Pedagogical Usability of the Geometer’s Sketchpad (GSP) Digital Module in the Mathematics Teaching

NORAZAH NORDIN, EFFANDI ZAKARIA, MOHAMED AMIN EMBI, RHIZAN MOHD YASSIN
Department of Foundation of Education
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor
MALAYSIA

Abstract: - The study investigated the pedagogical usability of a digital module prototype that integrates a dynamic geometry software, Geometer’s Sketchpad in Mathematics teaching. The prototype was developed based on Reiser’s and Dick’s Instructional Design Model that integrates Geometer’s Sketchpad software in the teaching of Quadratic Functions. The digital module was developed using Macromedia Authorware 7.0 as its platform. The pedagogical usability criteria include student control, student activities, objective-oriented, application, value-added, motivation, knowledge value, flexibility and response. Subjects include 34 Mathematics secondary school teachers in Selangor, Malaysia. The instrument used is pedagogical usability questionnaire. The results showed that the prototype modules meet the requirements of the pedagogical usability criteria mentioned. It also facilitates the integration of Geometer’s Sketchpad in mathematics teaching.

Key-Words: - pedagogical usability; dynamic geometry; Geometer’s Sketchpad; digital module; Mathematics teaching; Quadratic Functions

1 Introduction
Teaching is a systematic approach that is required from teachers in the process of developing knowledge through suitable methodology to induce effective learning in the classroom. Meanwhile, learning is related to the learning activity process that happened in the classroom [1]. Both play important roles in Mathematics education. According to Tengku Zawawi, in Malaysia, in general, the methodology used by Mathematics teachers were still teacher-centred and they were influenced by conventional methods [2]. Students tend to memorise mathematical formula and law without understanding the concepts that lie behind it. This produced students who were able to calculate but do not know how to solve every day’s problem that involve concepts and mathematical skills.

Teacher plays an important role in ascertaining effective teaching of mathematics. Thus, teachers must be able to cleverly improvise teaching when and where necessary. A variety of approaches can be used to increase students’ Mathematical skills and their understanding of mathematical concepts [1]. A case in point is the use of information and communication technology (ICT) that could help teachers not only in the teaching of Mathematical concepts but also to lighten their workload and allow teachers to solve students’ problem individually [3]. According to a research conducted by Norazah and Effandi, the use of computers in Mathematics education was able to make the teaching and learning methodology of the subject more up-to-date and interesting as compare to the conventional method [4]. Indirectly, this helped to mould young generation to be physically, emotionally, spiritually and intellectually excellence.

There are a few factors that affect the uses of information technology in the education field. Factors like personality, attitude and environment are known to have positive relation with ICT usage in the classroom. On the other hand, low level of knowledge and skills coupled with limited sources were known to be the deterrent factor for successful ICT usage in the classroom [5]. The deterrent mentioned above can be overcome through training or participating in professional development programme. However, this was not the case as educators in in Malaysia, the teachers of Science, Mathematics and technology information included, faced a number of obstacles in participating in their professional development programme.

According to a study by Effandi et al., two factors have been identified as the main culprit in the application of technology in the teaching and learning of Mathematics: teachers and school [6]. The teacher factor rested mainly in the teachers’ perception that the use of technology did not help in the teaching and learning of Mathematics. This was further worsened by the fact that teachers always claim that they did not have sufficient time to prepare for lessons ICT integrated lessons. According to Haslina et al, in teachers’ professional
development courses, there might be hands-on activities but this was not supported by relevant modules or manuals for the facilitators and course participants [7]. The activities conducted in those courses were teacher-centred and in most situations courses were conducted using softcopy materials supplied by vendors. The approach was rather ineffective in the learning of a particular software which normally requires active participation from the participants.

Based on all of the deterrents mentioned, a prototype module on the learning and teaching of Mathematics was developed. The prototype integrated Geometer’s Sketchpad (GSP) in the teaching of Mathematics. For this study the prototype was developed under the topic Quadratic Functions. GSP is an exploratory dynamic geometry software. The features of this software enable dynamic image construction and the images could be manipulated. It could then be analysed, conjectured and tested before reasoning was made [8]. The use of this software enabled the construction of an animated and interactive Mathematics module. The prototype was developed based on Reiser and Dick instruction model [20]. The module developed was validated by two teacher experts. The first checked on the language and the second validated the content. The feedback received showed that the module was suitable for the teaching and learning of Quadratic Functions. However, some improvement was made on the language as well as the content. Fig.1, 2, 3 and 4 illustrated the interfaces samples of the developed digital module.

