

An early start to STEM education among year 1 primary students through project-based inquiry learning in the context of a magnet

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Abstract. For the needs of the 21st century, the Government of Malaysia has conceptualized the Malaysia Education Blueprint 2013-2025 which embodies 11 strategic and operational shifts. In Shift 1, it is emphasized that the quality of Science, Technology, Engineering, and Mathematics (STEM) Education will be enhanced. This study employed the mixed-method approach using the “one-group pre-test and post-test design”. Accordingly, this paper describes the pedagogical practice of Project-based Inquiry Learning (PIL) which promotes STEM Education among Year 1 students in the move to progress in tandem with Shift 1. Specifically, using the context of a magnet which has been stipulated in the Primary School Standard Curriculum, Year 1 students experienced the STEM Education through the STEM Pedagogy in which they raised questions upon the presentation of a relevant stimulus (Inquiry Phase), explored the ways in which a train carriage or coach could be assembled by means of recycled materials and magnets (Exploration Phase), designed a train carriage (Design Phase), and ultimately reflected on their inventions (Reflection Phase). The cognitive and affective impacts through the use of this Project-based Inquiry Learning are presented. Implications for the teaching and learning of science are discussed within the context of STEM Education.

1. Introduction

In the quest of becoming a developed nation by 2020, Malaysia has given great emphases on education. Moreover, given that science, technology, engineering and mathematics education plays a big role as the catalyst in meeting the challenges and demands of our present and future economy, Malaysian government has instituted a number of related policies such as the 60:40 Science/Technical: Arts (60:40) Policy in 1967. Statistics indicate that, as of 2014, only about 45% of students graduated from the higher secondary schools were from the Science stream, including technical and vocational programmes. Additionally, the percentage of secondary school students who chose not to pursue the Science stream despite meeting the requirement based on their Form 3 National Standardised Examination (PMR) had increased to approximately 15% [1].

Meanwhile, in the context of rising international education standards and the aspiration of better preparing Malaysia’s children for the needs of the 21st century, the Government of Malaysia has conceptualized the Malaysia Education Blueprint 2013-2025 [2] which embodies 11 strategic and operational shifts. Essentially, there are five outcomes that the Blueprint aspires to achieve for the



Malaysian education system as a whole: access (i.e. 100% enrolment across all levels from preschool to upper secondary by 2020), quality (i.e. top third of countries in international assessments such as PISA and TIMSS in 15 years), equity (50% reduction in achievement gaps: urban-rural, socioeconomic and gender, by 2020), unity (an education system that gives children shared values and experiences by embracing diversity), and efficiency (i.e. a system which maximises student outcomes within current budget).

Research indicates that when children engage in projects in which they conduct investigations and/or involve in creation or invention around their personal questions, their intellectual capacities are very likely to be provoked and utilized [3–5]. Furthermore, engagement in projects places children in an active and interactive role where they take responsibility and initiative in inquiring by means of generating questions which they would like to seek answers to; exploring by means of collecting relevant data or information culminating in a suitable design or procedures; investigating based on the procedures or inventing based on the design; and showcasing or reporting their work [4], and ultimately yields better school participation and achievement in the long term [5].

Ong et al. [6] concocted a STEM pedagogical approach termed as Project-based Inquiry Learning or PIL which entails 4 phases, namely Inquiry, Exploration, Invention, and Reflection. Using the context of a ship, Ong et al. [7] illustrate that the inquiry-based learning centres on “Inquiry” regarding a ship, culminating in a question on “how to build a ship?” which in turn, leads to the “Exploration” of the phenomenon on floating and sinking, and of information pertaining to ships of different shapes and sizes which concludes with a design of a ship. Such design will then be accomplished and materialized through project-based “Invention”, and this is then followed by showcasing and reflection of the completed projects/inventions/investigations, and appreciation of the projects by peers. The STEM integration in this Project-Based Inquiry Learning encompasses the *science* concepts on buoyancy and energy, the *technology* which is reflected in building ships, the *mathematics* which is manifested in size and symmetry in ships, and *engineering* which involves designing of a ship.

