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International Journal of Current Research
Vol. 8, Issue, 06, pp.33780-33786, June, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

THE DEVELOPMENT AND VALIDATION OF A THINKING MAPS-AIDED PROBLEM-BASED LEARNING MODULE FOR PHYSICAL SCIENCE THEME OF YEAR 5 SCIENCE

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ARTICLE INFO

Article History:
Received 21st March, 2016
Received in revised form 07th April, 2016
Accepted 18th May, 2016
Published online 30th June, 2016

Key words:
Development,
Evaluation,
Problem-based learning module,
Thinking Maps,
Science Year 5.

ABSTRACT

The main objective of this study is to explain about the development and validation of a Thinking Maps-aided Problem-Based Learning module for Year 5 Science subject of Physical Science Theme (energy, light, electricity and heat) which is less mastered by the students. The development of this module was based on ADDIE instructional design model that is the basis of other instructional design models. ADDIE model consists of five phases, namely analysis, design, development, implementation and evaluation. Four experts were involved in this study; a Malaysia public university lecturer, a director of Malaysia Regional Centre for Education in Science and Mathematics, a primary school science pedagogy lecturer at the Institute of Teacher Education, a Primary School Science's Excellent Teacher for the purpose of content validity and a linguist to perform face validity in terms of the use of language in the module. The findings of the expert panel evaluation show excellentmodule validity. The module prototype has been tested in a pilot study which involved 30 students from Year 5 at a primary school in Tawau, Sabah. The findings of this study show that the total value of the module reliability is high (Cronbach's Alpha = .96). This describes that the developed module has high internal consistency and is suitable to be used in the process of teaching and learning of Year 5 Science for the topics in Physical Science theme. Therefore, this study suggests that the developed module can be used as a teaching aid for topics in Physical Science theme of Science Year 5.

Citation: Ruslan Mapeala and Nyet Moi Siew, 2016. "The development and validation of a thinking maps-aided problem-based learning module for physical science theme of year 5 science", *International Journal of Current Research*, 8, (06), 33780-33786.

INTRODUCTION

Based on the TIMSS 2011 reports, as many as 38% of Malaysian students do not reach minimum level of proficiency in Science. Recently, the PISA 2012 study report found that the level of problem solving and scientific literacy of Malaysian students is very limited. This finding is supported by the study report of Kestrel Education Consultants in the United Kingdom and 21 Century Schools in the United States of America that find that the Higher Order Thinking Skills among teachers and students in Malaysia is very low (Curriculum Development Division, 2012:5). Fazliza and Abdul Majeed (2012) find that Science teachers are less clear about the concept of thinking and an appropriate method to improve these skills in students. The report of Schools Inspectorate and Quality Insurance, Malaysia Ministry of Educationon teacher competence in teaching and learning showed 52 percent of teachers is at the level of expectancy, 31 percent at satisfactory level, 5 percent at poor level and only 12 percent at excellent level (Inspectorate and Quality Assurance, 2013). 30 percent of teachers are at satisfactory score and below which shows that teachers are less challenging the critical thinking skills of the students (Inspectorate and Quality Assurance, 2013). Fatin Aliah *et al.* (2012) finds that the attitude, interest and motivation toward science learning in Malaysian students has declined over the period of their schooling. The launching of the Malaysia Education Blueprint (2013-2025) (Ministry of Education, MOE, 2013) that emphasizes on higher order thinking skills is timely. The objectives of the Primary School Science Curriculum are to instil and develop the students' creativity through experience and investigation in order to master scientific knowledge, scientific skills and thinking skills as well as scientific attitudes and values (Curriculum Development Division, MOE, 2014). Through this plan, the *i*-THINK programme was introduced as a strategy to improve students' higher order thinking skills. Eight kinds of Thinking

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Maps have been introduced to students at all levels of schooling since 2013.

