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Dynamic Mathematical Learning Tools: Does It Work For Malaysian Classroom Learners?

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1. Introduction

This is a very exciting time in the development of the educational tool because of recent breakthroughs in technology which are making mobile computing devices ever smaller, powerful, robust, affordable and practicable. In Malaysian schools, we have already seen considerable developments in the educational use of Information and Communication and Technology (ICT) to support classroom teaching of mathematics with nearly all teachers having access to laptops, data projectors and the Internet, and also accessible to mathematical softwares as well as the use of handheld graphing calculators. Currently, Malaysia is in full gear to steer its economy towards a knowledge-based society which also calls for sustained, productivity-driven growth and technologically literate workforce prepared to participate fully in the global economy of the 21st century. In line with this vision, Malaysia's National Philosophy of Education calls for „developing the potentials of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally, and physically balanced and harmonious."
Much transformation has taken place, from the Smart School project to providing computer laboratories to thousands of schools in both rural and urban areas of the country. In tandem, other ICT-related projects which involved the training of teachers, school administrators and other school staff and innovative projects like the use of electronic books, e-learning, online learning and introduction of mathematical softwares and graphing calculators were rolled out to schools in the country.

2. Role of ICT in Mathematics Teaching and Learning

The role of ICT in mathematics education faces multiple challenges with the influx of new technologies introduced in the education system. Hence, computer-based technologies are now common in mathematics classrooms and the integration of these technologies into teaching and learning mathematics is supported by government policy in most countries. In Malaysia, the use of technology in teaching and learning of mathematics has consistently been one of the major emphases in Malaysian Integrated Curriculum for Secondary School

Mathematics. The concept of ICT in Malaysian Educaton System includes systems that enable information gathering, management, manipulation, access and communication in various forms. This means that ICT is used as an enabler to reduce the digital gap between the schools.

Teachers are encouraged to use the latest technology to help students understand mathematical concepts in depth and to enable them to explore mathematical ideas (Curriculum Development Centre, Ministry of Education, Malaysia, 2005). This emphasis is congruent with the NCTM's Technological Principle which states that, "Technology is essential in teaching and learning mathematics, it influences the mathematics that is taught and enhances students' learning" (NCTM, 2000, p. 24). The emphasis on integrating technology in the teaching and learning of mathematics is parallel with the aim of the mathematics curriculum: to develop individuals that are able to face challenges in everyday life that arise due to the advancement of science and technology (Curriculum Development Centre, Ministry of Education, Malaysia, 2005). However, technology does not replace the need for all students to learn and master the basic mathematical skills. Without the use of technologies such as the calculators or other electronic tools, students should still be able to add, subtract, multiply and divide efficiently. The mathematic curriculum therefore requires the use of technology to focus on the acquisition of mathematical concepts and knowledge rather than merely doing calculation.

There are many kinds of technology that are considered relevant to school mathematics which range from very powerful computer software such as Mathematica, Maple, and MathLab to much powerless technologies. For example, based on the Mathematics Curriculum Specification of Integrated Curriculum for Secondary School, the use of technology such as calculators, computers, educational software, websites in the Internet and relevant learning packages was highlighted as tools that can help to upgrade the pedagogical approach and thus promote the understanding of mathematical concepts in teaching and learning (Curriculum Development Centre, Ministry of Education, Malaysia, 2005). In addition, the application of these teaching resources will also help students absorb ideas, be creative, feel confident and be able to work independently or in group. School books are supplemented and complemented with CDs to enhance and enrich students understanding and make mathematics a fun-to-learn subject. The books were also organised with systematic features including exposes students to use of scientific and graphing calculators to obtain or check answer as well as introducing simple computer programming. Supplementary learning materials such as multimedia galleries, interactive activities, E-Tests and E-Maths Glossary were also provided to enrich and reinforce learning. Furthermore, the net-links materials were also attached at the end of each topic to encourage students to explore and gather more information as well as do research and to use ICT.

