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EVALUATION OF THE IMPLEMENTATION OF A SCIENCE PROJECT THROUGH THE APPLICATION OF INTEGRATED STEM EDUCATION AS AN APPROACH

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Abstract: *Despite the growing number of resources, references, and support groups in integrated STEM education, there is a need to evaluate the implementation of these programs in school to identify the strength and problems for further improvement by the teachers and school administrators. This case study describes the evaluation of the implementation of a KSSM forms two science projects through the application of integrated STEM education as an approach. The individual science project organises and connects related concepts and skills of the STEM disciplines through engineering design practice (EDP) to solve a contextual problem based on a theme from the Sustainable Development Goals (SDG). The objectives of this study were to compare the actual and intended learning process and, to identify the strengths and weaknesses during the implementation process. Data were collected mainly from classroom observation and interviews. This study revealed that the actual process did not fully match the intended process as most of the students seem to be a lack of motivation to engage and persist through the design task. Besides, the lack of resources, tools and material, number of students, classroom setting, and the time frame may also contribute to the motivation of the students. The findings lead to suggestions to improve the implementation of similar science projects in the future.*

Keywords: *Evaluation, Science Project, Integrated STEM Education, Engineering Design Process (EDP), Sustainable Development Goal (SDG)*

Introduction

In the Implementation Guidelines for Science, Technology, Engineering and Mathematics (STEM) Education in Teaching and Learning by the Ministry of Education (KPM, 2016b), there are general guidelines and a few teaching plan examples to assist teachers in carrying out integrated STEM education during class or co-curricular activities. Further description and application of STEM education as an approach is found in the recent STEM resource modules for Physics, Chemistry, Biology, Additional Mathematics, Computer Science and Design and Invention (Rekacipta), respectively (Bahagian Pembangunan Kurikulum, 2017a, 2017b, 2017c, 2017d, 2017e, 2017f). These six STEM resource modules are based on solving a contextual problem related to the content for each discipline. Detail description of the approach used, content and activity teaching plan, pre-tests and post-tests, students' activity sheets, assessment rubrics, and references are included in each book. The comprehensive resource aimed to assist the teacher before, during, and after the teaching and learning session. As for the students, the modules emphasise the application of the design process and scientific inquiry as to the main approaches in solving contextual issues. However, the degree of STEM content and skills integration in each subject varies depending on the issues or problems posed for each topic. These resource modules are among some of the initial resources available for the teachers at the time of writing. They are targeted for the upper secondary school students who are in the pure science and technical classes, which may not meet the needs of other students, especially those in the lower secondary level. The design of the series also aimed to serve as a model for teachers to develop their STEM education material for other topics in the future. Hence, teachers can plan, develop, and implement their integrated STEM lessons or programs that suit the context of their students.

On the same note, Loh, Pang, and Lajium (2019) described the planning of integrated STEM education based on the available curriculum standards of form one Science, Mathematics, and Design of Technology (Rekabentuk Teknologi, RBT). The descriptions also include contextual problems based on the themes of Sustainable Development Goals (SDG) of the United Nation (UN) 2017. Besides, there are various online resources made available for the implementation of integrated STEM education in the classroom, for example, STEM Content Provider Network (Friends of STEM, 2019), Creative Minds (Creative Minds, 2019), STEM academy Malaysia (STEM Academy Malaysia, 2019) and many more.

Despite the growing number of resources, references, and support groups in integrated STEM education, there is a need to evaluate the implementation of these programmes in school to identify the strength and problems that need to be addressed for further improvement by the teachers and school administrators. Evaluation helps to examine a program or project by collecting and analysing information about a program's activities, characteristics, and outcomes to make judgments about a program, inform decisions to improve its effectiveness (Patton, 2002; Stufflebeam, 1983). There are not many studies that evaluate the various aspects of STEM education. Among the few are Shernoff et al. (2017) and Yang et al. (2015), who documented studies on the needs assessment of STEM education teachers. Both studies revealed teachers in STEM education require comprehensive STEM professional development for them to implement integrated STEM education lessons or activities effectively. Furthermore, they also suggested a few decisions to guide decision-makers in improving STEM education.

This study describes the evaluation of the implementation of a KSSM form two science project through the application of integrated STEM education as an approach to complement formal classroom teaching and learning. The individual science project focused on the multidisciplinary aspect of STEM integration that organises and connects related concepts and skills of the STEM disciplines through engineering design practice (EDP) to solve a contextual problem. The implementation of the project was guided by the intended process based on the steps (EDP). The design challenge was based on one of the curriculum standards of form two KSSM science and a theme from the Sustainable Development Goals (SDG). The objectives of this study were first to compare the actual and intended learning process. Secondly, this study seeks to identify some of the strengths and weaknesses or problems during the implementation process. As this is a case study that took place in one of the secondary schools, the findings cannot be generalized. However, the evaluation process can be replicated in a similar setting to inform and guide decisions for further improvement of the implementation process.

