

Stem Integration in Classroom Practices among Biology Teachers in Mara Junior Science College (MJSC)

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Abstract

The purpose of this study is to explore the teacher's understanding and practices of STEM integration in Biology classrooms at MARA Junior Science College (MJSC). A semi-structured interview was conducted with five Biology teachers from three different MJSC. These teachers were purposefully selected from teachers who integrated STEM in their classrooms. The aim of this study is to explore the Biology's teachers' understanding about STEM integration and how they practice STEM integration in their classroom despite all the challenges faced by them. Data was analysed using a comparative method based on the results of the interview. Findings from the interview suggest that, firstly, student-centred activities are the keys to integrate the four disciplines of STEM in the classroom. Secondly, all five teachers understand STEM as the integration of Science, Technology, Engineering and Mathematics in Biology. Thirdly, there are four main challenges faced by the teachers in order to integrate STEM which are: time constraint, lack of teaching aids, lack of professional trainings in STEM and students' attitude in the classroom. Lastly, all the teachers agree that STEM integration will change the attitude of their students towards Biology.

Keywords: STEM Integration, Teachers' Understanding, Classroom Practices, Biology Education, Challenges

Introduction

The Malaysian Education Development Plan (MEDP) 2013-2025 highlights the importance of STEM implementation in education (KPM, 2015). In this plan, the new curriculum standard for secondary school is revised to enhance Science, Technology, Engineering and Mathematics (STEM) skills in students in order to prepare them for 21st century challenges. In this global multidisciplinary society, we need multi skilled citizens with high capability to compete globally. This shortage of multi skilled citizens can be overcome through STEM integration in the early stages of education (Xie, Fang, & Shauman, 2013).

Teacher as an important element in education has a crucial role to make sure STEM integration in the classroom is at its best. However, STEM disciplines are currently taught in

schools separately as individual subjects (Wang, Moore, Roehrig, & Park, 2011) but the nature of the work of most STEM professionals blurs the lines between disciplines. There is a call for the education industry to seriously integrate all four disciplines in order to prepare the students for real life challenges after school. Even though there are some teachers who are aware of the importance of STEM integration, teachers at school face numerous problems. Among which includes the existence of very few models and general guidelines for teachers to follow in order to integrate STEM in their classrooms (Bell, 2016).

Biology is one of the subjects that must be taken by the students in MJSC. Biology always stands on its own as a separate subject unlike the other science subjects like Chemistry and Physics. Students also visualise Biology to be difficult as there are lots of concepts, abstracts and complex processes that cannot be observed by naked eyes (Çimer, 2012). There is a need to integrate Biology with other disciplines in order to make sure students understand the concepts in Biology easily and subsequently, apply it in their daily life. This study is conducted to explore the Biology teachers' understanding about STEM integration and how they practise STEM integration in their classrooms despite all the challenges faced by them.

Research questions

This study explores the teachers' understanding of STEM integration and their classrooms practices in teaching Biology at MJSC. Attention was paid to the level of their understanding of STEM and how they integrate STEM disciplines in their classrooms despite the challenges they faced and also how STEM integration may affect the students' attitude towards Biology. The research questions that guide this study are as follows:

- i. To what extent the teachers understand STEM integration?
- ii. How do teachers integrate STEM in their Biology classrooms?

Stem integration

STEM is an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics (Bell, 2016). This acronym is always used when referring to education policies or subject curriculum in schools. The STEM integration has been specifically defined as the level of academic increase. The definition of STEM varies based on approaches used and situations it is applied to. STEM has become a discussion all over the world to improve the lifestyles of citizens. STEM is embedded into education to make sure all the students are well-prepared for the after school challenges.