2. Methods

2.1 Research Design

This study employed the mixed-method approach using the “one-group pre-test and post-test design” in which quantitative attitudinal data were collected and then triangulated by interview data which mainly solicit children’s view on their self-perceived understanding [8]. In the qualitative data, interview approach was used by means of interviewing seven randomly selected students from the single group students after they have undergone the learning of magnet using PIL approach to ascertain their interest towards the learning of magnet based on Project-based Inquiry Learning and equally, their understanding of the concept of magnet and their reflection. The reflection of a science teacher (the first author) in conducting a lesson on magnet through the using of a Project-based Inquiry Learning was shared.

2.2 Sampling

A purposive sampling was used as selection criteria that only involves a school namely Primary School A (name withheld for anonymity purpose) in the Ipoh district where students were in Year 1 class. Table 1 provides a breakdown of the sample by gender. Overall, there were 27 years 1 students who participated in this study.

Table 1. Breakdown of sample based on gender

Gender	Total
Boys	15
Girls	12

2.3 Instrumentation

The questionnaire contains two parts. Part 1, consisting of three-point Likert-scale items, measures students' attitudes towards learning of science through the Project-based Inquiry Learning approach, while Part 2, consisting of 3 interview questions: (a) Do you enjoy making train carriage? (2) What have you learned about magnets from the train project? (3) How can you improve your train (invention)? The reliability of Part 1 of the Questionnaire was established using the data set of 27 students of which the Cronbach's alpha was measured at 0.917, indicating that the questionnaire has high internal reliability [9].

2.4 Lesson Plan on Project-Based Inquiry Learning Model

The PIL-based lesson plan on Magnet, carried out for the duration of 3 weeks, entails four major steps/phases. In the first phase (inquiry), the teacher draws the attention of students to the various pictures and video clips of a train as a stimulus, and students are asked to state what they knew about the train and subsequently, what they want to know more about the train. They also explore how magnet could be used to connect the carriages of the train. In the third phase (design), students build and design train carriages (i.e., engineering inaction) based on their earlier sketches produced in the second phase.

2.5 Data Gathering and Analysis Procedures

Part 1 of the questionnaire was administered to the students before and after the lesson so as to obtain feedback on their attitudes towards learning science through Project-based Inquiry Learning. The data collected were analyzed using a paired samples t-test. Meanwhile, seven students were interviewed based on the 3 interview questions in Part 2 so as to obtain feedback on their interest towards learning science and the knowledge acquired, and their reflection on the aspects their invention could be improved. The interview data will be transcribed and analyzed thematically.

3. Results

Research Question 1: To what extent does the Project-Based Inquiry learning increase Year 1 students' attitudes towards learning science?

Table 2. Results Obtained from t-Test for Paired Samples (Students' interest in learning Science)

Attitudes Before PIL			Attitudes After PIL			T	p
N	Mean	SD	N	Mean	SD		
27	11.04	4.49	27	24.00	0.00	14.99	.000

A paired-samples t-test was conducted to compare the self-perceived attitudes towards science before and after the magnet science lesson using Project-based Inquiry Learning (PIL). There was a significant difference in the scores for the attitudes towards science before magnet lesson using PIL (M=11.04, SD=4.49) and the attitudes towards science after the magnet lesson using PIL (M=24.00, SD=0.00) conditions; $t(26)=14.99$, $p < .001$. These results suggest that Project-based Inquiry Learning does have an effect on students' attitudes towards science. Specifically, our results suggest that when Project-based Inquiry Learning was employed, the attitudes towards science increases.

Research Question 2: To what extent does the Project-Based Inquiry learning increase Year 1 students' students' interest, understanding about magnet and reflective ability?