Literature Review

Integration and contextual-problems solving are the two main features in integrated STEM education. Integration provides more value compared to subjects learned separately, as it makes the subjects more relevant to students and teachers (Bybee, 2013; Vasquez, 2014). Besides, the application of integrated STEM to solve contextual problems makes learning more relevant and meaningful. The following discusses the engineering design process (EDP) as an integrator and Sustainable Development Goal (SDG) as the themes for the global contextual issues in integrated STEM education.

Engineering Design Process (EDP)

Bryan et al. (2016) argued that meaningful connection between STEM disciplines could be created through learning goals derived from selected primary disciplines; application of engineering design practice (EDP) as the integrator; application of science and mathematics in design or solution justification by students; the inclusion of 21st-century skills in learning; the focus of contextual problem-solving. EDP is an iterative process consisting of a few steps in designing and creating products to solve problems, as presented in Figure 1. The application of EDP as the main integrator of STEM education provides a systematic approach to solve problems, allowing the application of scientific knowledge and inquiry process and providing opportunity for students to build science and mathematical knowledge through design analysis and scientific investigation (Bryan, Moore, Johnson, & Roehrig, 2016; Guzey & Moore, 2015; Jolly, 2017; Kelley & Knowles, 2016; Moore et al., 2014; National Academy of Sciences, 2014; Truesdell, 2014). Therefore, by applying EDP, there is a blending of scientific, mathematical, and technological concepts and skills in exploring the possible solutions, selecting and planning solutions, developing, and testing the solution. It is also an approach that incorporates the 21st-century skills of critical thinking and creativity. In terms of collaboration and communication, EDP provides a platform for teamwork and active discussion in the process of designing, presenting, and justifying the solution. Therefore, the design process promotes content and skills connection between the STEM subjects as well as promoting the inculcation of the 21st-century learning skills.

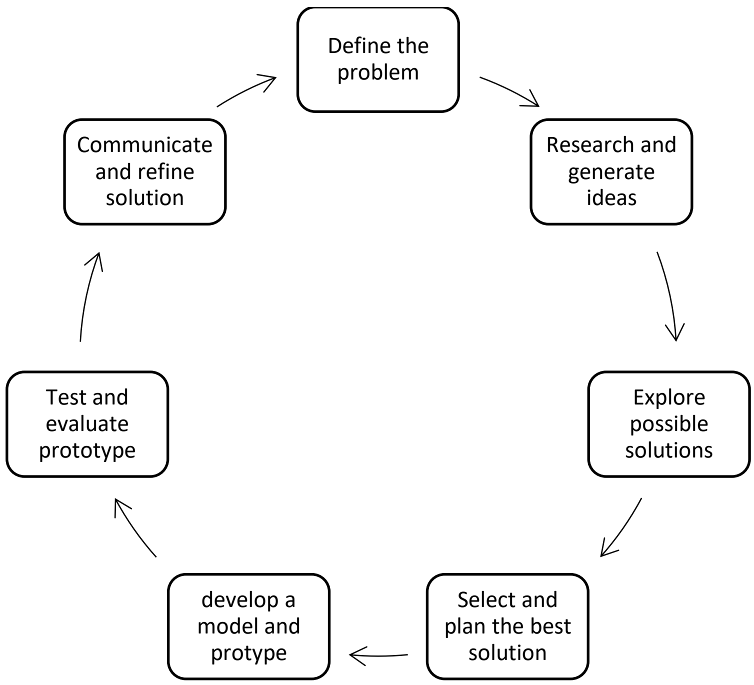

Figure 1: Engineering Design Process (EDP)

Source: (Jolly, 2017; Morgan, Moon, & Barroso, 2013; Truesdell, 2014)

Sustainable Development Goals (SDG)