The importance of STEM is very broad to the extent of promoting a highly capable STEM workforce for the country (Wiswall, Stiefel, Schwartz, & Boccardo, 2014). STEM integration can also contribute to personal well-being and prepare oneself to face the challenges in their life as a human being. The most important goals are to integrate at least two or more disciplines in STEM through education so that they can apply that knowledge in their daily life situations and develop a STEM literate citizen (Storksdieck, 2016). At the end of the day, students who pursue their ambitions in STEM fields stand tall as valuable human resources for the country and at the same time have an excellent quality as a person (Malaysian Blue Print, 2012).

STEM Integration in Malaysian Context

In Malaysia, science education has shown an interesting development in the last 50 years to adapt to world trends and challenges. There have been numerous efforts from the government and educators in Malaysia to successfully deliver science education to students. However, the low achievement of students in Science in this country is alarming. Analysis from the Ministry of Education (2012) stated that Malaysian students have very limited scientific knowledge and can only apply it into examination. Malaysia is struggling to compete in world economy and in Science and Technology related fields (Buang, Halim, & Mohd Meerah, 2009). Hence, the government's education policy (1967) implemented for upper secondary Malaysian students to enrol in Science and Social Science subjects are targeted at a ratio of 60: 40 (Ministry Of Education, 2012b).

Until today we are facing with the situation where a very low number of students choose Science subject and this situation is known as STEM crisis according to MOE report. In the new curriculum standard for secondary schools, STEM is in the lime light and all the educators are urged to use STEM as one of the pedagogical approaches in the classroom. This is to ensure the learning will become more meaningful. The new revised curriculum stresses on STEM integration in the classroom to prepare the students to become Science literate students at the end of the process. At the same time, students may apply the knowledge into their daily life (Ministry of Education, 2013).

In order to attract more students into STEM fields, schools have to provide meaningful learning to the students to relate to their own context. The students have to be motivated and encouraged to be involved in the learning activities. Teachers play an important role to promote these learning experiences to the students (Bell, 2016). Teachers should be capable of offering meaningful learning experiences that engage students in real life situations, problem-solving, cooperating with others, and applying their knowledge, skills and creativity in finding solutions to certain problems (Siew, Amir, & Chong, 2015). It may be a challenge for teachers since there are very few models and guidelines available in Malaysia to integrate STEM in the classroom. However, despite these challenges the teachers from MJSC who are involved in this study are still able to implement STEM integration in their Biology classrooms.

Theoretical framework

It is clear that teachers' preparation to facilitate learning has a profound bearing on the success of their instruction in the classroom (Crippen & Archambault, 2012). Teachers are the most important source when it comes to education. It is very important to explore STEM integration from the teachers' perspective. From this theoretical framework, the classroom practices of the teacher in integrating STEM are explored. The teachers need to understand what is STEM in nature so that they can apply it into their classrooms practices.

They also have to be exposed to STEM activities and engage them with STEM in order to learn real life experiences before they can implement STEM in their classroom. The main factor that will encourage teachers to integrate STEM is the interest in STEM itself. Teachers need to nurture their own interest in STEM through engaging activities, exposure and understanding so that they will blend together perfectly. This STEM integration research is guided by the theoretical framework in Figure 1.

