Integrating STEM education through Project-Based Inquiry Learning (PIL) in topic space among year one pupils

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Abstract. This research aims to investigate the effect of integrating STEM education through Project-based Inquiry Learning (PIL) and the users of the STEM modules which consists of five projects on topic Space in Year One Mathematics Syllabus in Kurikulum Standard Sekolah Rendah (KSSR) of Malaysia. STEM education in primary school focuses on the introduces and awareness of students about the importance of STEM education. The projects in STEM modules are covering the different ethnic cultures in Malaysia. The modules are designed using the four phases in PIL. Concepts and the explanation of STEM education on each project are emphasized and provided in the modules so the teachers able to carry out the projects by using the modules. By using the modules in primary Mathematics, the students and teachers will be more understanding on how to integrate the Mathematics' concepts in STEM education.

1. Introduction
To enhance the quality of education in Malaysia, the Ministry of Education (MOE) has developed and launched the Malaysia Education Blueprint 2013-2025 (PPPM) which aims to transform the education system in Malaysia in order to compete with the growing international education system. To achieve this objective, the MOE has identified 11 shifts that can result in changes in the education system in Malaysia. The first shift in this blueprint has stated: Provide Equal Access to Quality Education of an International Standard. One of the benchmarks in the first shift is to strengthen the quality of Science, Technology, Engineering, and Mathematics (STEM) education.

In order to produce the educated citizens and meet the needs of 21st-century skills, STEM education is an important interdisciplinary subject which fulfilled the needs. Each individual must know and understand the basic concepts of the STEM. STEM education has given the best opportunities for students to understand the world in a holistic manner. According to Hays Blaine Lantz, Jr. (2009), STEM education offers students one of the best opportunity to make sense of the world holistically, rather than in bits and pieces. STEM education removes the traditional barriers erected between the four disciplines, by integrating them into one cohesive teaching and learning paradigm [1].

To equip the students with the skills needed to face the challenges of a changing global with the application of STEM, the MOE is responsible for ensuring an increase in the ratio of students who wish to pursue scientific and technical fields. In the PPPM 2013-2025, the MOE has stated the five factors that cause the decline and the quality of student outcomes in STEM education,
● Lack of awareness in STEM education.
● STEM subjects considered difficult.
● A solid curriculum content.
● Less consistent with the quality of teaching and learning.
● Old and inadequate infrastructure.

These factors or problems must be overcome so that the desire of MOE in PPPM 2013-2025 can be achieved. In 2014, Dr. Suhaidah Tahir, Dominador D. Mangao and Dr. Nur Jahan Ahmad of the Southeast Asian Ministers of Education Organization Regional Center for Education in Science and Mathematics (SEAMEO RECSAM) have designed a conceptual framework for the development of STEM education in Malaysia. In this framework, it divided the development of STEM education into six phases, which is from early childhood to industry or community. In this paper, we focused on the second phase which is on the primary or elementary school, the focus is helping the students to make the connection or build the foundation in STEM education [2].

In the primary or elementary school, the STEM education focuses on the introduction and gives the awareness to students about the importance of STEM education. In other words, it gives a draft idea of the integration of the four fields in STEM education. Initial step to introduce STEM education is to provide the standards-based learning which based on the problem-solving and inquiry-learning method in real situations to link up the four subjects in STEM education. In other words, the goal of STEM education is designed based in the inquiry-learning by used the thinking skills in science and technology to solve the everyday real life problems.

The purpose of this research is to enhance the integration of STEM education in Mathematics Kurikulum Standard Sekolah Rendah (KSSR) through an inquiry-based approach which the activities focus on project-based learning using the Inquiry-Based Learning Project (PIP).

2. Project-based Inquiry Learning (PIL)

Inquiry-Based Learning Project (PIP) is the method that emphasizes on the sciences skills and attitude, high order thinking skills, creative problem solving, design and construction of the object-based technology and encourages the children to communicate and work in teams [3]. There are four phases in PIP, namely Inquiry, Exploration, Experimentation, and Reflection.

In the Inquiry Phase, students ask questions about what they want to know and with the guidance of teachers, the students may decide the issues or topics they want to be investigated.

In the Exploration phase, students are looking the information about issues or topics that have been identified. Search information by using various methods, such as the internet, video, nature walk, visit, study science books, and so on. The students develop the new knowledge and strengthen the existing knowledge on the subject they studied or had been exploring. After receiving all the necessary information, the students will determine the suitable materials for the projects.

In the Experimentation phase, students build or develop their inventions or ideas by creating the model according to what they had planned in the Exploration phase. Students demonstrate the product and answer questions that they ask in the first phase.

In the Reflection phase, students reflect on the learning process which they had gone through and give a view of the product or invention that they have produced. In this phase, students also will be asked to give the opinion on the interest, awareness, appreciation and what they want to do next.

These four phases in PIP are adapted and modified from the implementation of STEM education in the PERMATA curriculum. The aim of modified PIP is hoped that it can be implemented into the Malaysia's primary school curriculum [4].

PIP is the method should use in teaching STEM education which can be represented in Figure 1. The inquiry is the initial phase to stimulate the curiosity of students. 3E in the PIP is Exploring, Experiment and Experience and 3C in the PIP are Collaborate, Create and Communicate.
3. STEM modules
In Malaysia, the development of STEM education is an important agenda for the transformation of the education system and prepares the students to meet the challenges of the 21st century. To help the teacher to enhance the knowledge and development of STEM education, in this research a STEM modules using the PIP method based on the ADDIE Module has designed. 