Prepelita-Raileanu (2008) suggested that teachers are to be educated concurrently with the increase use of information, communication technology (ICT). The role of teachers as organizers and distributor of the teaching have to be developed concurrently with the integration of ICT in any educational programmes. However much has to be explored and ICT, as any other tools in teaching and learning must be utilized and adapted to serve educational goals. Technology indeed has changed the way classrooms operate, integrating multimedia during learning, online accessibility thus making teaching and learning more interactive and participatory (Butler, 2008).

The rapid progress of technology has influenced the teaching and learning of mathematics. Many efforts are being made to enhance the learning experiences for students in learning mathematics. In the traditional teaching of mathematics, students are passive recipients when teacher passes complete information to them. Meanwhile, with the integration of technology such as computers and calculators, students are encouraged to get deeper understanding of concepts. Furthermore, technology can also develop a better understanding of abstract mathematical concepts by their visualization or graphic representation where it shows the relationships between objects and their properties. By having deeper understanding of concepts, this will increase the ability of the students when working with mathematics knowledge. Findings from Abu Bakar, Tarmizi, Ayub, Yunus (2008), also confirmed that students learning mathematics with the integration of technology were found more enthused and were enjoying their lessons more than students who had undergone the traditional approach. Consistently on students' level of avoidance, the mean of the group using technology was lower than that those perceived by the traditional group. This indicated that the technology group would not avoid using the software during mathematical learning activity.

Technological tools have been proven to be a very important aspect of the teaching learning process. Numerous studies show that the quality can be significantly enhanced when the tools are integrated with teaching. Research conducted showed that technological tools can enhance critical thinking, the level of conceptualization, and problem solving capacity. This novel technology is supposed to add value to education and to support more effective pedagogy by providing knowledge for learners and by enhancing communication that promotes learning.

The issue now being addressed is that does providing hands-on access for students to ICT in their normal mathematics lessons improved learning among these secondary students. These include the use computer softwares to provide mathematical modeling with 2D geometry and algebra; the use of 3D geometry software to develop visualization and modeling in space; and the use of hand-held devices with data-loggers in capturing and analyzing for experimental data. This paper sets out to exemplify the importance of educational use of ICT which can be to stimulate students' excitement and interest in dry and difficult subject like mathematics.

3. Use of Graphing Calculators

The use of technological props in mathematics teaching and learning namely the graphing calculators may benefit students and hence could materialise the Malaysian national agenda of introducing technology in the classroom. However, many teachers and parents believe that using technology may deprive students from employing their brains to perform computations and algebraic manipulations.

In Malaysia, calculators were strictly prohibited at both the primary and lower secondary levels before the year 2002. However, in 2002, usage of calculator was introduced for Form Two and Three students in lower secondary mathematics curriculum (Curriculum Development Centre, Ministry of Education, Malaysia, 2005). Currently, the usage of calculators is still prohibited in the primary grades while the usage of scientific calculators is prohibited in Form One. The latest reform in the Malaysian Secondary School Integrated Mathematics Curriculum calls for the need to integrate information technology in teaching

and learning of mathematics. In response to this call, mathematics teachers and students are now encouraged to use scientific and graphing calculators in the upper secondary mathematics classroom. Moreover, currently, scientific calculators are already allowed to be used at the Malaysian Certificate of Education examination level (Curriculum Development Centre, Ministry of Education, Malaysia, 2005).

The use of graphing calculators in teaching and learning enable various kinds of guided explorations to be undertaken. For example, students can investigate the effects of changing parameters of a function on the shape of its graph. They can also explore the relationships between gradients of pairs of lines and the lines themselves. These activities would have been too difficult to attempt without technology. Exploratory activity in mathematics may facilitate an active approach to learning as opposed to a passive approach where students just sit back passively listening to the teacher. This creates an enthusiastic learning environment. This clearly shows the application of constructivist learning environment.