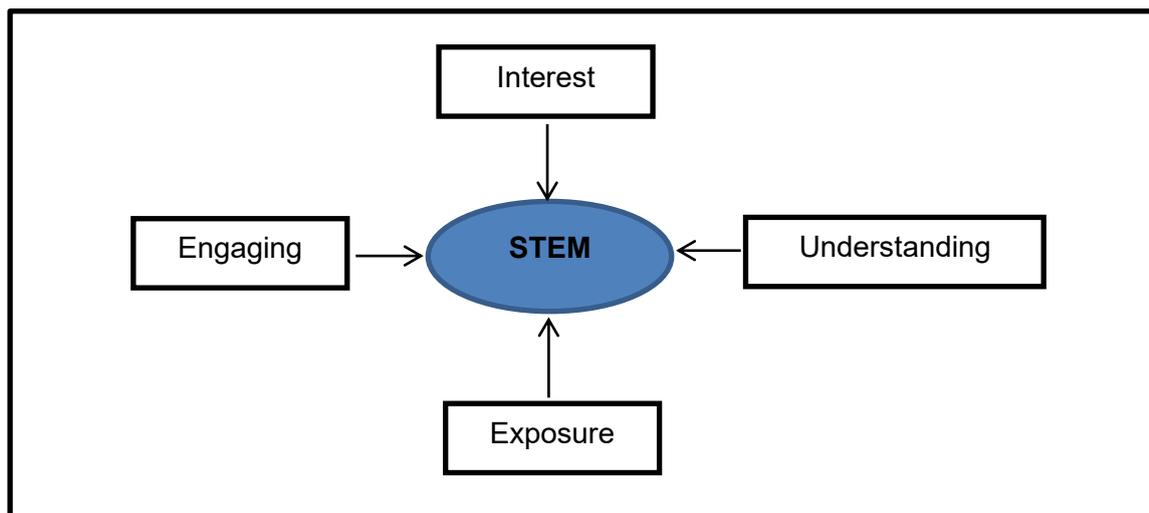


Figure 1: *Theoretical Framework (STEM integration research paradigm, Moore, 2011)*

Methodology

A qualitative semi-structured interview was conducted on five Biology teachers from MJSC to explore the teachers' understanding and classroom practices to integrate the four disciplines in STEM. The data was analysed using Atlas.ti to create a theme for findings and discussion.

Participants

Five teachers are purposefully selected based on three criteria: firstly, they have all shown high interest in integrating STEM in their teaching and learning processes. Secondly, they are teachers from MARA Junior Science College (MJSC) who focus on producing Science literate students and thirdly, they are good Biology teachers who are recognised by their peers at college. Teacher's demographic information are summarised in Table 1.

Teacher	Subject	Teaching Experience (years)	STEM Integration Experience (years)	Class Teaching
Ani	Biology	7	3	Form 4
Aimi	Biology	16	5	Form 4 Form 5
Hanisah	Biology	7	4	Form 4 Form 5
Khadijah	Biology	14	6	Form 4

				Form 5
Salmah	Biology	11	2	Form 4

Table 1: *Teacher's Demographic Information Summary***Teachers' Interview**

One interview was conducted with each teacher from three different MJSC. The interview consisted of 8 questions. There were five parts to the interview: firstly, teachers were asked to fill up the first section that contained personal information and teaching experiences. Secondly, the teachers were asked to describe the nature of STEM on their own words. Thirdly, the questions focused on classroom practices by the teachers to integrate STEM. Fourthly, the teachers were asked to describe the challenges faced by them and how they overcame those challenges to integrate the STEM in the classroom. Finally, the teachers were asked about their belief on the impact of STEM integration on students' attitude towards Biology. This interview was approximately 10 minutes' long. The interview data was transcribed verbatim to produce meaningful findings to be analysed (Pansky & Tenenboim, 2011).

Findings**Ani's interview**

From the interview session with Ani, we found that she believes that STEM disciplines are related to each other. This is especially for Biology which can be related in so many ways. The following are STEM-related classroom practices by Ani:

1. Build up a model (based on topic)
2. Use technology to deliver contents: videos, online application, online games, KAHOOT.
3. Field work to collect data
4. Experiment: create hypothesis, find relationship, do calculation.

In her classroom she always encourages and motivates students with hands-on activities such as build up a model, conduct sampling and once in a while she conducts an experiment for her students. Ani believes if she has a chance to improve her classroom practices, she will start to use more technology in her teaching and learning processes. She says, "We are moving towards 21st century education. For MRSM students they have IGCSE curriculum, so students can bring their laptop to the classroom (starting with form 4 students next year). She can use online applications to explain the contents to the students.

However, there will be a few difficulties to integrate STEM in her classroom. The two difficulties faced by Ani at her college: firstly, from the students aspect. Some students are not interested in hands-on activities while some of them cannot relate the knowledge to their daily life because not every student has the same life experiences. They hardly understand the questions that apply higher order thinking skills. Secondly, the Wi-fi connection is unstable, so she could not use online applications and play online videos when the need arises.