Based on the responses of seven students to Question 1, resounding major theme emerged, which has students enjoyed science. The enjoyment was expressed in different forms such as they enjoyed making and creating their own train carriage models, and enjoying the lesson as a whole. This theme is supported by the following transcripts of the interview data:-

- Yes, I enjoy making the train carriage.* (Student A)
I like to make train carriage. (Student B)
Yes, I want to make train carriage again. (Student C)
Yes, I was very excited making train carriage. (Student D)
Yes, I enjoyed [the lesson]. (Student E)
Oh, I enjoyed making the train carriage. (Students F & G)

When asked about what they have learned which was posted as Question 2, the responses revealed students' understanding of magnets which could be categorized into 3 general themes:

- **The use of magnet**

Students A, D and G seem to show the understanding that magnets are able to connect the carriages, although the way in which the connection may occur was not explicated specifically.

- Yes, I understand how to use magnets to connect train carriage.* (Student A)
The magnet can connect the carriages. (Student D)
The magnet can attract the train carriage. (Student G)

- **The things that a magnet attracts**

One of the understandings which emerged from the interview data is that of the things which a magnet attracts. During the exploration phase, students explored about the magnets, and it was specifically explicated in the interview data that ...

- The magnet can attract iron.* (Student B)

- **Differing poles of magnets attract**

Students did learn the basic facts of a magnet such as same poles repel while opposing poles attract each other. This is supported by the following transcript:

- Magnets can attract each other if [they are of] different poles.* (Student C)

When asked how the students could improve their train (invention) which was posted as Question 3 as a means to solicit their reflection, the responses could be categorized into three aspects in which the students would like to see improvement of their designs. The three aspects are:

- **Loads**

Students would like to see that improvement could be made in terms of load. They would like to see an improvement is made to their design so that their invention would be able to withstand and carry more loads as succinctly supported by the following transcription:-

- My train carriage will carry more goods.* (Students A & F)

- **Speed**

Meanwhile, the majority of the students interviewed expressed an improvement in the speed that the train could move. They have not have learned, let alone explored in the science classrooms about friction, axles, and wheels although they have encountered them in the real-life situation, the following expressions should someday be realized:-

- My train carriage will move faster.* (Student B)
My train carriage will be much ... faster. (Student C)
My train can move faster. (Student D)
My train carriage will move faster. (Student E)
My train magnet carriage moves faster. (Student G).

• Size

Finally, the third aspect of improvement to the invention is in terms of the size of the train. They would like to see that, in future, they are able to build a bigger train as depicted in one of the transcriptions:-

My train carriage will be much bigger and faster. (Student C)

4. Reflection and Conclusion

The findings of this study indicated that students perceived that their attitudes towards learning Science have been elevated through the Project-based Inquiry Learning, evident in the significant differences between self-perceived attitudes towards science before and after learning science through PIL. Additionally, students' understanding of the concept at hand has also been elevated and the understanding was categorized into three themes, namely the use of a magnet, the things that a magnet attracts, and differing poles of a magnet attract. Students also indicated that should they asked to improve on their designs, improvements to the loads that a train may carry, the speed that a train travels, and the size of a train would be their priority.

There are some pedagogical implications for teachers based on the experience of conducting the current study. Firstly, the teacher should allow students the opportunity to raise questions upon the presentation of a relevant stimulus train. Project-based Inquiry Learning is one of the ways teachers could do so. Besides, the teacher needs to be able to handle student questioning and be tactful in convincing students which question should be explored and investigated. In this case, how to make a train using magnets was the question being explored and investigated to which students did enjoy themselves and learn the concept at hand (i.e., magnets). As evident in this research, teachers should be convinced on the beneficial use of Project-based Inquiry-based Learning as it not only enhances students' understanding of the concept at hand, it also increases creativity students when Project-based Inquiry Learning method is maximally utilized due to the higher level of student engagement and on-task behavior.

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