2 Geometer’s Sketchpad Software (GSP)

Geometer’s sketchpad software (GSP) is a dynamic geometry software that uses exploratory approach in Mathematics. This software enables the construction and the animation of an interactive Mathematics model to be used and explored by teachers and students. The features in this software opened up space for dynamic image construction which can be manipulated, analysed, conjectured and tested. Thus, the learning of Mathematics was made easy in the way which was difficult for the conventional way to achieve [9]. Malaysian Ministry of Education was granted the GSP license in 2004 hence enabling learning institutions under its umbrella to use the software [10]. That can be translated as giving the opportunities to students as well as educators not only to enhance their skills and knowledge in using the computers but also to explore the potentials of GSP. Using GSP technology is parallel with the suggestions given in the syllabus content of Additional Mathematics [11]. It was spelled out in the syllabus that the uses of computer technology, dynamic geometry software, courseware courses,
internet and graphic calculator were encouraged in the activities carried out so that learning using higher order thinking skills can be practiced.

According to Stacey, the use of GSP software with exploratory technique was suggested in many teaching and learning of Mathematics activities to enhance the understanding of Mathematical concepts [12]. In addition, the use of dynamic geometry software enhanced many aspects of Mathematics learning. Among them was to strengthen the understanding of variables and function, to clarify the understanding of problems, to produce simulation as well as motivate the learning of Algebra. Research under the topic of Circular Measurement discovered that the software had many advantages [13]. Among its advantages was the ability to allow students to explore geometry features without erasing or redrawing the figure. Automatic calculation can be done for angles, side length and ratio while adjustment of the drawing was being made. It also enabled user to build, measure and manipulate what was presented on the screen as well as giving immediate feedback when the size and shape of the object is changed [14].

GSP software was popular because of its potential in helping teachers to carry out teaching and learning by testing conjecture on geometrical shapes, relation and transformation [15]. The measurement presented on the screen will also change when users manipulate the object. Users can drag and change the position of the object without redrawing thus giving more time for users especially students to think about geometry rather than wasting time reconstructing the diagram. Consequently, this allows students to explore the possibilities of something which is difficult to perform if they were to depend on textbook, paper and pencil. Such activities evidently increase the cognitive competency. Teoh & Fong demonstrated that the teaching and learning using dynamic visualisation approach helped students to better understand the concepts taught [10].

3 Purpose
The purpose of this study was to evaluate the pedagogical usability of the digital module for the integration of Geometer’s Sketchpad in mathematics teaching.

4 Methodology
The study involved 34 secondary school mathematics teachers (20 females and 14 males). The pedagogical usability instrument used was adapted from Nokelainen [21]. The criteria involved were student control, student activities, objective oriented, application, value added, motivation, knowledge value, flexibility and response. The instrument used a Likert scale with a range of strongly agree to strongly disagree. A total score is calculated by assigning a value of 1 (strongly disagree) to 5 (strongly agree) to each item and then adding the values. Possible scores range from 11 to 55. The reliability index of the instrument is 0.74. Descriptive statistic was used for data analysis.

By applying the Reiser and Dick Model, the researcher developed the digital module prototype that integrates dynamic geometry software, Geometer’s Sketchpad in Mathematics teaching. A one day training course was conducted to thirty four participants from all over the state of Selangor. The participants came from schools which were equipped with GPS. The trainers of the course were the researchers themselves. The participants were introduced to the content of the module as well as the technical aspect of the software. The participants then returned to their institutions and they were given two weeks to try out the module in their schools. After two weeks, they were asked for their feedback. All 34 teacher participants returned the questionnaire and the findings were as discussed in the findings section.

5 Results
Evaluation was done based on the research question on usability aspect. Pedagogical usability illustrated how the materials function in simplifying the learning content delivered. The usability criteria was evaluated through the eleven items constructed. The results were as shown in Table 1. Table 1 evaluation results on the usability items shows that value of the overall mean in 4.25. The mean value is categorised as high. Respondents agreed that the module can be used in the teaching and learning of mathematics in the classroom. 63.1% agreed and 30.7 strongly agreed on the usability aspect of this module. The mean value of 4.50 for the item Printed Item is an added value is the highest for the usability aspect. 97% of the respondents agreed whilst the remaining 50% agreed with the statement. 97% of the respondents agreed that goals were clearly stated in the module.
Table 1 Results of Usability Criteria