Graphing calculators also offer a method of performing computations and algebraic manipulations that is more efficient and precise than paper-and-pencil method alone (Waits & Demana, 2000). Examples include finding the solutions of simultaneous equations or determine the equation of a straight line that is passing through two points. The mathematical concepts underpinning those procedures are rich and important for understanding. However, students often seem to put more effort in calculation and correspondingly less to making sense of the problems. Both attention to concepts and skill would be desirable in mathematics learning.

Rather than just the development of mechanical and computational skills, graphing calculators also allow for cultivation of analytical adeptness and proficiency in complex thought process (Pomerantz, 1997). Problems representing real-world situation and data with complicated numbers can also be addressed. This would offer new opportunities for students to encounter mathematical ideas not in the curriculum at present. With appropriate use of graphing calculator, students can avoid time-consuming, tedious procedures and devote a great deal of time concentrating on understanding concepts, developing higher order thinking skills, and learning relevant applications.

Jones (2000) argued that when students work with graphing calculator, they have potential to form an intelligent partnership, as graphing calculator can undertake significant cognitive processing on behalf of the user. This argument is in line with the distributed cognition and cognitive load theories. Distribution of cognition such that the larger part of cognitive process is taken over by the graphing calculator thus allowing learners to focus more on problem solving. From the cognitive load perspective, the focus of learning is to acquire problem solving schema rather than to acquire automation of mental arithmetic per se that distracts the real aim of problem solving. The distracting activities might exhaust learners' mental resources such that these activities will impose extraneous cognitive load and hence will be detrimental for learning. Therefore, instructional strategy that integrates the use of graphing calculator seems logical to reduce extraneous and increase germane cognitive load. This is because, as a result of distribution of cognition, graphing calculator offloads part of the cognitive process that reduces extraneous cognitive load, and this allows the learners to focus on more processing tool relevant for learning. The tool will help free the mental resources to enable them to acquire the necessary schemas and automation, or in other words the strategy simultaneously increases the germane cognitive load.

The formation of an intelligent partnership between the user and the graphing calculator also provides a crucial aspect of constant monitoring and checking of information (Jones, 2000). This is to make sure that the solution produced by the tool is consistent with the user's knowledge and understanding of the problem at hand. Indeed, with intelligent technology like the graphing calculator, the potential exists for the partnership to be far more intelligent than human alone (Salomon et al., 1991). The fact that learners work intelligently with the tool can be considered as helping learners to reflect upon their cognitive processing activities during learning which improve their metacognitive awareness levels and hence reduces cognitive load of the learning activities.

4. Use of Autograph Softwares

Autograph is another technology which is a dynamic software for teaching calculus, algebra and coordinate geometry. Its environment has 2D and 3D graphing capabilities for topics such as transformations, conic sections, vectors, slope, and derivatives. In real-time, users can observe how functions, graphs, equations, and calculations. Autograph can be used for drawing statistical graph, functions, and vector and for transforming shapes. It also enables users to change and animate graphs, shapes or vectors already plotted to encourage understanding of concept. In mathematics class the use of mathematical software enable students to visualize and further understand mathematical phenomenon in real life.

Teaching by integrating Autograph in schools might increase the effectiveness and the quality of teaching. As mathematics class needs lots of interaction, reasoning, observation the above view clearly indicates that interactive software like Autograph can be useful in teaching and learning mathematics effectively. Use of Autograph help teachers in making students attentive towards the interactive whiteboard and acts as a medium of interaction among students or between teacher and the students with rapid responses. Teacher can attract the whole class to the interactive whiteboard just by using the mouse and keyboard, save the work and can be viewed later on. These facts clearly indicates that Autograph is an extremely useful educational tool for both mathematics teachers and students which help teachers to present the content for the whole class easily and students understand better due to its visual demonstration.

The use of Autograph allows learners to acquire skills and knowledge in using the computers whilst concurrently explore the potentials of the software (Nordin, Zakaria, Embi & Mohd Yassin, 2008; Ayub, Tarmizi, Abu Bakar & Yunus, 2008). Their findings indicated that integration of GSP in teaching mathematics can be aided by the module developed and that learning of graphs and functions through utilization of technology simplified learning and increase students understanding. Specifically, Stacey (2007) contended that the use of software in mathematical learning enhanced the understanding of mathematical concepts related to variables and functions as well as provides motivation for the learning of Algebra.