According to Dochy *et al.* (2005), problem-based learning (PBL) method is suitable to be implemented in various institutions and levels of schooling. Through this PBL, students' ability to retain information is longer as compared to the traditional learning method (N. Drake and Long, 2009), in addition to improving problem-solving skills and teamwork (Ferreira and Trudel, 2012), students are also more active during their learning process (Akınoğlu and Tandoğan, 2007), thereby improving students' academic achievement (Inman, 2011) and mastery of concepts through thinking tools such as FILA table (Faaizah, 2008; Ruqayyah *et al.,* 2013) and mind map (Yee *et al.,* 2011). Therefore, the use of thinking tools is catalytic to students' critical thinking skills. Hyerle and Alper (2011) state that Thinking Map is an effective thinking tool in improving the thinking skills of students. This is because Thinking Map is based on the human cognitive process to understand the concept, analyse the problem and thus solve the problem. Thinking Map has been proven effective in the skills of classifying, observing and making conclusions (Salah and Mohamed, 2014), comparing and differentiating and also explaining (Wies, 2009). All these have a positive impact on students' understanding, achievement and motivation (Fahmi, 2008). In addition, the use of Thinking Map is also proven to be able to alter the behaviour of the students to be more positive and diligent (Muhamad Sidek *et al.,* 2012) albeit Thinking Map has only been practised for a short period of time (Muhamad Sidek, 2013).

Therefore, through the infusion of PBL method as a teaching element for thinking and Thinking Map as a teaching element of thinking into a single module, gives a positive impact in the context of teaching and learning Science in order to improve the critical thinking skills and motivation towards learning Science. According to Beyer (1997), combining both of these components, will not only make learning more explicit, but also make thinking-based learning more systematic, clear and focused. This situation also has an impact on students' mind to be more open (Marzano, 2007; Swartz *et al.,* 1998). Thus, it is necessary to develop a learning module in order to attract the interest of the students, increase aspects of knowledge, understanding, abilities, needs and experiences which are the basics to an effective teaching especially if it involves a large number of students per classroom (Auditor and Naval, 2014).
This is because the module can provide a learning environment and context to help students build and appreciate certain knowledge (Nik Azis, 2014), to reduce competition and threats on facing failure and increase interest and motivation (Shahrom and Yap, 1991, Sidek and Jamaludin, 2005), to be able to identify the uniqueness of pupils (Norlidah and Saedah, 2012), to improve achievement (Habibah and Wan Rafaei 1994) and to enhance the pupils' learning experience (Gagrin, 2003). Thus, the teaching module is an effective instrument to help realising the objectives of education. In conclusion, the use of modules can facilitate the teaching process, facilitate students' understanding as well as to attract students' interest and increase their motivation to learn. However, the validity and reliability of a module developed needs to be determined before it being put to use. Some earlier studies regarding the development and module evaluation had been organised, one of them is the research by Auditor and Naval (2014), Norlidah and Saedah (2012), Haspiah (2006) and also Gargarin (2003). With that, this study should also be conducted to know both of the two important aspects of learning module that were developed for Physical Science theme of Year 5 Science.

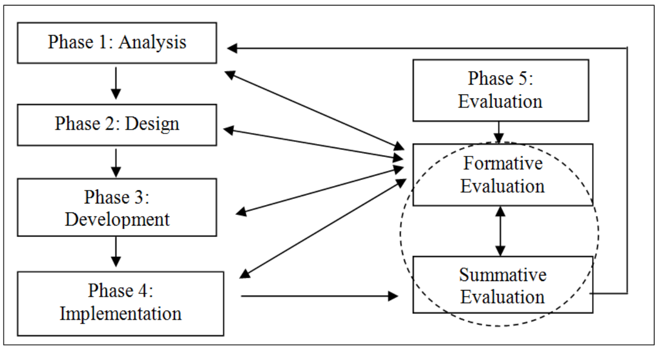
The Importance and Scope of the Study

This study provides guidelines for teachers to design and develop a module based on Thinking Maps-aided problem-based learning method. Providing input to the teacher in determining the criteria when designing and developing a module is important. Physical Science theme which consists of topics like Energy, Light, Electricity and Heat have been chosen because the topics in this theme are the ones that are less mastered by the students.