STEM modules in this research have been characterized by using variety traditional culture of Malaysia. Projects in the STEM modules chose the traditional culture in Malaysia because Malaysia is a country made up from different races and ethnic such as Malay, Chinese, Indian and other which practices different and unique traditional culture. In the modules, students not only understand the STEM concepts involved, at the same time the students also can understand the tradition of different races in Malaysia.

In these modules, five projects that use PIP methods have been designed. The skills in these five projects are integrating the knowledge of science, technology, engineering, and mathematics while producing products. These five projects have been a focus on the topic of space in Revised KSSR Year 1 Mathematics Syllabus. These five projects are:

| No | Project  | STEM Concept Involved                                                                 |
|----|---------|---------------------------------------------------------------------------------------|
| 1  | Tangling | Shape and size of the tangling, a number of materials that needed such as color paper, burning, light, and design of tangling. |
| 2  | Tudung Saji | Measure and counting, shape and size, the usage and design of the Tudung Saji.            |
| 3  | Kolam   | Measure, shape, size, symmetry and how to stick the rice or sands on the paper and the design of Kolam. |
| 4  | Wau     | Measure, shape, size, symmetry and how to let the Wau fly in the sky.                    |
| 5  | Chinese Yoyo | Measure, shape, size, symmetry and how to balance the Chinese Yoyo while playing.      |

4. Research methodology
The respondents in this research are a focus on the year one student in the ordinary schools under the Ministry of Education of Malaysia. Two classes of the year, one students were chosen as the population for the study. One class of the student as the treatment group while another class as control class. To get effectiveness on integrating STEM education in Mathematics, this research used a quasi-experimental design for the study group and used the existing year one class. This research will be conducted in six weeks and depend on the progress of the students[5].

In this research, four instruments were built to evaluate the effectiveness of implementing the PIP method based on STEM modules. These instruments are intended to support the validity and reliability of the PIP. These instruments are pre-test and post-test, questionnaires, interviews and the project implementation monitoring report to support the outcome of the research. This study aimed to identify the reliability integration of the STEM education in the field of Mathematics, results of pre-tests and
post-tests, questionnaires and interview can only give a rough idea about the integration of STEM education.

Questionnaires to evaluate the understanding, interest, and attitude towards the STEM education was distributed to the treatment group's students. The Cronbach's alpha test was conducted to determine the internal consistency. This method assumes that each item is considered to be a similar test and all correlations between the measured items are the same. The result of the questionnaires shown that confidence coefficient Cronbach's alpha value is 0.76, so the reliability for this questionnaires is accepted.

| Reliability Statistics |
|------------------------|
| Cronbach's Alpha       |
| Alpha Based on Standardized Items | N of Items |
| .756                   | .775        | 30          |

Figure 2. Reliability statistics

5. Pilot Study

A pilot study had been done using the project five in the STEM modules, make a Chinese Yoyo. The project had carried out in two places, for example, the Expo Mampan in RTC Gopeng, Perak and the Majlis Professor Negara at FELDA UMAS, Tawau, Sabah. During the activity, teacher or the facilitator guides the students on how to make a Chinese Yoyo. The teacher or the facilitator used the instructions in module five to carry the project. While the students are making the Chinese Yoyo, the facilitator asked the students questions about the shape, the size and how to make a yo-yo balance while playing. The questions asked by facilitator as below

- What is the shape of Chinese Yoyo?
- What is the design of Chinese Yoyo to make it spin?
- How to make a Chinese Yoyo?

These questions are asked in the Inquiry Phase, the purpose asked these questions is to cause the curiosity among the students. From the curiosity, the students are interested to find out more about the Chinese Yoyo. In the same time, the facilitators guide the students followed the four phases in Project-based Inquiry Learning (PIL) and let the students understand the integrated STEM knowledge in this project. The Chinese Yoyo in STEM modules can consider special and interesting because the materials that used in this project are recycled materials, such as mineral water bottles, chopstick, screw, and nylon string to make this project.

From the responses and feedback from the students, noticed that the students are enjoying themselves while making the Chinese Yoyo, they also feel excited because the used the recycled bottles to make a Chinese Yoyo. The Chinese Yoyo in this project not only because it is a Chinese traditional game but it also consists of STEM knowledge, such as how to make a balance Yoyo, how to keep its balancing while played the Chinese Yoyo and what is the design can use for Chinese Yoyo.
3.1. Students make the Chinese Yoyo

3.2. Facilitator gives instructions

3.3. Students play the Chinese Yoyo

3.4. Students play the Chinese Yoyo

**Figure 3.** Pilot Study at *Expo Mampan* in RTC Gopeng, Perak

This two pilot study was facilitated by main author and co-author. The project made by students has followed the four phases of PIL in the STEM modules. There was no boredom among the students, from the participated of students, they had employed the hands-on and minds-on while making the Chinese Yoyo.

4.1 Students sit in a group

4.2 Students sit in a group
6. Conclusion and Discussion
The purposes of this study are to improve the integration of STEM education in Mathematics through PIP. The stem is a teaching and learning approach that involves the application of knowledge, skills, and values of STEM to solve the real-life problem in the context of daily life, society, and the environment. This approach encourages students to ask questions and explore the environment through inquiry and solve the issues related to the real world situation to cultivate the practice of STEM. By using the STEM modules based on the PIP, the teacher will be more confident and able to carry out the STEM education in school. To achieve the goals of PPPM 2013-2015 of MOE, the teacher themselves must change their mind and accept the challenges of the teaching and learning in this new era, so they can produce the students fulfilled the need of 21st century [6].

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