Regardless all the difficulties, Ani still puts up efforts to integrate STEM in her classroom by creating more activities for her students and always relates it to their daily life situations. Ani also believes through integration of STEM, the students' attitude towards Biology will become more positive. She says, "They have more interest to learn biology. Developing their soft skills

and making them closer to the creator. They are having fun in the Biology classroom because they are doing what they like". She also adds that STEM is good to prepare the students for their career field and become marketable because students who are involved in STEM have more skills than those who are not.

Aimi's Interview

Aimi understands that STEM is an integration of four disciplines of Science, Technology, Engineering and Mathematics. She believes that Engineering and Technology are the key to integrate other disciplines in STEM. She says, "The nature of engineering and design through technology will be applied in learning and teaching activities". In Biology, STEM can be related to each other in many topics especially the topic that involves calculation and experiment. The followings are STEM-related classroom practices carried out by Aimi;

1. Student-centred activity: build up model, games, presentation
2. Experimenting: create hypothesis, find relationship, calculate data
3. Use Technology: play online videos to explain certain topics that are too abstract

If she has a chance to improve STEM practices in her classroom, she chooses to do more experiments and bring the students to visit the laboratory or university for a real life experience.

She also says, "We have to boost the student's potential using an engineering approach to build creative and precise thinking skill regardless of the syllabus constraints. Aimi also states that there are a few challenges and difficulties at her college to integrate STEM in the classroom. She says, "There is not enough time to plan hands-on activity as the teacher needs to complete the syllabus in a short time. We have limited time to bring students out of the school to experience the real processes. Teachers lack professional training in STEM integration. Most of the teachers are very rigid and just follow the learning outcomes that are provided by the ministry".

Despite the difficulties, she always improves herself to become more creative in integrating all four disciplines of STEM. She chooses to add on more experiments for her students because she believes through experiments all four disciplines of STEM can be integrated well. Aimi emphasizes that through STEM integration, the students will have a more positive attitude towards Biology. This can increase their interest in Biology and will encourage them to choose Biology-related fields as their career in the future.

Hanisah's Interview

STEM from Hanisah's point of view is Science, Technology, Engineering and Mathematics are integrated to each other and in reality all four disciplines are related in a very natural way. The existing Biology syllabus has the integration element already. However, it really depends on the teacher to implement it in their classroom. She says, "For example in Biology, when I teach genetics, I will relate the topic to the latest instrument used to test DNA like fingerprinting and polymerise chain reaction (PCR). I will usually relate it to the careers that apply that particular knowledge and technology".

The STEM-related classroom practices carried out by Hanisah are as follows:

1. Experiment: students have to calculate a data through formulae
2. Technology: students are encouraged to find information through computers and search for a new issue in social media that was related to Biology.

3. Problem-based learning: students find an issue or problem and present it to the class
4. Students-centred activities: games, presentations, group discussions

If she has a chance to improve her practices, she chooses to bring the students to the learning sources, so students will have the first hand learning experiences. This type of learning activity will provide a higher opportunity for students to remember for a long time.

She also stated four difficulties and challenges faced by her to integrate the STEM; firstly, the syllabus content. The syllabus content needs to be revised so that it is parallel to the STEM integration and fulfils the current need of education. Secondly, time constraint. She says, “We have very limited time to creatively conduct STEM because so many topics need to be completed in a short time”. Thirdly is shortage of teaching resources, especially technology appliances like computers and teaching models. Lastly is lack of professional training for teachers to improve their skills towards the integration of STEM.

Hanisah personally agrees that STEM integration will increase students’ interest in Biology. She also adds, “Through STEM, the knowledge can be remembered for a long time by the students. They can use such knowledge in their daily life .In the future, the students can also learn to think and act in various ways and become a multitasking person who can relate to all the four disciplines”.