Methodology

The Study Design

The development of this module is based on the five phases of the ADDIE instructional model which intertwined with each other. According to Nik Azis (2014), in the development of a learning module based on ADDIE instructional model, each phase is not necessarily in a sequential pattern, but each phase provides input to the other phases. The five phases include Phase 1: Analysis, Phase 2: Design, Phase 3: Development, Phase 4: Implementation Phase 5: Evaluation. Figure 1 shows the ADDIE instructional design model.



Source: Nik Azis (2014: 382)

Figure 1. ADDIE instructional design model

The Subject of the Study

This study was conductedin an urban fully government-funded primary school in Tawau, Sabah, Malaysia. Five experts were appointed, namely (i) Associate Professor of a public university in Malaysia that specializes in the field of the development of problem-based learning modules, (ii) the Director of Regional Centre for Education in Science and Mathematics (RECSAM) who holds a doctorate in Science and Maths for primary school, (iii) a senior lecturer of Science Pedagogy for Primary School subject at the Institute of Teacher Education Malaysia, (iv) Excellent Teacher of Science for primary school who was experienced for 12 years, and (v) Master Teacher of Malay Language to help out with the language register in this module.

This module's pilot study involved 30 Year 5 students. Year 5 students were chosen because they are not having any public examination in Malaysia, therefore the pilot study would not interfere their process of teaching and learning. All students involved in this pilot study were those of the same class that had been assembled based on the achievement of the final exam when they were in Year 4. This shows that they have achieved the same or almost the same level. In addition, all of them had also been exposed to different kinds and Thinking Maps application via *i*-THINK programme introduced by the Ministry of Education Malaysia in early 2014.

Instrument

Data for module validity were obtained through Module Validity Evaluation Form (MVEF) instrument, which was designed by the researcher. MVEF was built based on the eight criteria of module evaluation by the experts as suggested by Russell (1974). The eight evaluation criteria are (i) Daily Lesson Plan, (ii) Learning Outcomes, (iii) Problem Scenario, (iv) Teaching and Learning, (v) Thinking Maps, (vi) Critical Thinking Skills, (vii) Motivation Towards Learning and (viii) Overall Module. The five appointed experts will give feedback on whether they "agree" or "disagree" and comment on each of the activity contained in this module, based on the eight evaluation criteria. Next, for reliability purpose of the module, the data were obtained by using the Module Reliability Questionnaire (MRQ) form, which was also built by the researcher. The researcher built this MRQ based on the criteria proposed by Sidek and Jamaludin (2005) and Russell (1974) in which each questionnaire that measure the reliability aspect of a module must be based on the measures taken for each activity contained in this module. This MRQ instrument is distributed to each student as soon as they have followed all of the activities in the module.

Development Procedure and Module validation

Module was written in Malay language because the teaching and learning process of Primary Science in Malaysia are carried out in Malay language. The development and validation of the module was carried out based on the phases of the ADDIE instructional model: Phase 1: Analysis, Phase 2: Design, Phase 3: Development, Phase 4: Implementation Phase 5: Evaluation. Each phase is different in terms of the process, method and findings as summarized in Table 1.

The front page of the module is designed by using mind graphical elements and cartoon elements. In addition, the front page of this module also displays three types of Thinking Maps in line with the three types of critical thinking skills which is the main focus of this module. One of the characteristics of PBL that emphasizes on group activities are shown through the characters of five children holding hands is also displayed at the bottom of the front page of this module.

Problem Scenario Presentation

Figure 3 shows an example of problems presentation that was given to students to complete in a small group which usually consists of four to five people in accordance with the characteristics of PBL (Barret and Moore, 2011; Faaizah, 2008). The problems provided in this module function as a trigger (Barret and Moore, 2011; Savin-Baden and Major, 2004), are authentic and relevant to the daily lives of students (Hung, 2006) which is an important characteristic of PBL.

This module comes with Thinking Maps application placed at the bottom to be completed by the students. Only three of the eight kinds of Thinking Maps used in developing this module are parallel to the three types of micro critical thinking skills. Figure 3(a) shows the Double Bubble Maps application for critical thinking skills of 'compare and contrast', 3(b) Flow Map application for critical thinking skills of 'create a sequence', while 3(c) is the Multi Flow Maps application for critical thinking skills of 'identify the cause and effect'. This module that has been developed is printed on A3 size poster paper. The purpose of this is to ensure that all team members have an equal opportunity to use the activity sheets during the discussions fairly. It is unlike the common activity sheets in the learning modules available in schools that are mostly in A4 size. These small activity sheets will limit the use of activity sheet modules to all group members simultaneously during the discussions conducted. To ensure that the students experience a more meaningful PBL process, thus the element of progression is applied in the development of this module.