5. Use of Geometer's Sketchpad

The teaching and learning of geometry utilizing dynamic geometry softwares have been explicitly indicated in the new Malaysian secondary school syllabus implemented in 2003. In the mathematics syllabus, teachers were recommended to utilize the Geometer's Sketchpad (GSP) software licensed to be used in the Malaysian schools. It was developed partly under

the Geometry Visual Project conducted in Pennsylvania and sponsored by the National Science Foundation. Geometer's Sketchpad (GSP) is a software programme that revolutionized the teaching and studying of mathematics especially in geometry. It is a computer software system for creating, exploring, and analyzing a wide range of mathematics concepts in the field of algebra, geometry, trigonometry, calculus, and other areas (Geometer's Sketchpad, Reference Manual, 2001). It is a dynamic geometry construction and exploration tool, which can make an enormous difference in the students' learning of Mathematics. It is easy to use and encourages a process of discovery in which students first visualize and analyze a problem and then make conjectures before attempting a proof. It is versatile enough to be used from primary six onwards through university undergraduates studies. Subject of mathematics that are relevant to be used with GSP are algebra, geometry, pre-calculus and calculus.

The GSP lets the user explore simple, as well as highly complex, theorems and relations in geometry (Giamatti, 1995) and has the ability to record students' constructions as scripts. The most useful aspect of scripting ones' constructions is that students can test whether their constructions work in general or whether they have discovered a special case. In addition, the GSP software provides the process of learning and teaching in a more creative way (Finzer and Bennett, 1995).

The purpose of this study is to investigate the instructional efficiency index of using graphing calculator (TI-84 Plus) and Autograph Software in teaching and learning of mathematics on Form Four secondary school students' in learning Quadratic Functions. Specifically, the objective of this study mainly is to compare the effects of utilizing the three technologies i.e. the graphing calculator, Autograph software and Geometer's Sketchpad on various performance measures in learning of Quadratic Functions topic.

6. Methodology

Experimental design was used for this study with students selected at random and assigned to four groups. The experimental group underwent learning using GSP, Autograph and graphing calculator technology while the control group underwent learning using conventional instructional strategy. Four phases were conducted, firstly the introduction to the software to be used by each particular group, followed by induction to the Quadratic Functions topic. Thirdly, students undergo the teaching and learning phase with the integration of the technology and Learning Activity Module. (see example of lesson activity using graphing calculator in Appendix 1) Finally sudents undergo the testing phase to examine the effects of the intervention provided during the learning sessions. An Achievement Test, the Paas Mental Effort Rating Scale and questionnaire were administered to the students. The data were analyzed using ANOVA and post-hoc analyses.

6.1 Population and Sample of Study

The target population of this study was Form Four students in National Secondary School in Malaysia. The samples selected for this study were Form Four students from two schools. The students were brought to the university to participate in the learning sessions. They were assigned to either of the four groups whereby group one were following the graphing calculator mode of learning, group two followed the Autograph learning mode, group three utilize the GSP and the fourth group was the conventional learning group.

6.2 Procedures

Four phases were conducted. In the first phase, the treatment groups were first introduced to the software. Each student in GC group was provided with one graphing calculator each. Students in Autograph group were provided with one computer installed with Autograph software whilst the third group was provided with GSP during the learning phase. In this phase, the students were required to explore and get familiar with the graphing calculator buttons and its functions and same also for the Autograph and GSP groups.

Then in second phase, students were introduced to the basic concept of the Quadratic Functions topic. In the teaching and learning using software phase, students were thought with constructivist approach where they were required to use exploratory and discovery learning on the topic. During the teaching and learning phase, students were given assessment questions to evaluate extent of short term learning. At the end of the learning or treatment session, students were given an achievement test. Teaching and learning phase for the GSP and Autograph group were same with the GC group. The control group's students were also guided by the same instructional format with one exception where the method used will not incorporate the use of TI-84 Plus graphing calculator, GSP and Autograph software. To assess mental load, students were required to state their mental effort expended or used for each question they answered in assessment and achievement test based on Paas Mental Effort Rating Scale.

