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THE DEVELOPMENT AND TEACHERS' PERCEPTION ON ELECTROMAGNET TEACHING AID: MAGNOBOLT

A. M. Sharif*[1], M. N. A. Azman[2], B. Balakrishnan[3], M. I. H. Yaacob[4], H. H. M. Zain[5]

[1,4,5]Post Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, Malaysia
[2]Faculty of Technical and Vocational, Universiti Pendidikan Sultan Idris, Malaysia
[3]Faculty of Art, Computing and Creative Industry, Universiti Pendidikan Sultan Idris, Malaysia

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ABSTRACT

Magnobolt is a teaching aid built on hands-on activity and exercises. This study examined a framework that could integrate both theoretical and practical of learning science in Malaysia. ADDIE model was used for Magnobolt module development. The perception of 300 science teachers across the Perak on Magnobolt studied via questionnaire includes two parts; Pedagogical Approach to Teaching and Learning and training suitability. The reliability for Magnobolt was tested on a total of 30 teachers which were not involved in the actual study. An analysis of the Cronbach's Alpha exhibits 0.945 showed very good reliability. Three content domain experts were involved to evaluate the validity of the Magnobolt. A real case study on 300 science teachers agreed that the Magnobolt was developed for a pedagogical approach to teaching and learning and suitable for training with the total mean score of 4.34 and 4.25 respectively. This science module also injects the element of creativity and innovation to build fun in learning science and creative capacity of teachers.

Keywords: electromagnet, soft skill, teaching aid, STEM education

INTRODUCTION

Science education is important in developing generation which has creative, critical and innovative thinking. In Malaysia, the aim is to have the ratio of students taking Science compare to Art is 60:40 (Phang et al., 2014; Kementerian Pendidikan Malaysia, 2012). Unfortunately, the number of students who took the Malaysian Certificate of Education Examination; Sijil Pelajaran Malaysia (SPM) examination in Science course in 2016 was only 90,000, far less than the 270,000 required each year (Bernama, 2016). In 2017, the ratio students pursue their study in Science compare to Art is 20:80 (Bernama, 2017).

The lack of students' participation in the field of Science at both secondary school (age 11 to 17 or from 1 to 5) and university levels become a concern for all parties. Nordin & Lin (2011) in their research found that there was a weak significant positive relationship between the attitude towards Science and mastery level of Science's basic concepts. Other previous research which investigates aspects that were closely related to motivation such as student interest (Bryan et al., 2011), student attitudes (Kususanto et al., 2012), students' engagement

*Correspondence Address
E-mail: aisyah@fsmt.upsi.edu.my

(Sinatra et al., 2008), student enrollment in Science courses (Bøe, 2012) and self-confidence (self-efficacy) (Glynn et al., 2011; Britner, 2008) found that students' attitudes, interests and motivation towards science learning declining after learning this subject especially while in secondary school.

One of the science topics which become a challenge for students to understand and develop the self-concept in understanding its fundamental is electromagnet (Rohadi, 2016). The electromagnet is a temporary magnet generated by the electromagnetism, which is the effect of an electric current flowing through a conductor example an electric wire (Baharoom & Samar, 2016; Nicolaide, 2012). The magnetic field is only produced when the current flow through the conductor and the magnetic field will disappear when there is no current flow through the conductor.

In Malaysia, learning on electromagnet is introduced in the syllabus of science subject for form 3 students (age 15). It is covered under topic 1.9 Understanding of Electromagnetism (Kementerian Pendidikan Malaysia, 2011).In this topic, students learn theoretically on fundamental of electromagnetism concept, the factor of electromagnet's strength and diagram of the electromagnet circuit.

This learning technique is known as a hard skill technique (Fakhriyah, 2014). Hard skill helps students master textbook materials. It does not help students in the form of critical thinking and problem-solving which known as soft skill technique (Wagner, 2008). In Science, students need both to understand the concept and how it can be applied in real life. Ministry of Education (MOE) has introduced STEM (Science, Technology, Engineering, and Mathematics) module in school (Adnan et al., 2017; Zainudin et al. 2016). STEM encourage the development of student interest in Science, Technology, Engineering, and Mathematics. STEM module is a Project-based Inquiry Learning (PIP) approach. There are four learning phases in this method which are; Inquiry phase, Exploration phase, Design and Experiments phase, and Reflection phases (Adnan et al., 2017).

Therefore, in order to enhance understanding of the electromagnet for form 3 students, the main objective of this research is to introduce a teaching aid to help students to understand the concept of the electromagnet. This module suite the STEM module and will help to develop the soft skill of their learning technique in identify, analyze and logical thinking to have a better understanding on the concept that they learn through hard skill.

METHODS

Magnobolt was prepared using the ADDIE model which are Analyze, Design, Develop, Implement and Evaluation (Jones, 2014). The research was performed at Perak, Malaysia. Magnobolt consists of an educational kit and a module.

