Improving Student’s Higher-Order Thinking Skills in Solving Pythagoras Theorem Problems through Digital Learning Module

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Abstract: The aim of this study is to improve student’s higher-order thinking skills (HOTS) in solving Pythagoras theorem problems through digital learning module. The digital learning module involved in this study is the i-Think module (Mi-T1). This study employed the quasi experimental design with pre and post-test applied to both, control and experimental groups. The control and experimental groups consisted of the same number of Form One (aged between 12 and 13 years old) student that about 30 students each, with the control group had 14 females and 16 males, whereas the experimental group had 15 males and 15 females. Learning activities were carried out according to the teacher’s time-table and were completed in 5 weeks, approximately 10 hours per group, whereby the control group used the official text book (provided by the Ministry of Education for all students to be used in school) and the experimental group utilized Mi-T1. In addition, a survey was administered to the experimental group to measure the participants’ perceived usefulness of digital learning module. The analysis of independent sample t-test showed that the experimental group had significantly improved in their higher-order thinking skills compared to the control group. The survey data also indicated that the participants in the experimental group perceived the usefulness of the digital learning module to be equally high. Premised on these findings, the digital learning module, Mi-T1 can be used to improve students’ higher-order thinking skills in solving Pythagoras Theorem problems.

Keywords: Digital learning module, higher order thinking skills, Pythagoras theorem problems

1. Introduction

The Malaysian Education Development Plan 2013-2025 sets out the Standard Curriculum for Primary School (KSSR – acronym in Malay Language) and the Standard Curriculum for Secondary School (KSSM – acronym in Malay Language) to be fully implemented in 2011 for KSSR and 2017 for KSSM (Kementerian Pendidikan Malaysia, 2012). The KSSR and KSSM transformations were scheduled in three stages. The first stage or Wave 1 (2013-2015) aims to improve the existing curriculum and prepare for structural change. The ministry will study the materials needed at the secondary level to help teachers deliver KSSM that emphasizes 21st century skills and competencies. Wave 2 (2016-2020) and Wave 3 (2021-2025) are the stages in which the implementation of KSSR and KSSM that will involve the integration of feedback elements, benchmarks, and finding through stress-testing tests that determine the stability of the system run during Wave 1 (ibid, 2012). KSSR in 2011 emphasized the application of knowledge, the development of critical, creative and innovative thinking. Subsequently the emphasis on HOTS was expanded into KSSM in 2017.

The Malaysian Curriculum Development Division (Ministry of Education Malaysia, 2013) defined HOTS as the ability to apply knowledge, skills and values in reasoning, problem solving, and decision making that nurtures innovation and creativity. Similarly, Malaysia Examination Board (2013) described HOTS as the ability to apply knowledge, skills and values in reasoning and reflection to solve problems, make decisions, innovate and be able to create something. HOTS involve cognitive skills that can help the learner in analysing, synthesizing, evaluating, and producing new idea. Subsequently, a learner can use relevant facts and make connections between facts or concepts, categorize and manipulate them, and apply them creatively in creating new solutions to unfamiliar situations (Thomas & Thorne, 2014). Being able to apprehend this process, a learner is observed to perform creative and critical thinking skills, which involve HOTS (Hassan, Rosli & Zakaria, 2016).

When we talk about Mathematics, it is never easy to convince students how wonderful Mathematics is. Improving student’s HOTS, especially in Mathematics, is not something easy said than to be done. Mode of teaching and learning has to be modified, revamped, or even reformed in order to improve student’s HOTS. Innovative learning should be put into practice, as it supports creative and critical learning among students (Idris, 2005). Students will be able to experience meaningful, exploratory, and collaborative learning, specifically the kind that helps to develop HOTS. One of those materials that can be employed to develop HOTS among students is digital learning modules, which can be accessed by simply using the internet. Lately, the usage of digital learning modules has shown promising results (Mohd Faizal Nizam Lee & Leow, 2017).
2. The Digital Learning Module (Mi-T1)

The i-THINK or Thinking Maps program was introduced by the Ministry of Education Malaysia and implemented in 2012. Several researchers have researched the effectiveness of the i-THINK program in the teaching and learning process. The findings of the researchers have revealed that i-THINK thinking maps can improve high level thinking skills. According to the study by Khalidah Othman et.al, (2014) majority of students agreed that the application of i-THINK thinking maps in the teaching and learning process can help in developing students’ thinking skills.