Another feature that defines STEM education is the focus on contextual problem-solving. This differs from many of the simulated problems or written problems that are often used in traditional classroom teaching and learning. Contextual problem refers to real-world issues that are relevant in our daily life situation. Learning in context improves students' interest and making learning more meaningful (Pilot & Bulte, 2006). By applying integrated STEM in relevant real-world situations, students are more competent and embedded in the surrounding community (Sevian et al., 2018). Educators may select any global contextual issues as a focus for a STEM education programme. However, consideration has to be given to its relevance and impact to the students, community, and surroundings. In 2017, the UN general assembly adopted the 2030 agenda that listed 17 Sustainable Development Goals (SDGs) (Appendix 1) that cover global challenges that need to be addressed for a sustainable, peaceful, prosperous and equitable life of humanity in this world (UNESCO, 2017). It is a globally agreed agenda on the major challenges that the world is facing in the 21st century (Figure 1). Sustainable development can be generally defined as development that meets the needs of the present without compromising the needs of the future generation (Brundtland, 1987). It involves preservation and conservation efforts of nature and, at the same time, accommodating the human aspiration for development. One of the important strategies to achieve the SDGs is through education. Education is both a goal in SDGs, and a means to achieve the other goals. UNESCO has been promoting education for sustainable development (ESD) since 1992. There are 17 SDGs centered around different global issues such as climate change, zero hunger, sustainable consumption, and production that require a shift and transformation of lifestyle, thinking, and action. A new mindset, skills, values, and attitudes are required to achieve this change that may lead to a more sustainable world. ESD empowers learners to make informed decisions and responsible actions, reflecting their actions, considering their current and future social, cultural, economic, and environmental impact from their local and global perspectives. Science, Technology, Engineering, and Mathematics (STEM) education as ESD can be a vehicle in achieving the SDGs as learners can integrate various STEM knowledge, skills, and attitudes that empower them to solve global issues in their local context in achieving the SDG.

Figure 1: Sustainable Development Goals (SDG)

Source: (Leleux, 2019)

With regard to STEM education, the 5E learning model can allow students to experience integrated learning experience of science, EDP, and other crosscutting concepts of other STEM subjects (Bybee, 2014, 2010, 2013). For instance, Kaniawati, Kaniawati, and Rahma Suwarma (2017) applied the 5E model to Improve Concept Understanding On Direct Current Concept through the integration of mathematics, technology, and engineering. Similarly, this study applied the 5E model to guide and plan learning experiences for the students, especially in facilitating the EDP in the design challenge.

Methods

This is a case study carried out in an all-girls secondary school in which one of the researchers is currently teaching. It is a pragmatic approach based on a few practical considerations. The main purpose for this evaluation is to help the researcher to improve further the implementation of science projects using an integrated STEM approach in the school in the future. Furthermore, the researcher is bounded by rules and ethics as a secondary school teacher, which does not allow her to enter other schools to teach and observe. Apart from that, the researcher has on-going teaching duties in the school, which is not possible for her to do so. The participants are lower secondary school level composed of 42 students in one of the form two classes. The class chosen was one that was assigned to the researcher to teach the subject of science. Being a part of the class, it was the natural setting that allows the researcher to elicit rich and in-depth data.

This STEM education activity program was carried out as an individual science project based on chapter 7 in the science learning standards, which is electricity and magnetism. Students who completed this simple project will achieve the performance level of 6 which has the descriptor of ‘design a task using knowledge and science skills on electricity and magnetism in a creatively and innovatively way in the context of problem-solving and decision making or carry out a task in a new situation with regards to the social values/economy/culture of the community’ (KPM, 2016a, p. 72). The integrated STEM activity is planned according to the description from Loh et al. (2019) in which a design challenge is formulated based on one of the themes in the SDGs and involved the integration of key concepts and skills from the curricular standards of Science, Mathematics and RBT of form one and form two level. In this case, the design challenge is to design and produce a product from waste material with creative and innovative use of science, mathematics, and design technology knowledge and skills that promote sustainable consumption and production. The lesson plans and reflection of the implementation of this science project are presented in Appendix 1. The planning of the lessons was based on the 5E model (Bybee & Landes, 1990; Bybee et al., 2006). The whole lesson was carried out in five sessions in two weeks. This was implemented after the year-end examination as the students were more receptive to project-based activity during this time. There was flexibility to extend the lesson time as some of the other subject’s teachers were involved in the PT3 marking standardization meetings. Each lesson plan was prepared upon the outcome of the previous lesson.

This evaluation will involve the on-going monitoring of the implementation of the integrated STEM activity of a group of lower secondary school students in which students’ progress will be observed and documented. The researcher took the role of participant-observer who actively engaged in the activities of the participants. The actual process was observed and compared to the intended process. The intended process consists of steps engineering design process (EDP) that are used to design products for real-world problems. Notes were taken throughout the observation process and recorded as reflections in the lesson plans. Lastly, groups of students were interviewed in the natural setting of the class for students to be comfortable to answer spontaneously. The questions were asked when the researcher went to the table where the group was seated. The questions asked were: Did you enjoy this project? Why? What were some of the problems you encountered? This is similar to the naturalistic interview described by Greene (1989) in which naturalistic interviewing is designed as an in-class, small group discussion activity. Students were interviewed individually to elicit more information during the whole process to further understand the strength and weaknesses during the implementation process. The findings were analysed to assess the actual implementation process as compared to the intended process.