6.3 Instruments

6.3.1 Mental Effort Rating Scale

Mental effort refers to the total amount of controlled cognitive processing in which a subject is engaged (Paas and Tuovinen, 2004). Mental effort is measured by a nine-point symmetrical category scale where the perceived mental effort is translated into a numerical value. Mental effort indicated the perceived amount of mental effort a student expended when solving mathematics problems given in the learning assessments during the acquisition phase and the posttest. It has 9- point symmetrical Likert scale measurement on which subject rates their mental effort used in performing a particular learning task.This is indicated by circled responses to the nine point symmetrical scale shown by students on the Paas Mental Effort Rating Scale (PMERS) given at the end of each question on acquisition as well as test phase.

6.3.2 Instructional Efficiency Index

This is a term which shows the relationship between learning and test (mental) effort and performance. In the study by Paas and Tuovinen (2004), mental effort (E) was measured on a scale of 1 (very, very, low mental effort) to 9 (very, very, high mental effort) whereas performance (P) was measured as the percentage of correct answers. The relative condition efficiency (E) is then calculated as

$$E = \frac{P - E_L - E_T}{\sqrt{3}}$$

Where E_L is the learning effort and E_T, the test effort (Paas & Tuovinen, 2004).

6.3.3 Mathematical Knowledge/Performance

Currently, there is more interest in how students acquire knowledge, how procedural and conceptual knowledge are linked and the mutual benefits of this linkage. Conceptual knowledge is defined by Hiebert and Lefevre as knowledge that is rich in relationship. It can be thought of as a connected web of knowledge, a network in which students are able to apply and link mathematical relationships to a variety of problems. Conceptual knowledge is characterised by links and a unit of conceptual knowledge cannot be an isolated piece of information. Furthermore, they emphasised that a piece of information is part of conceptual knowledge only if the holder recognises its relationship to other pieces of information. Hiebert and Lefevre note the following example of conceptual knowledge such as the construction of a relationship between the algorithm for multi-digit subtraction and knowledge of the positional values of digits (place value).

It is also assumed that conceptual knowledge is stored in some form of relational representation, like schemas, semantic networks or hierarchies (Byrnes & Wasik, 1991). It can be largely verbalized and flexibly transformed through processes of inference and reflection due to its' abstract nature and the fact that it can be consciously accessed. Therefore, it is not only bound up with specific problems but also can be generalised for a variety of problem types in a domain (Baroody, 2003).

On the other hand, as defined by Hiebert and Lefevre (1986), procedural knowledge in mathematics is composed of two parts namely the formal language or symbol representational, of mathematics and the algorithms, or rules, for completing mathematical tasks. It means that procedural knowledge can be classified as structural knowledge and algorithmic knowledge. The former is knowledge related to the meaning and appropriate use of mathematical symbols. It implies only an awareness of superficial features, but not knowledge of meaning or underlying structure. For example, we can write the string $x+2=3$ for some integer x, however the notation $2+=x3$ doesn't give an appropriate mathematical statement that falls under the first type of procedural knowledge. The algorithmic knowledge refers to step-by-step instructions that define precisely how to complete mathematical tasks or exercises in a predetermined linear sequence. For example, students who are able to do the algorithm for determining the value of x in $x+2=3$ is said to have the second type of procedural knowledge.

Procedural knowledge can also be described as the knowledge of operators and the conditions under which these can be used to reach certain goals (Byrnes & Wasik, 1991). This type of knowledge to some degree is said to be automated as it enables people to solve problems quickly and efficiently (Sweller, 2004; Tarmizi & Sweller, 1988; Schneider & Stern, 2005; Hiebert & Carpenter, 1992). According to Johnson (2003), automatization is accomplished through practice and allows for a quick activation and execution of procedural knowledge. In addition, as compared to the application of conceptual knowledge, its application involves minimal conscious attention and few cognitive resources. The automated nature of procedural knowledge implies that it is not or only partly open to conscious inspection and hence can be hardly verbalised or transformed by higher mental processes.