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<tbody>
<tr>
<td>Module could be applied in the teaching of mathematics</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4 (11.8)</td>
<td>21 (61.8)</td>
<td>9 (26.5)</td>
<td>4.15</td>
<td>High</td>
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<tr>
<td>Learning goals are clearly stated in the module</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (2.9)</td>
<td>18 (52.9)</td>
<td>15 (44.1)</td>
<td>4.41</td>
<td>High</td>
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<tr>
<td>Module does integrate ICT in the teaching of mathematics</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4 (11.8)</td>
<td>21 (61.8)</td>
<td>9 (26.5)</td>
<td>4.15</td>
<td>High</td>
</tr>
<tr>
<td>Plotting graphs using Geometer’s Sketchpad in mathematics lesson is appropriate</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (5.9)</td>
<td>21 (61.8)</td>
<td>11 (32.4)</td>
<td>4.26</td>
<td>High</td>
</tr>
<tr>
<td>Application of the module makes learning more interesting</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (8.8)</td>
<td>20 (58.8)</td>
<td>11 (32.4)</td>
<td>4.24</td>
<td>High</td>
</tr>
<tr>
<td>Experience as mathematics teacher does have an added value in using this module</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (5.9)</td>
<td>24 (70.6)</td>
<td>8 (23.5)</td>
<td>4.18</td>
<td>High</td>
</tr>
<tr>
<td>Module is flexible and allows learners to navigate freely</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (5.9)</td>
<td>25 (73.5)</td>
<td>7 (20.6)</td>
<td>4.15</td>
<td>High</td>
</tr>
<tr>
<td>Module allows learners to check their performance</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (2.9)</td>
<td>21 (61.8)</td>
<td>12 (35.3)</td>
<td>4.32</td>
<td>High</td>
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<tr>
<td>Module motivates learning</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (5.9)</td>
<td>22 (64.7)</td>
<td>10 (29.4)</td>
<td>4.24</td>
<td>High</td>
</tr>
<tr>
<td>Learning is controlled by the learner</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (5.9)</td>
<td>26 (76.5)</td>
<td>6 (17.6)</td>
<td>4.12</td>
<td>High</td>
</tr>
<tr>
<td>Digital module is an added value</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>17 (50.0)</td>
<td>17 (50.0)</td>
<td>4.50</td>
<td>High</td>
</tr>
<tr>
<td>Overall mean</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>23 (6.1)</td>
<td>236 (63.1)</td>
<td>115 (30.7)</td>
<td>4.25</td>
<td>High</td>
</tr>
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</table>
6 Discussion
The results of the study showed that teachers agreed that the module can be used in the classroom to teach Quadratic Functions. The mean value of 4.25 clearly illustrated a high agreement. The usability aspect of this module in the teaching and learning process showed that the integration between information technology and communication in the teaching of mathematics can be aided by the module developed. The findings of this study agreed with Hennessy who demonstrated that learning graphs in Mathematics through the use of technology simplified learning and increase students understanding and confidence [22]. Similarly, analysis from Teoh and Fong gave positive feedback on the use of Mathsoft in the learning of movements on straight lines which was also related to graphs [10]. Their findings shows that the graph visualisation method using technology could aid learning and enhanced students understanding. Thus achieving better level of learning [23]. The findings of this study was also parallel with the findings of Marzita and Rohaidah which explained that the use of interactive multimedia was necessary in enticing students attention and increasing students understanding of mathematics [13]. The examples and images supplied helped students in constructing the concepts learnt [3]. The study conducted by Haslina et al [7]. Amily and Ahmad Yasir (2004) discovered that the multimedia elements in Mathematics could interest students and increase students performance in Mathematics.

The module has successfully integrated information technology and communication in the teaching of Quadratic Function. The use of GSP software in this module is suitable in plotting graphs and other dynamic simulations. The facilities are suitable and can make learning more interesting. Learning through the use of module is learner-centred in nature and therefore is controlled by students at maximum level. Teachers are mere facilitators. The exploration learning method and the discussions involved in understanding the concepts of Quadratic Functions can help boost higher order thinking skills.

7 Conclusion
From the results and explanation given, it can be concluded that the digital module prototype developed, that integrates a dynamic geometry software, GSP in the secondary mathematics teaching module can be used as materials that integrated technology in the teaching of Mathematics under the topic of Quadratic Functions. The module has also successfully met the requirements of the pedagogical usability criteria that includes student control, student activities, objective-oriented, application, value-added, motivation, knowledge value, flexibility and response. It also facilitates the integration of Geometer’s Sketchpad in mathematics teaching.

8 Implications
The main implications of this study are two-folds: First, implication on the teachers and second, implication on the students. Teachers might have to spend hours constructing materials using this software but in the long run, it might save them a lot of time. They might be able to look at the topics which pose problems to the students and focus on developing information and communication technology (ICT) on those topics. As ICT materials can run by themselves, students will undoubtedly benefit from it. With the use of GSP, students can be more investigative in trying out their ideas and they will not have to worry about time as the use of GSP negates time as the deterrent. Consequently, the use of GSP may produce generation who are not only ICT literate but also Mathematics literate.

References: