miles *et al* (1994), the researcher must identify the limitations in choosing respondents, limitation of time, permission to access into field work [26]. Hence, six teachers in Skudai district were purposively selected as research respondents. The selection of the respondents was based on the willingness of the teachers to be actively involved in interview and teaching in STEM fields. In this study, the interview process and documents analysis will be carried out to the extent that there is no longer saturation in which new findings are expected to be obtained from the respondents.

4.2 Data Collection

In order to answer the research questions, the selected instruments was chosen so that the result obtained is accurate and accordingly with the objective. In this case study, the collected data are the semi structured interview about the teacher's knowledge regarding the involving art in STEM fields and analyses of the lesson plan.

4.2.1 In- Depth Interview

In this study, the in-depth interview involved the face to face interaction with the respondent. This interview is the most frequently used method to understand the teacher's knowledge and understanding [27]. In this study, the main objective is to explore the teachers' conception regarding art in STEM fields. Therefore, the semi structured interview protocol is used as an instrument to collect the data. The information from the interview session was recorded and written in the notebook. After each interview, the recorded was transcribed verbatism. The researcher gave a copy of the transcribed interview to the respondents for review purpose. After completion of validation from the respondents, the full text of the interview is prepared to be analysed.

4.2.2 Document Analysis

The document analysis is one of the crucial data in this study. It is a data that the researcher can relate with the written text documentation. According to Merriam (1998), the document including the written material, pictorial and physical document are relevant to study and easy to get by the researcher. In this context of this study, the document analysis was used as supporting data that attached with the interview data. The lesson plan is the main document used to be analysed and compared with the interview data. The information in this document analysis have been reported by research and was made as a research reference.

4.3 Data Analysis

Data analysis applied was the qualitative which is content analysis. The process included in content analysis are open coding, creating categories and abstraction. Open coding means that notes and headings are written in the text while reading it [28]. The written material is read through again, and as many headings as necessary are written down in the margins to describe all aspects of the content [29-31]. The headings are collected from the margins on to coding sheets and categories are freely generated at this stage [32-34]. After this open coding, the lists of categories are grouped under higher order headings. The aim of grouping data was to reduce the number of categories by collapsing those that are similar or dissimilar into broader higher order categories. Abstraction means formulating a general description of the research topic through generating categories [35]. Each category is named using content-characteristic words. Subcategories with similar events and incidents are grouped together as categories and categories are grouped as main categories. The abstraction process continues as far as is reasonable and possible.

5. FINDING AND DISCUSSION

5.1 Teaching strategies

Results from the analysis of the interview and lesson plan showed that all participants implemented the active teaching and learning appropriately based on the syllabus. Most of the participants (4 out of 6) knew the term "Art" in STEM fields. The minority of the participant (2 out of 6) did not know or heard the term "Art" in the STEM fields. However, all of the participants stated that they have used "Art" skills such as drawing graphic or diagram when teaching STEM subject.

5.2 Project Based Learning

Result showed that all participants have implemented project based learning in their teaching based on the topic in the syllabus. They believe that project based learning can enhance student's problem solving skills. Some of the transcription of the interview as follows:

"…actually..project based learning can only be teach if it is appropriate with the syllabus. But, in new KSSM syllabus, the project based learning become one of the requirement for students because..for example in science subject.. 20 marks will be evaluate for this project..so..we really need to use this project based learning..

"Form 1..one of the project is to produce some food with different density..so students in a small group will discuss and plan on how to create the food with different density. One of the group that I can see is they bring a lot of raw material so that they can try and try to create the food not only delicious but accordingly with the density concept too."

"The project is to build a greenhouse building model. Students actively will come and see me to consult on how to build the model. Students are motivate to learn and try to solve the problem. We can see the positive effect from it."

"Most of the students will made the similar project but with different creation. Students like to improvised and innovate something new and always consult to the teachers."

From the data it can be conclude that all participants believe students will have one product or prototype from the project based learning. Within the process to complete the project, students are able to enhance their skills especially in STEM fields. The result is in line with study of Jusoff and Daud (2010) that the product produced at the end of the study is the characteristic for project based learning [36].

5.3 Problem Based Learning

The main characteristic of problem based learning is that students are able to solve the problem arise based on the real life situation. The problem based learning focuses on the process of problem solving process and the results obtained as the solution of the problem. Students are given the opportunity to test their understanding of one concept based on the situation given. All of the participants believes that from problem based learning, students are able to think maturely and responsibly. Some of the transcribed as below.