This element of progression can be observed through problem presentation that is more general and the structure of Thinking Maps which is not as complete as the Thinking Maps structure on the activity sheet 1. This is to encourage students to think more deeply. Next, Figure 4 shows an example of an activity sheet 2 which is contained in the module with the progression element module developed.

This module provides more opportunities for students to create their own Thinking Maps as a result of the discussions. This is because it is a characteristic of Thinking Maps that it can be infinitely expanded and it is not static (Hyerle and Alper, 2011). Other than that, this allows them to easily visualise their ideas and findings to the entire class. This indirectly promotes social interaction among students. Furthermore, through social negotiation with group members, students have opportunities to compare and evaluate their understanding of subject matter with each other through what Barrett and Moore (2011) describe as dialogical knowing, this they claim being central to collaborative PBL practices. This module is also printed in colours to attract the attention and interest of students to use them during the learning session.

Data Analysis

The data obtained from MVEF for the module content validity was analysed using percentages. Meanwhile, the data obtained from MRQ for reliability analysis module used inferential analysis to determine the value of Alpha Cronbach.

Evaluation and improvement process were conducted simultaneously based from the comments and suggestions of experts and students during the process of development and implementation of the prototype module. This is because the results of each phase in the ADDIE model provide input for the other phases (Nik Azis, 2014).

Table 1. Module Development Process

Phase 1: Analysis		
Process	Method	Findings
•Analysis of the problems of teaching and learning •Analysis of the objectives •Analysis of the schools involved •Analysis of the sources •Analysis of the students involved •Analysis of the knowledge •Analysis of the skills •Analysis of the behaviour	•Analysing Year 5 Science Syllabus. •Determining the theme and topic that are not mastered by interviewing Science teachers and students. •Determining the goals and objectives of the module. •Analysing the Science results of UPSR 2014. •Appointing expert panel.	•Teachers are aware about the Thinking Maps but don't apply as much. •Students are positive towards Thinking Maps. •Teachers are knowledgeable about PBL. •Students are weak at the topics of Physical Sciences theme •Four specific objectives of the module are listed. •A school is selected for the pilot study of the prototype module which involves 30 Year 5 students. •Five experts are appointed.
Phase 2: Design		
Process	Method	Findings
•The theory and model involved •Implementation strategy. •Designing the module	•Linking the theory and related teaching and learning model. •Identifying the strategies to implement the module built.	•List of the specific objectives of module. •Theory of cognitive and social constructivism. •Expectancy-value theory of motivation •ARCS model of motivation •Needham's Five Phase Model •Briefing to the teachers involved •Methods of evaluation.
Phase 3: Development		
Process	Method	Findings
•Developing a manual for the module. •Developing a measuring tool. •Developing activity sheets.	•Building a module manual •Forming a critical thinking skills test. •Constructing activity sheets.	•A manual for teachers and students is produced •18 activity sheets. •A set of pre- and post-tests of critical thinking skills is produced.
Phase 4: Implementation		
Process	Method	Findings
•Experts assistance •Testing module prototype	•Handing prototype module to experts for evaluation. •Implementing pilot study •Interview •Module validity questionnaire	•Feedback from experts and students for modification if necessary. •Improvement of the module in response to feedback during the pilot study.
Phase 5: Evaluation		
Process	Method	Findings
•Analysing information given by experts and pupils.	•Performing descriptive and inferential analysis on the module evaluation forms for each instrument assigned to experts and students on the module.	•Knowing the validity and reliability of the module.

