PEDAGOGICAL USABILITY OF THE GEOMETER'S SKETCHPAD (GSP) DIGITAL MODULE IN THE MATHEMATICS TEACHING

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ABSTRACT
Teacher played an important role in ascertaining effective teaching of mathematics. The objective of this paper was to investigate the pedagogical usability of a digital module prototype that integrated a dynamic geometry software, Geometer's Sketchpad (GSP) in mathematics teaching. The prototype was developed based on Reiser's and Dick's Instructional Design Model that integrated GSP software in the teaching of Quadratic Functions topic. The digital module was developed using Macromedia Authorware 7.0 as its platform. The pedagogical usability criteria included student control, student activities, objective-oriented, application, value-added, motivation, knowledge value, flexibility and response. This was a quantitative study that involved 34 mathematics secondary school teachers in Selangor, Malaysia as samples. The instrument used was pedagogical usability questionnaire. The results showed that the prototype digital modules met the requirements of the pedagogical usability criteria mentioned. It also facilitated the integration of GSP in mathematics teaching. It is suggested that a study on the applications of GSP in mathematics teaching to be carried out to promote higher order thinking skills among secondary school students.
Keywords: pedagogical usability; dynamic geometry; Geometer's Sketchpad; digital module; Mathematics teaching; Quadratic Functions

INTRODUCTION

Teaching in a systematic approach 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 (2002), in general, the methodology used by mathematics teachers were still teacher-centred and they were influenced by conventional methods. Students tend to memorise mathematical formulae and law without understanding the concepts that lie behind it. This situation produce students who are able to calculate but do not know how to solve every day's problem that involve concepts and mathematical skills.

Teacher plays important roles in ascertaining effective teaching of mathematics. Thus, teachers must be able to intelligently improvise teaching when and where necessary. A variety of approaches can be used to increase students' mathematical skills and their understanding of mathematical concepts (Efandi et al, 2007). An alternative approach 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 (Oldknow & Taylor, 2000). According to a research conducted by Norazah and Effandi (2007), 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 compared to the conventional method. Indirectly, this has helped to mould young generation to be physically, emotionally, spiritually and intellectually capable in solving mathematical problems.

There are a few factors that affect the usage 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 (Norizan & Mohamed Amin, 2007). The deterrent mentioned

above can be overcome through training or participating in professional development programme (Frey & Fisher, 2009). However, this was not the case as educators in Malaysia, particularly the Science, Mathematics and ICT teachers, faced a number of obstacles in participating in their professional development programme.

According to a study by Effandi et al.(2007a), two factors have been identified as the main factors in the application of technology in the teaching and learning of mathematics. The first factor is the teachers' perception that the use of technology is not able to help in the teaching and learning of mathematics. This was further worsened by the fact that teachers always claim that they do not have sufficient time to prepare for ICT integrated lessons. According to a research by Haslina et al (2000), in the present teachers' professional development courses, there are hands-on activities but this was not supported by relevant modules or manuals for the facilitators and the course participants. The activities conducted in those courses are teacher-centred and in most situations, courses are 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.

The ICT software discussed in this paper is Geometer's sketchpad (GSP), dynamic geometry software that uses exploratory approach in mathematics. This software enables the construction and the animation of interactive mathematical model to be used and explored by teachers and students (Ismail et al, 2009). The features in this software opened up space for dynamic image construction which can be manipulated, analysed, conjectured and tested. Research findings have revealed that the learning of mathematics with GSP was made easier compared to the conventional method (Teoh & Fong, 2005). Ministry of Education, Malaysia has bought the GSP license in 2004, hence, enabled the mathematics teachers in secondary schools to use the software in the teaching and learning process. The application of the GSP has given 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. It was spelled out in the Form Four and Form Five Additional Mathematics syllabi that the uses of computer technology, dynamic geometry software, courseware courses, internet and graphic calculator were encouraged in the teaching and learning activities.

According to Stacey (2007), 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. 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 (Marzita & Rohaidah, 2004). One of the advantages of GSP software was its ability to allow students to explore geometric 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 (Hannafin & Scott, 1998).

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 (Kurz et al, 2005). 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 (2005) demonstrated that the teaching and learning using dynamic visualisation approach helped students to better understand the mathematical concepts taught.

Based on all of the literature review described, a prototype digital module module on the learning and teaching of mathematics was developed (Nik Rahimah, 2008). The digital prototype integrated Geometer's Sketchpad (GSP) in the teaching of Mathematics. For this study the prototype was developed on *Quadratic Functions.* GSP is an exploratory dynamic geometry software, which 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 (REiser & Dick 1996). The purpose of this study was to evaluate the pedagogical usability of the digital module for the integration of GSP in mathematics teaching.