Analyze

It started by analyzing the previous studies on finding the reason which causes students unable to understand the concept of electromagnet correctly. It was found that there are 4 problems that students are facing generally. They were misconceptions, insufficient understanding of science, weak in mastery the knowledge of science and difficult to build and master science conception (Drieberg & Sahoo, 2013).

This problem occurs because there is no practical approach in the syllabus that can enhance the students' understanding through experience it through hands-on activity. In the end, students only memorized the concept and its factors in for the sake of examination.

Design

The design of the Magnobolt was taking the feature from the practical experiment of electromagnetism topic in form 5 (age 17) but simplified according to the syllabus in form 3 (age 15) (Kementerian Pendidikan Malaysia, 2013). It also took STEM module as a reference to design the module.

Furthermore, this teaching aids was designed with the following criteria: (1) User-friendly; (2) Cost-effective; (3) Laboratory free; and (4) Be able to use it anywhere

Development

This teaching aid named Magnobolt which consist of different size of the bolt, multicolored wire, battery holder, paper clips and plastic holder. Comparing to the existing activities that have been taught for form 5 students (see Figure 1), the iron nail is normally used as the core of the solenoid to produce electromagnet, but the resulting electromagnetic force is relatively weak and the factors that influence the electromagnetic force cannot be manipulated and proven.

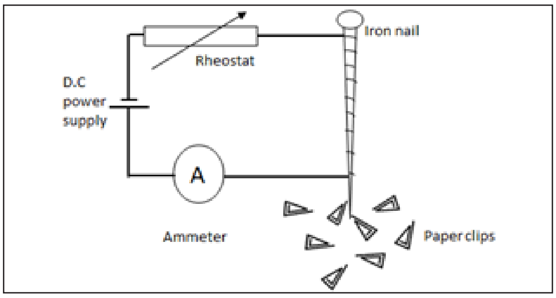


Figure 1. Experiment Diagram of Electromagnetism in Form 5

Therefore, Magnobolt introduces the use of construction bolt as the core. Similarly, students are required to coil conducting wires to the bolt and complete the connection to the battery to make solenoid and producing electromagnet (refer Figure 2). The electromagnet is then bringing near to paper clips as shown in Figure 3 and the numbers of paper clips attracted are recorded. Through this activity, students are exploring to the factors that affect the strength of the electromagnet by varying the number of coils, the diameter of the core, type of core and the amount of current which synchronize to their syllabus in form 3. Thus, students will be able to manipulate these factors and to think creatively about how these factors affect the strength of the electromagnet.

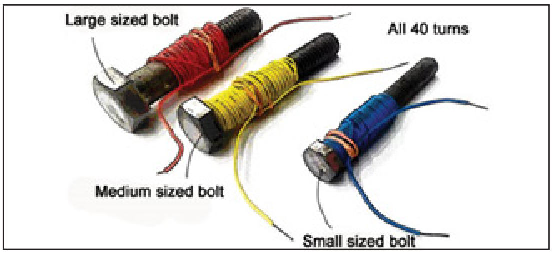


Figure 2. Wires are Coiled onto Bolts of Different Size

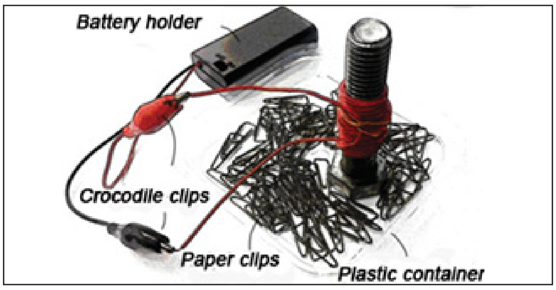


Figure 3. Circuit of Magnobolt to Test Electromagnet by Amount of Paper Clips Attracted to Bolt Head.

This teaching aid is also equipped with a module to guide students based on the STEM module.

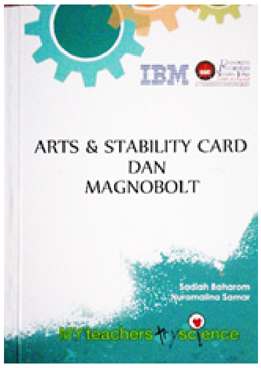
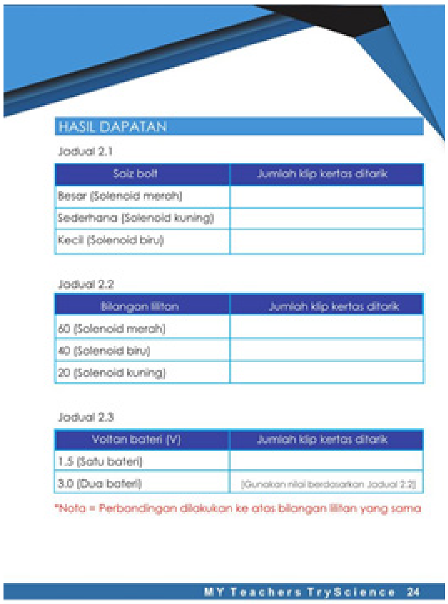


Figure 4. Module of Magnobolt

In this module, students were given the basic introduction of the electromagnet. Before starting the experiment, the students went through the objectives that they would achieve at the end of the experiment. These objectives were the Inquiry phase in STEM module.