Front Page of the Module

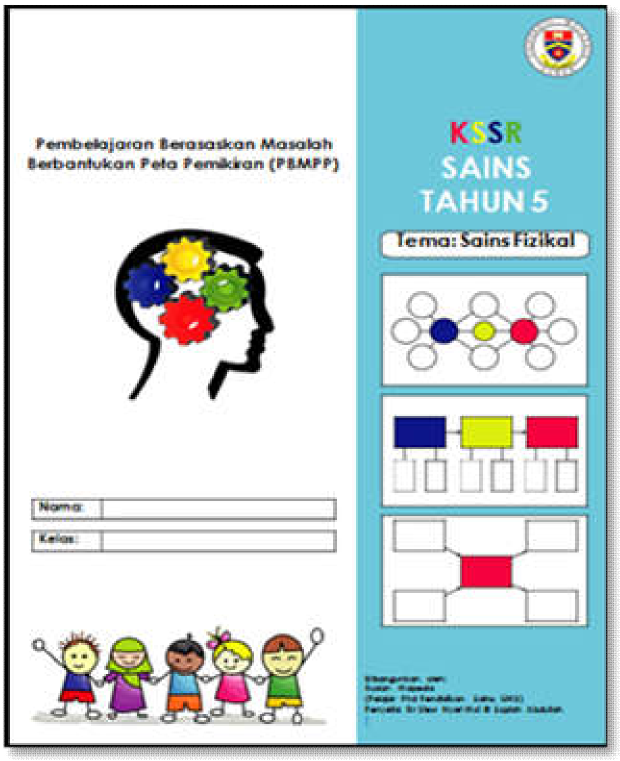


Figure 2. Front page of the module

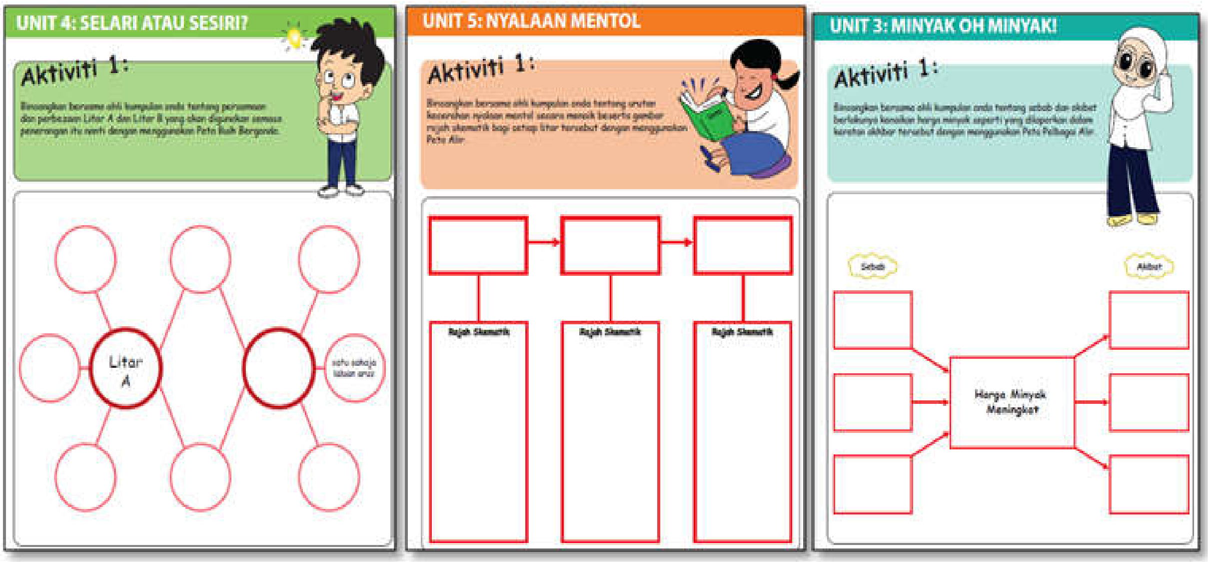


Figure 3(a) Figure 3(b) Figure 3(c)