Khadijah’s Interview

Based on the answers from Khadijah, STEM in her point of view is the integration of Science, Technology, Engineering and Mathematics in classroom practices. She also believes, in Biology there are so many ways she can integrate all four disciplines or at least two disciplines at one time. She says, “For example, in Biology, we can use technology to do assessment for students. To evaluate students’ understanding, we can use online games instead of using a bundle of questions on paper”. The STEM-related classroom practices carried out by Khadijah are as follows:

1. Build up model: lung model and cell model
2. Technology through virtual experiment: quadrat sampling technique students are not required to go outdoors. They can use software to complete the experiment virtually.
3. Students centred activities: storytelling, games, create songs that relate to Biology topics.

If she has a chance to improve her classroom practices, she chooses to give an opportunity to students to create an activity that requires them to explain the lesson, instead of just finding a solution to the problems that have been created by the teacher. Students will become more confident and will not give up easily.

Khadijah also states three challenges to integrate STEM in her classroom. Firstly, teacher has very limited time to implement student-centred activities in the classroom. Secondly, teachers have to complete the syllabus and have to obey the date line that has been given by the management. Thirdly, some students cannot comprehend hands-on activities because they just do not like it. They prefer to memorise things by reading the book contents. Lastly, teachers need more professional trainings to face all situations in the classroom while they are trying to integrate STEM with their students.

However, Khadijah believes that by integrating STEM in the classroom, the students can apply the knowledge they gained in the classroom into their daily life. This will be a meaningful learning method for them and can be a factor to determine their career pathway in the future. She takes this as her motivation to never give up and try her level best to overcome all the challenges. She has put in a lot of effort to implement and practise STEM in her classroom for the benefits of her students in the future.

Salmah's Interview

Salmah is the last teacher in this interview session. According to Salmah, at the beginning, it was quite difficult for her to understand what STEM was all about. She was lucky enough to be chosen to take part in a 21st century pedagogy workshop that was held in United States of America, after which she started to implement STEM in her classroom. She says, "STEM is the integration of Science, Technology, Engineering and Maths in the classroom. This effort is to help increase the number of students who will enrol in Science and Mathematics to fulfil the country's needs". She realises that this integration can also be implemented in her Biology classroom.

The STEM-related classroom practices by Salmah are:

1. Teacher as facilitator in the classroom
2. Build up model such as lung model and organelles in the cell
3. Student-centred activities: students create a presentation based on the topic given
4. Technology: multimedia presentations and animation are used to explain complex topics

She emphasizes that if she has a chance to improve her classroom practices, she would prefer to use more technology in her classroom and perform more experiments with her students.

Salmah states three challenges that she faces in implementing STEM integration in her classroom; firstly, bureaucracy issue. She says, "When we want to implement some new methods of teaching, there will be a group of teachers who will look at it from a negative point of view". Secondly, time constraint to creatively create any activities in the classroom. Thirdly, the teachers need to follow the date line from the management to complete the teaching syllabus.

Despite all the challenges, she works towards positively improving herself to continuously integrate STEM in her classroom. She also believes by integrating STEM, the students will be more interested in Science and will perceive Science as easy and fun. This attitude will encourage them to build interest in the Science field and the possibility of them choosing Science-related courses in the university is very high. She added to her own statement, "They will apply the knowledge into their daily life. In the classroom students learn through experiences, so they will easily understand the phenomena that occur outside the classroom".

Discussion

Teacher's Understanding & Classroom Practices

From the semi-structured interview session conducted, all the five teachers believed and understood that STEM is integration between Science, Technology, Engineering and Mathematics. All the teachers also said that Biology can be related to STEM disciplines in so many ways. It is found that all five teachers have some similarities in their classroom Through

student-centred activities, the knowledge will become meaningful and can be withheld for a long time (Vergara et al., 2014).