The i-THINK or Thinking Maps are used to guide students to develop their thinking process. Hence, this will gradually help students to be a successful thinker as these thinking maps have various functions of fundamental thinking processes. There are eight thinking maps. The Circle Map is used for defining context; the Bubble Map, described with adjectives; the Flow Map, sequencing and ordering; the Brace Map, identifying part and whole relationships; the Tree Map, classifying or grouping; the Double Bubble Map, comparing and contrasting; the Multi-Flow Map, analyzing causes and effects; and the Bridge Map, seeing analogies (Gallavan & Kottler, 2007).

This digital learning module, Mi-T1 was developed for Form One students (aged between 12 and 13 years old) using the principles of thinking maps and questioning based on HOTS. The digital learning module, Mi-T1 consists of 10 topics. For the purpose of this study, the topic of Pythagoras Theorem was chosen. Fig.1 is the main interface of Mi-T1 for the topic Pythagoras Theorem. Fig. 2 and Fig. 3 are questions with calculation steps using thinking maps in this module. These two questions employed the circle map and the brace map.
3. Research Questions

To guide the research, two research questions were formulated as follows:

1. Is the use of Mi-T1 able to improve Form One students’ higher-order thinking skills significantly in solving Pythagoras Theorem problems?
2. Are the students in the experimental group perceived the usefulness of Mi-T1?

4. Research Method

Research design and participants

The research design employed was a quasi-experimental, involving two intact classes of Form One students in the same normal daily school, as these form a control and an experimental group. The control group and the experimental group consisted of the same number of students that is 30 students each. However, there was a slight difference in the number of gender, whereby, the control group had 14 females and 16 males, whereas the experimental group had 15 males and 15 females.

Procedure

In this study the focused topic was the Pythagoras Theorem. Generally, students were taught the principle of Pythagoras Theorem that applies only to a right-angled triangle. The principle states that the square of the longest side, called hypotenuse is equal to the sum of the squares of the lengths of the two shorter sides, called the legs. Then, students were to apply this principle to solve five questions.

These two groups were taught by two qualified Mathematics teachers, both having bachelor degree in Mathematics Education, but they employed different approach in solving Pythagoras Theorem problems. For the control group, the teacher used the method shown in the text book, which is using the Polya Model to solve problems. Meanwhile, the teacher who taught the experimental group utilised the digital learning module, Mi-T1, which implements the thinking maps in solving problems.

Before any learning activities on the Pythagoras Theorem topic were carried out, a pre-test of 5 HOTS questions to be completed in 40 minutes was administered to these two groups. This was to ensure that both groups had a similar understanding on this topic before any teaching and learning take place. Learning activities were carried out according to the teacher’s time-table and were completed in 5 weeks, approximately 10 hours per group. Following on, a post-test of 5 HOTS questions that was similar to the pre-test, which had to be completed in 40 minutes was administered.
5. Findings

A pre-test was administered before any activities on Pythagoras Theorem topic were engaged with students from both groups. Result from the test, as shown in Table 1, significantly proof that the students’ achievement was at the same level.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Mean Diff</th>
<th>Sig (2-tail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30</td>
<td>0.0833</td>
<td>0.26533</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Exp</td>
<td>30</td>
<td>0.0833</td>
<td>0.26533</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After nearly 10 hours of learning activities, both groups attempted a post-test. Result, as shown in Table 2, the experimental group performed significantly better compared to the control group with a mean difference of 2.1500.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Std. Dev</th>
<th>Mean Diff</th>
<th>Sig (2-tail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30</td>
<td>0.89763</td>
<td>2.1500</td>
<td>0.000</td>
</tr>
<tr>
<td>Exp</td>
<td>30</td>
<td>0.57361</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The students from the experimental group were inquired on the usefulness of the digital learning module, Mi-T1. As shown in Table 3, all students in this group strongly agreed on the first three items. For item 4 and 5, all students, regardless of their gender, some strongly agreed and some agreed on these items. All female students strongly agreed that Mi-T1 is a useful tool in their work, whereas the male students had mixed perception amongst them.

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>Female(N=15) Mean</th>
<th>SD</th>
<th>Male(N=15) Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Using Mi-T1 module will improve my learning.</td>
<td>5.000</td>
<td>0.000</td>
<td>5.000</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>Using Mi-T1 module makes me more creative.</td>
<td>5.000</td>
<td>0.000</td>
<td>5.000</td>
<td>0.000</td>
</tr>
<tr>
<td>3</td>
<td>Using Mi-T1 module will enhance my effectiveness in learning.</td>
<td>5.000</td>
<td>0.000</td>
<td>5.000</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
<td>Mi-T1 module makes it possible for me to work more productively.</td>
<td>4.400</td>
<td>0.507</td>
<td>4.533</td>
<td>0.516</td>
</tr>
<tr>
<td>5</td>
<td>Using Mi-T1 module will increase my productivity in learning.</td>
<td>4.800</td>
<td>0.414</td>
<td>4.467</td>
<td>0.516</td>
</tr>
<tr>
<td>6</td>
<td>I find Mi-T1 module to be a useful tool in my work.</td>
<td>5.000</td>
<td>0.000</td>
<td>4.867</td>
<td>0.352</td>
</tr>
</tbody>
</table>

6. Discussion

This research focused on improving students’ HOTS in solving Pythagoras Theorem problems through a digital learning module, Mi-T1. The findings, from the post-test showed significantly that the experimental group performance better in solving Pythagoras Theorem problems compared to the control group. Hence, this also provides sufficient evidence that the digital learning module, Mi-T1 can be used to improve students’ HOTS in solving Pythagoras Theorem problems. As such, this answered the first research question. Furthermore, the Mi-T1 provides different type of thinking maps to guide and enhance students’ HOTS in solving problems. With these thinking maps, students can visualize the mathematical processes involved in deriving precise solutions to the given problems.

In this digital learning module, Mi-T1, it demonstrates that different problems can be solved using different thinking maps. Essentially, Mi-T1 will help students to adjust and make use of their thinking skills according to
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the problems. In addition, employing learning material with relevant activities and adequately allocated time for students to develop their thinking skills are very important (Coe, Aloisi, Higgins, & Major, 2014).

The second research question focused on the usefulness of Mi-T1. The findings showed that regardless of gender, all students in the experimental group solidly agreed upon the usefulness of Mi-T1 in improving their learning, making them more creative and enhancing their effectiveness in their learning. In addition, Mi-T1 also help student to work more productively and to increase productivity in learning. This group of students also 100% agreed upon Mi-T1 module to be a useful tool in their work. This finding is both encouraging and interesting, as it means learning to solve HOTS problems would benefit students irrespective of their gender.

In light of the above findings, the use of learning modules, notably in digital form, would be beneficial to students in learning to solve HOTS problems. Using such modules, they would be able to use visual aids, such as thinking maps, to help them visualize relevant steps or processes involved in solving mathematical problems. Through such visualization, students would be able to perform the appropriate mathematical operations with ease and precision. With persistent use, their HOTS could be further improved, which would help them to learn and solve more complex problems. Obviously, more studies are required to examine the impact of such learning modules on the development of HOTS by focusing on other factors, such as spatial ability or age. Overall, this study has helped provide greater insights into the understanding on the development of students’ HOTS using novel digital learning materials, which surely would have significant impact on the teaching and learning process.

7. Acknowledgement

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