Figure 3. Example of activity sheet 1 of the module

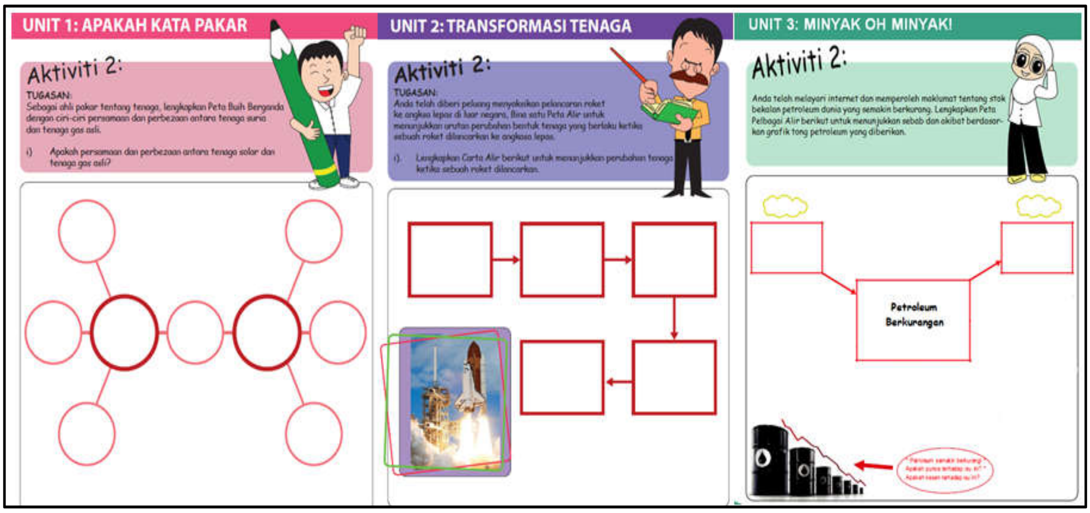


Figure 4. Example of activity sheet 2 of the module

Table 2. Module Validity

No	Evaluation Criteria	Agreement (%) percentage				
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5 (Language)
1	Daily Lesson Plan	100	100	100	100	Very good, but with a few improvements
2	Learning Outcomes	100	100	100	100	
3	Problem Scenario	100	100	100	100	
4	Teaching and Learning	100	100	100	100	
5	Thinking Maps	100	100	100	100	
6	Critical Thinking Skills	100	100	100	100	
7	Motivation	100	100	100	100	
8	Overall	100	100	100	100	

Table 3. Module Internal Consistency

Unit and Topic	Cronbach's Alpha	Number of Item
1: What Do The Experts Say?	.74	4
2: Energy Transformation	.72	5
3: Oil Oh Oil!	.89	4
4: Parallel or Series?	.77	4
5: Lighting of a Bulb	.74	4
6: Electric Shock	.72	4
7: Shadow Dialogue	.86	4
8: Help Ramesh	.70	4
9: Let's measure heat	.77	4
Total = .96 37		

RESULTS AND DISCUSSION

Module Validity

Table 2 shows the percentage of approval of the expert panel that was appointed to the eight criteria of module evaluation. The findings confirmed that the language of the validity aspect of module contents that have been developed as well as the aspect of the language register validity used in this module is very suitable.

Module Reliability

Table 3 shows that the value of Cronbach's alpha module is high. In conclusion, all the module activity units obtain high reliability.

Conclusion

This module has received positive feedback from experts in terms of the validity of the module that was developed based on eight module evaluation criteria by using MVEF instruments namely the daily lesson plans, learning outcomes, problem scenario, teaching and learning, Thinking Maps, critical thinking skills, motivation and overall evaluation. Similarly, in the aspect of reliability, this module also received excellent feedback from students by using MRQ instrument of 5 point Likert scale which shows high internal consistency. Overall, the developed module is suitable to be used for the teaching of Year 5 Science topics of Physical Science theme to enhance critical thinking skills and motivation towards the learning of Science.

Recommendation

The main objective of this study was to develop and evaluate a module for Year 5 Science subject based on ADDIE instructional model. The results of data analysis show that this module can be applied for the teaching and learning of Year 5 Science for Physical Science theme that is less mastered by students. However, this study suggests that a module evaluation process in a long period of time involving the pre and post-tests can also be carried out to better understand the aspects of validity and reliability of the module developed.

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