All five teachers also agreed that experiments will make the integration of all the disciplines become more meaningful. It was said that through experiments students will enjoy hands-on activities and at the same time, they will gain knowledge through real life experiences (Storksdieck, 2016). In the experiment, students will build up hypothesis, find a relationship through variables and have to perform some calculations in order to gain the result of the experiment. For Khadijah, in certain topics, she preferred a virtual experiment using software. The students are not required to go out of the classroom but still can complete the whole experiment. It is said that technology will contribute to innovative way to integrate STEM content that can be used to develop and demonstrate students understanding, and to be shared between them in the classroom (Beal & Cohen, 2012).

All other teachers would also prefer to use more technology in their classrooms. Through online videos, multimedia animation and real live videos many concepts in Biology can be well-explained especially the dynamics and abstract nature of the structure in certain topics. Teachers can also use online applications to do a formative and summative evaluations on their students. According to Khadijah and Ani, the students' evaluation is shifted to another level when presented through online applications. With 3-D diagrams and labelling, students are generally more keen to answer the questions posted through online applications.

Challenges & Strategies

The teachers also shared some of their challenges and difficulties they faced in integrating STEM in their classroom practices. These challenges arose because there were not many teaching models and general guidelines for the teachers in Malaysia to implement STEM in their classrooms. One of the challenges is time constraint. Aimi, Hanisah, Khadijah and Salmah agreed at some point, teachers have limited time to plan an activity with their students. Teachers must also struggle to complete two different syllabuses which are the national curriculum and IGCSE curriculum. The second challenge is the lack of teaching aids. In STEM integration lessons, teachers have to prepare their own teaching aids to make sure the teaching and learning processes fulfil STEM integration. Unstable Wi-Fi connection can affect the STEM integration because teachers are unable to use live video, e-learning, game-based learning and other online applications in the classroom.

The third challenge is lack of professional trainings for the teachers. In this case, all five teachers agreed that more professional trainings should be provided to enhance teachers' awareness and creativity to implement STEM. Salmah added, sometimes bureaucracy also becomes one of the challenges that stops teachers from implementing the new teaching approach in the classroom. The last challenge is the students themselves. Some students are not interested to get involved in hands-on activities. They prefer to read and answer the questions rather than collaborate with other friends to solve problems. The different levels of understanding in students can affect the STEM integration too. Teachers need to prepare different types of activities for different types of students.

All these challenges will sometimes affect the teaching plans in the classroom. All five teachers agreed that they have to be more prepared and be able to adapt to the situation if any difficulties occur from the challenges explained above.

Students' Learning Experiences

From the teachers' point of view, all five of them agreed that STEM integration will change the students' attitude towards Biology. The students will become more interested to learn Biology because they are encouraged to do activities that they like. Once they like the lesson, they will have a positive attitude towards Biology. They can apply the knowledge that they learn in the classroom into their daily life. This will provide a more meaningful learning situation and they will remember the knowledge for a long time. The knowledge will be inserted in their working memory and will be a part of their life's lesson.

The teachers also shared their ex-students achievements. The students who are excellent in the classroom are more likely to choose a course in STEM once they enrol in the university. Most of them also choose STEM-related careers as their professional pathway. The importance of STEM integration is very broad to the extent of promoting a highly capable STEM workforce for the country (Wiswall, Stiefel, Schwartz, & Boccardo, 2014).

Conclusion

In STEM integration, the teaching and learning processes use a student-centred strategy while the teacher will act as a facilitator in most of the activities in the classroom (Cho & Brown, 2013). Based on the interview, the result has provided initial evidence that STEM integration can be implemented successfully and that teachers believe that this manner of teaching encourages students' learning and confidence in Biology. The teachers in this study felt that STEM integration is a natural way to think about teaching Biology, since most real world problems cross disciplinary boundaries. Despite the lack of facilities and guidelines in the education system, the teachers put in a lot of effort to prepare themselves to integrate STEM in their classrooms. With the new revised curriculum and full support from the Ministry of Education, one day our teachers can successfully implement STEM in their classrooms for the benefits and betterment of our students.

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