"..the students investigate problems by using the concept that they have learned. Students For example, they need to investigate the type of disease, how the disease spread, and how to prevent. Students will discuss among them and they will relate with the topic they have learn in chapter 4 science form 2."

"..they able to learned from their mistake and challenge themselves to understand the correct concept in one topic. They always collaborate with each other and always consult with me to make sure they have the correct concept. They seems eager to learn and understand the situation."

Most of the participants stated that mostly topics in STEM subject contain problem based learning as one of the learning strategies to enhance higher order thinking skills.

"…most of the question in new syllabus KSSM are challenging. It seems like problem based learning have in most of the topic in STEM subject. Students are required to do in a small group and brainstorming about the problem that are given. You can see it in mathematic subject, science even in RBT subject. With this, we can see that students need to think critically."

The result is in line with Lantz (2009) and Nadelson *et al* (2012) stated that the problem based learning is perfectly suitable to implement the concept of STEM for students [37,38]. Teachers play an important role as facilitator to guide students to get the solutions. However, most of the participants stated that the problem based learning is more efficient to implement in advanced class compared to lower class because students in advanced class is more prepare and have positive attitude towards learning [39-41].

5.4 Inquiry Based Learning

Inquiry based learning is a method that builds a new knowledge and connect it with the prior knowledge. By this definition, all participants agreed that they had practiced the inquiry based learning in STEM subject. They believes that inquiry based learning is one of the learning strategies that commonly used in STEM subject with the new syllabus KSSM. They said:

"…eventually, in this new syllabus that had been implement, teacher will always ask a lot of questions because the higher order thinking skills that had been stressed by the ministry. Students also will raise many questions. Then, after that, students will try to find the answers. Students will always consult with me. From there, I can see either the students really understand or not."

" For example, in topic of evaporation. I will students about their daily routine doing the house chores. Students will started to think and able to raise questions because they already have prior knowledge about that.."

The results also consistence with the study from Nur Diyana *et al* (2016) that the inquiry based learning able to facilitate students to get the information about natural phenomena that are being explored. The inquiry based learning in STEM fields was common because of the nature of the subject. The students who learn through inquiry based learning show a better understanding compare to students who being taught through conventional method [42-44].

5.5 Art in STEM fields

In this study, most of the participants (4 out of 6) understand the term "Art" in STEM fields. Participants able to explain when art skills being used through teaching and learning.

"..usually, I used to draw diagram when necessary based on the topic I teach.."

"..well, in science and mathematics subject..drawing the diagram is necessary. Especially if you want to teach for example like..matter in three states..how the matter in solid form..or in cell topic.."

The rest participants (2 out of 6) do not understand the term "Art" in STEM fields. However, when the researcher explained, they immediately understand the term and admit have used it through teaching and learning.

"..erm..I don't think I understand this term..art in STEM fields"

"it is art like dancing and singing right?.. I don't think I have used it in teaching.."

All participants agreed that when using art skills, students have better understanding compared to none. It is because they believed that arts make the abstract concepts in STEM subjects easy to understand and see.

6. IMPLICATIONS AND SUGGESTIONS

In the new syllabus that have been implemented, the active teaching and learning has become necessary and important to be used. The findings of the study showed that teachers practiced active learning while incorporating the art skills in STEM subjects. It shows that teachers have the knowledge and able to use it with the art skills when necessary. This is crucial because it will ensure the learning objective is achieved and able to attract students into STEM fields at higher level. The result of this research is expected to be used as a benchmark by the relevant authorities to enhance the existing activities in order to attract more students to choose STEM fields in higher level or even as their career. Further study by other researcher from various fields and disciplines is recommended as it can be integrated with the STEM fields. The exploration in other subject will enrich STEM data especially the existing findings in Malaysia.

7. CONCLUSIONS

In conclusion, teacher in secondary school especially who have been involved in the new syllabus have general knowledge on art skills in active teaching and learning. They are able to use it in the teaching process when necessary. Nonetheless, the use of art is limited by certain skills only, but it will become a pioneer in STEM education in Malaysia and will expand in the future. Finally, the STEM education in Malaysia is still new and at early stages of its implementation. The early stages in Malaysia are focused on teacher's preparation and teacher's understanding. It is important to promote STEM education among teachers as one of the method to enhance students' interest in STEM fields in the future.

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