Exploration phase was when the students acquired to familiarize with the tools to be used in the experiment. Furthermore, the students explored through the experiment's instruction and organize themselves for the experiment. After that, students will design the circuit according to the instruction given and modify it to perform the different test for the experiment. This is called Design and Experiments phase.Reflection phase was when the result that students gain for each experiment would be recorded in a table form (Figure 5). The students discussed in their group for the outcome based on the objectives in the Inquiry phase. Besides, in this module, there were 8 reflection questions to evaluate students understanding of the topic.


HASIL DAPATAN

Jadual 2.1

Saiz bolt	Jumlah klip kertas ditarik
Besar (Solenoid merah)	
Sederhana (Solenoid kuning)	
Kecil (Solenoid biru)	

Jadual 2.2

Bilangan lilitan	Jumlah klip kertas ditarik
60 (Solenoid merah)	
40 (Solenoid biru)	
20 (Solenoid kuning)	

Jadual 2.3

Voltan bateri (V)	Jumlah klip kertas ditarik
1.5 (Satu bateri)	
3.0 (Dua bateri)	(Gunakan nilai berdasarkan Jadual 2.2)

*Nota = Perbandingan dilakukan ke atas bilangan lilitan yang sama

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Figure 5. Table of Results

Implementation

A pilot study was run towards 30 science expert teachers were chosen with the help of Perak State Education Department (JPN Perak) to evaluate the reliability of Magnobolt. The purpose of the pilot study was to establish the psychometric properties of the research instrument. The pilot test also served to determine whether respondents could follow directions, and could interpret and understand the questionnaire items. In addition, piloting the questionnaire established whether the instrument was suitable for generating measurable data before utilizing the instrument for data collection of validity.

The Magnobolt Evaluation Questionnaire was developed for teachers to evaluate the modules. The instrument has two sections: (1) Section A, Respondent demography and (2) Section B, Module questionnaire. Section B was further divided into two parts: (1) Pedagogical approach to teaching and learning and (2) Training suitability. Each part had 8 items. The responses were measured on a 5 Likert Scale: (1) Most Disagree; (2) Disagree; (3) Uncertain; (4) Agree; and (5) Most Agree

Each of the expert teachers trained 10 science teachers in a two-day training course using experimental and project-based learning. Selection of the 300 teachers was also aided by JPN Perak. The science teachers' lesson plans were monitored by attendance sheets, pictures, and their recording videos. The questionnaire data collected and the results discussed in the results and discussion section.

Evaluation

There were two processes of evaluation. The first process is validation from content domain experts. Magnobolt was validated by 3 expert lecturers in Universiti Pendidikan Sultan Idris (UPSI).

The second process of evaluation was reliability. A reliability index is a degree to which a test consistently measures whatever it claims to be measuring (Gay & Airasian, 2003). Reliability of an instrument is typically judged by the instrument's stability over time and context as well as internal consistency. Reliability demonstrates how well the instrument measure what it purports to measure.

The guideline provided by DeVellis (2012) was used to check the reliability of the items in the instrument used are below 0.60 (unacceptable), between 0.60 and 0.65 (undesirable), between 0.65 and 0.70 (minimally acceptable), between 0.70 and 0.80 (respectable), between 0.80 and 0.90 (very good) and for values above 0.90, one should consider shortening the scale.

The standard reliability coefficient of 0.70 is usually associated with instrument reliability (Gay, 1996) and was adopted as the benchmark for the instrument used in this study. The reliability of the questionnaire was tested on a total of 30 teachers which were not involved in the actual study. An analysis on the Cronbach's Alpha coefficient was generated using the SPSS software package. The instrument had reliability at 0.945 which considered 'very good' based on the DeVellis (2012) guideline. This instrument was later used on the bigger population of 300 teachers selected as the sample for the study.

RESULTS AND DISCUSSION

The analysis of the questionnaire was done on each item of the questionnaire. A total of 300 teachers responded to the questionnaires. Each item's analysis is presented in Table 1 and Table 2.

Analysis of the Magnobolt Teaching Module

The Table 1shows the analysis outputs for each of the eight items in the pedagogical approach for teaching and learning the Magnobolt module.