Findings

The lesson plans were written based on the outcome of the previous lesson. Overall the actual process does not exactly match the intended process in this STEM education activity. The summary of the intended and actual process is presented in Table 1.

Table 1: Intended And Actual Process

Engineering design process	Intended process	Actual process
Define the problem related to sustainable consumption and production pattern	All the students discuss in pairs to identify problems in consumption and production patterns. All the students present their findings	Most students appeared to be passive and disinterested. There were not many students involved in the discussion. The teacher posed questions to elicit answers from the students. Not many students answered, and only a few key students appeared to be more responsive.
Research and Generating ideas	All the students discuss ideas and do references through books, online resources	Many students discussed among themselves what to do, asked teacher questions for clarification during the first and second sessions However, not many did reference through the internet or books at home or school None of them bring laptops or resources for references.
List possible products or solutions Select and justify the best method	All the students list all the possible strategies with consideration of the contextual limitation and constraint	None of them listed all the possible product None of the students presented their possible design on paper
Construct the product	- Sketch a 2D or 3D model of the design -Identify the required components and Students construct their product by using recycled and other material All the students identify some of the constraints and problems	None of the students presented any 2D or 3D sketches. Some students started construction in school and completed them at home. Most of the students construct their products at home.
Evaluate and improve their product	All the students test their product and improve them	Those who had completed their product brought to school and test them. They tried to improve their product if there are any weaknesses
Communicate their product	All the students present and communicate the product Relating any application of science, mathematics or /and RBT concepts and skills	1. Most of the students were not confident in communicating their products. They were very conscious of how their friends perceive them. 2. They were unable to relate more concepts of science and mathematics other than those suggested by the teacher

	Reflecting on any constraints and problems faced during the whole process Relating it as a solution to the problem posed	3. They were able to sincerely shared the problem they encountered during the design and construction process 4. None of them relate their product with solving the problem related to the SDG theme.

During the first session of this project, the time for the 'explore' phase was shortened significantly due to the poor response of the students. The teacher tried to elicit students to share their views on the problems on sustainable consumption and production pattern. The lesson ended up being more teacher-centred, and the teacher spent more time in explanation of EDP and the problem related to sustainable consumption and production pattern. However, after the design challenge was given, students were more excited. Students asked many questions for clarification. There were creative ideas about the type of products they want to create. However, over a period of 2 weeks, only 21 out of 42 students hand-in and presented their completed products. It needs a lot of encouragement and follow-up from the teacher to motivate the students to complete the project. Only a handful of the product displayed creativity and innovation. A significant number of them seem to imitate what their friends have done with a little bit of modification. Most of the products were hand-held fan and wall clock.

The 5E phases were not implemented according to the intended plan. The actual implementation process does not correspond with the intended process. This is maybe due to the instructional skill of the teacher and the interaction between the teacher and the students. The teacher was only assigned to take over the class for the science subject one month before this project took place. Within one month, there were year-end examinations and holidays in between. Thus, the teacher did not have much time to get to know and interact with the students. The teacher needs to learn how to elicit appropriate responses from the students as well as motivating them to be more excited about the activity. Students were lack of motivation to carry out and complete the project. Upon the completion of the activity, a few students were asked about how they felt about the project. They said they enjoyed the process of designing and assembling it to form a product. They described that they were excited at first with the ideas but found it difficult to start. They mentioned that they did not know how to start, and one said she did not feel like doing it. However, once they started, they said they enjoyed the process and felt happy once the product was completed.

The lack of motivation was evident among the students. This was reflected by their lack of enthusiasm in looking for the resources, material, and to complete the project within the required time. Some did mention the marks allocated for the product and presentation were too low to motivate them to complete the project. The marks for this project is only 10% of the year-end assessment for science. They said if the marks were higher, they might feel more motivated to complete them. Most of the students were not aware that their experience and learning process are much more valuable than the 10 marks on paper. Their motivation seems to be extrinsic as it seems to be affected by the allocation of the marks in completing the project. There was only a handful of them who have the intrinsic motivation to complete the project. This was reflected by their completed product within the required time, the creativity and the effort displayed in their product. For example, one of the students used a translucent instant noodle cup to make a rotating light. Another student made a device consisting of a fan and light using a plastic container.