METHODOLOGY

This study was conducted using quantitative method. The development of the digital module prototype that integrated the Geometer's Sketchpad (GSP) in Mathematics teaching was based on Reiser and Dick Model (1997). A one day training course was conducted to 34 secondary school mathematics teachers (20 females and 14 males) from all over the state of Selangor. The participants came from schools which were equipped with GSP software. The trainers of the course were the researchers themselves. The participants were introduced to the content of the module as well as the technical aspects of the software. The participants then returned to their schools and they were given two weeks to try out the module in their schools. After two weeks, they were asked for feedbacks by responding to the pedagogical usability questionnaire. The pedagogical usability instrument used was adapted from Nokelainen (2006). 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 was 0.74. Descriptive statistic was used for data analysis.

RESULTS AND DISCUSSION

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 shown in Table 1. The results showed that the usability items had the overall mean of 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. 50% of the respondents strongly 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

Usability Item	1 Strongly disagree *f* (%)	2 Disagree *f* (%)	3 Quite disagree *f* (%)	4 Agree *f* (%)	5 Strongly agree *f* (%)	Mean	Level
Module could be applied in the teaching of mathematics	0 (0)	0 (0)	4 (11.8)	21 (61.8)	9 (26.5)	4.15	High
Learning goals are clearly stated in the module	0 (0)	0 (0)	1 (2.9)	18 (52.9)	15 (44.1)	4.41	High
Module does integrate ICT in the teaching of mathematics	0 (0)	0 (0)	4 (11.8)	21 (61.8)	9 (26.5)	4.15	High
Plotting graphs using Geometer's Sketchpad in mathematics lesson is appropriate	0 (0)	0 (0)	2 (5.9)	21 (61.8)	11 (32.4)	4.26	High
Application of the module makes learning more interesting	0 (0)	0 (0)	3 (8.8)	20 (58.8)	11 (32.4)	4.24	High
Experience as mathematics teacher does have an added value in using this module	0 (0)	0 (0)	2 (5.9)	24 (70.6)	8 (23.5)	4.18	High
Module is flexible and allows learners to navigate freely	0 (0)	0 (0)	2 (5.9)	25 (73.5)	7 (20.6)	4.15	High
Module allows learners to check their performance	0 (0)	0 (0)	1 (2.9)	21 (61.8)	12 (35.3)	4.32	High
Module motivates learning	0 (0)	0 (0)	2 (5.9)	22 (64.7)	10 (29.4)	4.24	High
Learning is controlled by the learner	0 (0)	0 (0)	2 (5.9)	26 (76.5)	6 (17.6)	4.12	High
Digital module is an added value	0 (0)	0 (0)	0 (0)	17 (50.0)	17 (50.0)	4.50	High
Overall mean	0 (0)	0 (0)	23 (6.1)	236 (63.1)	115 (30.7)	4.25	High

The results also showed that teachers agreed that the module can be used in the classroom to teach *Quadratic Function*s. 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 the study by Hennessy (2000), who demonstrated that learning graphs in Mathematics through the use of technology simplified learning and increase students understanding and confidence. Similarly, analysis from Teoh and Fong (2005) gave positive feedback on the use of *Mathsoft* in the learning of movements on straight lines which was also related to graphs. Their findings showed that the graph visualisation method using technology could enhance student understanding, thus achieved better level of learning (Becta, 2003a). The findings of this study was also parallel with the findings of Marzita and Rohaidah (2004) which revealed that the use of interactive multimedia was necessary in enticing students' attention and increasing students' understanding of mathematics. The examples and images in GSP enabled students in constructing the concepts learnt (Oldknow & Taylor, 2000). The study conducted by Haslina et al (2000) and 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. This technique also allowed the students to use their creativity to explore new shapes, conjectures, and solutions to the difficult ratios (Fallstrom & Walter, 2009). The digital module developed is learner-centred in nature and therefore is controlled by students at maximum level. This also implied that teachers' awareness of the need for change and their increased flexibility to accept learners' autonomy in shifting from teacher-centred to learner-centred pedagogy. This statement is inline with the research output of Uworwabayeho (2009) that Geometer's Sketchpad challenged teachers' practice and then provoked reflection to improve student learning.

CONCLUSION

From the results and discussion, it could 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. 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. The implication of this study is that exploratory learning method and the discussions involved in understanding the mathematical concepts adopted from the gsp digital module can help boost higher order thinking skills. It is suggested that a study on the applications of GSP in mathematics teaching to be carried out to promote such thinking skills among secondary school students.

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