Table 1. Items in the Pedagogical Approach for Teaching and Learning

No.	Item	Mean Score
1	Suitability of content	4.38
2	Suitable for the given topic	4.40
3	Reflective questions are of diverse cognitive levels	4.22
4	Reflective questions encourage creative thinking	4.29
5	Questions were based on the learning standard for KSSM	4.27
6	Problem solving skill	4.30
7	Test on conceptual understanding	4.38
8	Increase student's motivation	4.47
	Total	4.34

Analyses of the pedagogical approach for teaching and learning of the Magnobolt module showed the mean score for the 8 items were more than Likert scale 4. All responses were skewed to the right suggesting that all respondents 'agree' or 'most agree' that the pedagogical approach for teaching and learning of the module is appropriate for the teaching of the topic of electromagnetism. The highest scoring item was Item 8 with a higher overall mean score of 4.47. This finding indicated that the activities prepared in this module motivated the students to learn the topic of electromagnetism. The motivational aspect of Science learning is crucial to building learning interest of students to involve further in exploring the subject (Vedder-Weiss & Fortus, 2012; Bawaneh et al., 2011).

Item 1 and Item 2 provided the mean score of 4.38 and 4.40 respectively indicating that the respondents agreed on the contents and topics of the module that coincided with the subject of science form 3. TheItem 1 and Item 2 were supported by Item 5 with the mean score of 4.27. This item agreed that the questions in the module were based on the learning standard for the students' learning syllabus in school. On overall conceptual understanding on the module (Item 7) showed that respondents agreed with the mean score of 4.38. Thus, this module has proven reliable as teaching aids in helping the students to understand the electromagnet concept.

Item 3 and Item 4 were related to reflective questions provided in the module with the mean score of 4.22 and 4.29 respectively. The reflective questions comprising diverse cognitive level which constructed from C1 to C4 in line with the level of science in form 3. The specification of from 3 science curriculum illustrated that the student learning outcome was to understand the concept of electromagnetism and able to explain the electrical current flowing through the conductor with magnetism (Kementerian Pendidikan Malaysia, 2011). According to Bloom's Taxonomy, every level has different complexity and specificity started from Remember (C1), Understanding (C2), Apply (C3), Analyze (C4), Evaluate (C5) and Create (C6) (Anderson & Krathwohl, 2001). Respondents also agreed with reflective questions in the module to encourage creative thinking. For example, "why different turns of wires attract the different amount of paper clips?" This question encouraged the students to relate the amount of wire turns to the resulting magnetic strength and interpret the magnetic force through the amount of paper clip that has been successfully pulled.

Questions in Magnobolt module were designed to encourage creative thinking. Creative thinking helps to enhance the problem-solving skill among students (Awang & Ramly, 2008). This was agreed by the respondents with the mean score of item 6 problem-solving skill; 4.30.

Table 2 shows the analysis outputs for each of the eight items in the suitability for training of the Magnobolt module.

Table 2. Mean Score for Each of the Eight Items in the Suitability for Training

No.	Item	Mean Score
1	Brief instructions	4.26
2	Clear instructions	4.26
3	Clear illustrations	4.30
4	Precise illustration	4.27
5	Suitable font size	4.20
6	Suitable font type	4.30
7	Correct use of language	4.27
8	Applicable duration time of activity	4.16
	Total	4.25

Moving on to the suitability for the training of the Magnobolt module, the responses were also skewed to the right suggesting that all respondents 'agree' or 'most agree' that the suitability for the training of the module was appropriate for the teaching of the topic of electromagnetism. The Magnobolt module showed the mean score for the 8 items was more than Likert scale 4. Two items had the highest overall mean score. These items were Item 3 and Item 6 with a mean score of 4.30.

The Magnobolt using clear and precise illustration (Figure 2 and 3) for students to understand the tools that they used and how they could perform the experiment. Font type Tw Cen Mt and size font 14 used in this module were agreed by the respondents suitable for training dimension with mean score 4.30 and 4.20. Font type Tw Cen MT has a writing character similar to the way student is writing at school. Especially on the small letter of "a" and "g". In school, the students were practiced to write that small letter like "a" and "g". Familiar writing style helped to reduce challenges for students to read. Using bigger font size did help the students to improve their reading comprehension by able to see the words clearly, distinctive and enhance attention which easied for the readers to remember the words (Mueller et al., 2014).

CONCLUSION

The developed Magnobolt teaching aid enabled the teachers and students to integrate both theoretical and practical elements in science teaching as well as enhanced the students' interest towards STEM subject. Since the materials of the experiment could be easily obtained, it can be used to illustrate the concept of electromagnetism to the students. The feedback from the teachers reflected this module may help in their teaching and generate ideas for them to develop other teaching aids in order to make science teaching and learning more fun in schools.

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