The lack of facilities, tools, and materials was obvious in this school. The school has very limited computers for students to access the internet. There are no computer labs in this school. Students have to bring their laptops to access the internet for the subject of Basic Science Computer (*Asas Sains Komputer*, ASK) in the assigned computer classroom. Many of the students do not have internet access at home to find the resources, references, and examples to guide them to complete their projects. Because of that, the teacher facilitated by showing a few videos on some of the electrical products that can be made using waste material in the second session of the project. Those who completed their project during the 3rd and 4th sessions come from households that have internet access. This may be another constraint that affects the motivation of the students. Apart from that, some of the essential parts such as DC motor were not available in the school and the shops in this area. The teacher and some of the students took the initiative to purchase them from online shops, which required some time to arrive.

There were 42 students in the class, and the teacher was unable to monitor the nature of the group discussion happened. Some seem to discuss the project, some seem to be lost, and some were talking about other things. Apart from that, the lessons were conducted in one of the labs in which there were eight students in one table. There is a sink in each table and thus occupy the space and limit the space for students to carry out their project. It was a bit crowded and cramped and was not conducive for maker-space activity.

The duration for this whole project was spread out over for two weeks as it utilised the time allocated for science and other available subjects in the time table with the permission of the subject teachers. In between the subject, students have to attend and complete other work and requirements of other subjects. This may pose difficulty for students to maintain momentum and motivation to complete the project.

The summary of the strength and weaknesses of the implementation process is presented in Table 2. As a whole, the teacher felt a sense of dissatisfaction with both the process and the outcome, in which only 21 out of 42 students handed-in their products after 2 weeks.

Table 2: Strengths And Weaknesses Of The Implementation Process

Strengths	Problems
The initial excitement of students in the design challenge	Many of the students were lack of motivation to complete the project
Creative ideas from the students in the initial lessons	There was a lack of facilities, tools, and parts that were essential to complete the project
	There were a large number of students in one class
	The class setting was not conducive for maker-space activities
	The time allocated for the completed project was spread in two weeks

Discussion

As this was the first time such activity was carried out, there are many rooms for improvement. The teacher needs to tap on their initial excitement and motivation when the design challenge was given. Table 3 presented some suggestions for further improvement of this integrated STEM education project in the future.

Table 3: Suggestions For Improvement

Problems	Suggestions for improvement
Many of the students were lack of motivation to complete the project	- A project that related to helping the community - Provide more structured guidance, examples and written steps
There was a lack of facilities, tools, and parts that were essential to complete the project	- Prepare the basic parts such as DC motor, rubber stopper, cable etc. before the task is given. - Provide internet access for students to generate ideas in the classroom setting
There were a large number of students in one class	- Train student facilitators/ peer leaders to help - Divide into smaller groups
The class setting was not conducive for maker-space activities	- Larger classroom space with tables equipped with functional power-point.
The time allocated for the completed project was spread in two weeks	- Allocate one or two whole days continuously

One of the major problems in the implementation of this STEM project in this study was the lack of motivation among students (amotivation). Even the subsequent problems listed in Table 4 contributed to the amotivation of the students to complete the project. Generally, four reasons that motivate students' learning: their ability beliefs, effort beliefs, the value placed on academic tasks, and the characteristics of the academic tasks (Ford & Roby, 2013; Legault, Green-Demers, & Pelletier, 2006). Ability belief refers to students' belief or disbelief on his/ her ability to complete a task. Closely related is effort belief, which is about that students' belief about whether they can initiate or sustain the necessary effort required to complete a task. Both beliefs are necessary for successful academic success. (Ford & Roby, 2013). The value placed on a task affects students' behaviour to complete a task (Lai, 2011; Ryan & Deci, 2000). When a task or project is not important or related to students' life, they will not incorporate their behaviour as the expression of themselves (Ford & Roby, 2013). Lastly is the characteristics of the task. If the feathers of the task or project do not direct, engage, or stimulate the students, there is a high possibility they will be disconnected (Ford & Roby, 2013). Unappealing and uninteresting characteristics of a task contribute to amotivation.

In this study, the reason for lack of motivation may be due to the value students placed on the project and also the characteristics of the project's implementation. Students lamented the marks allocated for the completion of the project was too low. One of the ways to increase students' motivation is to have a sense of meaningful purpose in their project. Holbert (2016) described that when making is centred on sets of practices, skills, and technologies that aimed to contribute to the community, learners, especially girls were highly motivated to engage in the activity. They persisted through the construction challenges and showed interest in further exploring to help others. This science project was based on solving the problem related to one of the SDG themes. However, the teacher has to put more effort into convincing the students about how they can contribute to the community and the society through their solutions to issues related to SDG instead of focusing it as a requirement for the year-end science assessment.

Another reason that may contribute to the lack of motivation is the characteristics of the project's implementation. For instance, in this study, the availability of resources, tools and materials, classroom setting, number of students, time frame, and the nature of guidance provided by the teacher. Students' motivation can be manipulated through certain instructional practices (Lai, 2011). A teacher is one of the crucial factors in ensuring the actual learning process takes place as the intended process. The teacher needs to have pedagogical knowledge that facilitates the instructions of integrated STEM lessons or projects in the classroom. Many teachers are not competent in implementing integrated STEM programs (Erdogan & Bozeman, 2015). They may not be familiar with managing students that allow effective engagement in projects with complex tasks. If teachers themselves have not experienced learning science, mathematics, engineering, and technology in an integrated manner and applying the integrated concepts and skills to solve contextual problem, they are less likely able to deliver a meaningful integrated STEM lesson (NAC & NRC 2014). Professional development in integrated STEM education is one of the interventions that can help teachers to acquire the necessary pedagogical skill.

Custer and Daugherty (2009) explained that professional development needs to infuse engineering into their curriculum. As engineering is not a subject in the secondary school level, engineering content in terms of the engineering design process with the integration of STEM content and skills can be incorporated. They further posit that STEM education teachers' professional development has to be in the form of active engagement in hands-on activities. Besides, STEM education professional development needs to emphasize on enhancing pedagogical contentment for delivering integrated STEM instructions (Nadelson et al., 2012). Pedagogical contentment refers to the extent to which one is contented or satisfied because of one's instructional practices achieve the desired teaching goals (Southerland, Sowell, & Enderle, 2011). Nadelson et al. (2012) further posit that teachers' comfort and pedagogical contentment are likely to increase their competency and effectiveness in carrying out STEM education. Nevertheless, it is necessary to identify the type of pedagogical discontentment towards STEM before implementing professional development so that intervention can be carried out to address teachers' needs. Teacher pedagogical discontentment can be contextual or process specific. Therefore, in implementing teachers' professional development on STEM teaching and learning, it is crucial to focus on content and processes which are predicted to influence pedagogical discontentment.

Conclusion

This study revealed that the actual process did not fully match the intended process. Students showed excitement and creativity during the initial stage of the project. However, only 21 out of 42 students completed their science projects. Most of the students seem to be lack of motivation to engage and persist through the design task. This may be due to the value students placed on the project as well as the nature of the implementation of the project. The lack of resources, tools and material, the large number of students in a class, unconducive classroom setting, and the time frame may also contribute to the lack of motivation of the students. The role of the teacher is crucial in helping students to embrace a sense of meaningful purpose in the project. Furthermore, teachers need to be equipped with pedagogical knowledge that facilitates the instructions of integrated STEM lessons or projects in the classroom. Professional development in the form of active engagement in hands-on activities and focusing on enhancing pedagogical contentment may facilitate teachers in improving the implementation of integrated STEM education as a learning approach. Thus, this evaluation study informs and guides the selection of interventions that may serve to improve the implementation of similar science projects in the future.

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Appendix

Lesson plan and reflection
Date: 14 – 10 -2019
Time: 8.30 – 10.00 (1 hour 30 minutes)
Class: 2Z
Number of students: 41

<table>
<tr><td>Lesson</td><td>Learning outcomes</td><td>Suggested activities</td></tr>
<tr><td>1 (A)</td><td>Identify and list out the steps in EDP</td><td><u>Engage:</u> What is STEM education? (5 minutes)
<u>Explore: (20 minutes)</u>
How do engineers work?
How do engineers solve problem?
<u>Explain (15 minutes)</u>
Teacher respond to students' feedback? Teacher explains EDP and its application.
<u>Extension (5 minutes):</u>
Introduce the theme 'Sustainable production and Consumption"</td></tr>
<tr><td>1 (B)</td><td>Students will be able to define the problem related to sustainable consumption and production patterns
.</td><td><u>Explore:</u> (15 minutes)
Working in pairs, students identify the problems in consumption and production patterns. Teachers pose questions to guide the students.
<u>Explain:</u> (15 minutes)
Students present their findings on how to pose questions to define problems, teacher clarify, conclude and relate with the SDG theme – Sustainable Consumption and production patterns

<u>Extension:</u> (5 minutes)
Teacher present the design challenge.
Design and produce a product from waste material with creative and innovative use of science, mathematics and design technology knowledge and skills that promote sustainable consumption and production.
Individual product
Group discussion
Scope: Electrical, mechanical, useful

<u>Evaluation:</u> (5 minutes)
_Students list out the EDP steps</td></tr>
<tr><td>Reflection</td><td colspan="2">Discussion about STEM, EDP and defining problems with students:
- Students were quite passive
- Not many students involved in discussion
- Students appeared to be disinterested
- Teacher spent more time in explanation
- More teacher centered than student centered

Extension: Design challenge
- Students were more excited after the design challenge was given
- A lot of questions asked for clarification.
- Students discussing among themselves of what to do – generating ideas, listing all possibilities, selecting best solution.</td></tr>
</table>

	Due to the response of the students during the explore phases in the lesson, the time was shortened significantly for that phase. However, the time for extension is extended to allow students to discuss the design challenge Teacher reminds students to bring laptops, material and other relevant resources for the next lesson to generate ideas, identify possible solution, select best solution and start to design and construct.

Date: 15- 10 – 2019
Time: 11.20 – 12.50 (1 hour 30 minutes)
Class: 2Z
Students: 40/41

Lesson	Learning outcomes	Suggested actitivities
EDP application in Sustainable consumption and production (1.5 hours) Idea Generation, explore possible solution, select best solution	Students will be able to 1. list possible products through books, online resources and/or collaboration with community of practice. 2. Select and justify the best method 3. identify the main component and material required in their design/ product.	Engage: (5 minutes) Reflect upon the problems posed in the previous lesson. Teacher once again relate to the design challenge. Scope is given to guide the students. Teacher demonstrate some products related to the design challenge Explore: (30 minutes) Working in groups, with books, online resources. 1. students list all the possible strategies and practices with consideration of the contextual limitation and constraint. 2. students select and justify the best strategy within their capacity and context. 3. sketch a 2D or 3D model of the design/ product 4. identify the required components and materials Explanation (30 minutes) Students present their findings and justification Teachers give feedback Extension (10 minutes) Students relate the concepts of science, math and RBT in their product/ design. Student relate any new concepts/skills/components in their product Evaluation (10 minutes) Reflect and evaluate the first 3 steps of EDP -idea generation. Evaluate the 2D or 3D sketch
Relection	Engage: Teacher asked how many students have ideas on what they want to do, many raised their hands. However, some were still clueless what to do All of them did not bring any laptops or resources for references. Few brought the necessary tools such as glue gun, scissors and cutter. Some brought some waste material to be used for construction, such as cardboards, plastic bottles, cans, plastic	

	plates. Only a few of them brought the necessary electrical parts such as DC motors, cables etc. There were two students brought their final product made at home but using potential energy from rubber band for movement. They were reminded of the scope of this design challenge – electrical and asked to modify and upgrade their designs. Explore: Teacher facilitated by showing a few videos on some of the products that can be done using waste material. Students excited and posed many questions. Most of them asked how to obtain some of the necessary parts especially DC motor, battery casing, cables, switches. Teacher suggested them to obtain them from used toys such as toy cars or other sources. Teacher also suggested some local shops where they can buy those parts. However, many of the local electrical and electronic shops do not have these parts and tools. Some were selling at a very high cost. Teacher suggested a few options. Students further discussed their constraints and how to design and construct the product within their capacity and the available tools and parts in groups. Teacher did not check any 2D or 3D sketches. Explain: None of the students presented any of their designs. Most of the time were used to discuss the constraint, how to obtain the parts, and the design of the products in their group. Evaluation and extension could not be carried out as planned As closure: Teacher pointed out that today's lesson was the continuation of idea generation, listing out possible solution and selecting best solution in the EDP in which students identify the constraints and trying to work out the best solution for their design and products. Teacher encouraged those with complete tools and parts to start constructing their product. As for those who are still lack of the parts, they were asked to try their best to find and obtain them within their capacity.

Date: 16- 10 – 2019
Time: 11.50 – 12.50 (1 hour)
Class: 2Z
Students: 39/41

Lesson	Learning outcomes	<u>Suggested activities</u>
EDP application in Sustainable consumption and production	Students will be able to 1. Produce the product by using available material through the application of	<u>Engage: (5 minutes)</u> Teacher relate today's unit with the session 3 <u>Explore (20 minutes)</u>

1. Design and construct 2. Evaluate 3. Communicate and refine solution	science, mathematics, RBT concepts and skills 2. Identify the constraints and problems 3. Communicate their product 4. Evaluate and refine their product.	Students identify the main components of their design/ product Students construct their product by using recycled and other material based on their design in session 3. Students identify some of the constraints and problems during the process <u>Explanation (30 minutes)</u> Description of assessment rubric for the presentation Students present their findings and justification Teachers give feedback (Evaluate) <u>Extension (5 minutes)</u> Students relate the concepts of science, math and RBT in their product/ design. Student relate any new concepts/skills/components in their product
Reflection	<u>Engage:</u> Teacher checked any completed product. Explore and explain: One student completed her product (a fan). Teacher checked on her product. She explained that it needed to be improved in terms of stability. Teacher also suggested that it need to be user friendly as there is no functional switch. One student had a semi-completed project, teacher asked questions, evaluated and gave feedback for improvement. Some students tested on the motor and the circuit, discussed among themselves on how to design the structure. The main problem was still the lack of essential parts such as battery, DC motor etc. Those who have complete parts proceeded with the design and construction. Some still figuring and yet to decide what they want to construct with all the constraints. Overall, there were active discussions. However, due to the number of students, there is difficulty to monitor their discussion. Some groups seems to be talking about other things. Those with complete or semi complete designs served as motivation and inspiration to others. It excites the other students to start planning their design projects. As a closure, teacher reminded students to complete the project over the weekend and	

Date: 21- 10 – 2019, 22-10-2019, 23-10-2019
Class: 2Z
Students: 39/41

Lesson	Learning outcomes	Suggested activities
EDP application in Sustainable consumption and production 1. Design and construct 2. Evaluate 3. Communicate and refine solution	Students will be able to 1. Identify the constraints and problems 2. Communicate their product 3. Evaluate and refine their product.	<u>Engage: (5 minutes)</u> Teacher relate today's unit with the session 4 <u>Explore (20 minutes)</u> Students presented their product by relating the application of science, mathematics and other in their product Students identify some of the constraints and problems during the process <u>Explanation (30 minutes)</u> Teacher gives feedback, asks questions to clarify (Evaluate) <u>Extension (5 minutes)</u> Teacher makes conclusion
Reflection	Teacher checked any completed product. Only three students were ready to present their product on the first day. 2nd and 3rd day, more students were ready Out of 41 students, 24 students completed and presented their product Explore and explain: Presentation 1. Students were not very confident in communicating their product. They were very conscious of how their friends look or think about them. 2. They were not able to relate more concepts of science and mathematics other than suggested by the teacher. 3. However, they were able to sincerely share the problems that they encountered during the design and construction process. 4. Teacher assessed their presentation and product. The remaining time was used to guide students who were still constructing their product.	

	Personally, I was disappointed over the lack of motivation and enthusiasm in completing their project through the weekend. Most of them already have the required parts. When asked about the problem, they answered they do not know how to construct their designs. They know how to assemble the parts, but unsure how to design them in order to be user friendly etc. In a casual conversation with a group of them, I asked whether they enjoy this project of designing and construction. They described that they were excited at first with the ideas, but found very difficult to start, but once they started, they said they enjoyed the process and felt happy. Some said that they don't know how to start and some said they don't feel like doing. Many students kept asking about the marks allocated for the completed project. As I had mention in the class, this project is part of the assessment for science. 10% is allocated for completed product and presentation of the product. Some did mention if the allocated marks are more than 10%, it may motivate them more. I reminded them that their experience and learning process are much more valuable than the 10 marks on paper. The students seem to need a certain amount of extrinsic motivation to complete their project. There is only a handful of them who have intrinsic motivation to carry out the project. This can be reflected by their completed project within the required time and the creativity displayed in their product. I also found out that many of them do not have internet access at home to find resources and examples to guide them to complete their project. Those completed their projects seem to come from household that have internet access. This is another factor which may affect the motivation of the students.

Problems	Suggestions
1. Lack of tools and parts - Many students' project are constrained by the lack of tools and parts. - seems to demotivate and limit their creativity	- Pre-packed basic parts - Facilitation and encouragement to be creative and find alternative
2. Lack of motivation - some students are not motivated to do and complete the project	- start with very guided project with complete examples and prepared materials - shows video of examples to guide and motivate. - provide internet access in class for students to generate ideas and guide
2. Number of students - teacher was unable to monitor the nature of the group discussion. Some seem to discuss about the project, some seem to be at lost, some seem to be talking about other things	- Group or paired project - Divide into smaller groups - Train facilitators
3. Class setting	- More space

The first lesson was conducted in the classroom. The subsequent lesson was in the lab in the biology lab which there were 8 students in one table. There is a sink in each table which is not necessary for maker space activity and occupied the space on the table	- Tables with functional sockets
4. Time frame	- Completion in one or two days in the class or after-class instead of splitting the time according to the time table
5. Students' presentation/ communication	- Lack of confidence - Unable to relate concepts - Did not relate to solving problem