7. Effects of Graphing Calculator, Autograph, GSP and Conventional Strategy on Overall Performance

The means, standard deviations of the performance variable are provided in Table 1. For all statistical analysis, the 5% level of significant was used throughout the paper. The mean overall test performance for the graphing calculator group was 15.54 (SD = 3.14) meanwhile the mean overall test performance for Autograph group was 10.72 (SD = 3.47), whilst the GSP group was 11.78 (SD = 4.10) and the mean overall test performance for conventional group was 13.03 (SD = 3.65).
The one way ANOVA test results showed that there was a significant difference in mean test performance between GC group, Autograph group and conventional group, [$F(2,125) = 19.97$, $p<0.05$]. Further, planned comparison test showed that mean overall test performance of GC group was significantly higher from those two groups followed by conventional group and Autograph group have lowest mean. This finding indicated that the GC strategy group had performed better in test phase than the conventional group and Autograph.

Group	N	M	SD	SE
GC	42	15.54	3.14	.48
Autograph	39	10.72	3.47	.59
GSP	45	11.78	4.10	.54
Control	47	13.03	3.65	.53

Table 1. Comparison of overall performance

8. Effects of Graphing calculator, Autograph, GSP and Conventional strategy on Mental Effort

Means and standard deviations of the mental load expended during problem solving of each of the test question were obtained and as stated in Table 2. The mean mental effort during test phase of the GSP group was 5.61 and was the highest compared to mean mental effort of the Autograph group (M=4.95, SD = 1.88), followed by GC group (M=4.79, SD = 1.48) meanwhile the mean mental effort during test phase for conventional group was 4.46 (SD = 1.48). The one way ANOVA test results showed that there was no significant difference in mean mental effort during test phase between GC group and conventional group, ($F(2,98)= .709$, $p>0.05$). Further, comparison test showed that mean mental effort during test phase of GC group was lower than those of the Autograph group. This findings indicated that the GC strategy group had benefited from the learning sessions hence their mental effort was lower compared to the Autograph group.

Variables	Group	N	M	SD	SE
Mental effort (Test phase)	GC	38	4.79	1.48	.24
	GSP	45	5.61	2.03	.54
	Autograph	35	4.95	1.88	.32
	Control	28	4.46	1.48	.28

Table 2. Comparison of mental effort

9. Comparison of 2-D Instructional Efficiency Index of Utilization of Graphing Calculator, GSP, Autograph and Conventional Strategy

Table 3 shows results for evaluating the hypotheses 'There is significant difference in instructional efficiency index on groups using graphing calculator technology, Autograph and GSP technology and the conventional method in learning mathematics. The mean 2-D instructional efficiency for the GC group was .45 (SD = .84) and the mean 2-D instructional efficiency for control group was .22 (SD = .97) meanwhile the mean 2-D instructional efficiency for Autograph group was negative .51 (SD = 1.22) and the GSP group was negative .52 (SD = 1.26).

The results of a one way ANOVA test showed that there was significant difference on mean 2-D instructional efficiency index ($F(2, 98) = 7.047$, $p<0.05$) between the GC group, Autograph group and the conventional group. The planned comparison test on mean 2-D instructional condition efficiency index showed that the mean for GC group was significantly higher than conventional group followed by Autograph group. This suggests that learning mathematics by integrating the use of GC was more efficient than using conventional strategy and Autograph mode of learning.

Variables	Group	N	M	SD	SE
2-D instructional efficiency	GC	38	.45	.88	.1428
	Autograph	35	-.51	1.23	.2072
	GSP	45	-.52	1.26	.2213
	Control	28	.16	1.02	.1930

Table 3. Comparison on instructional efficiency

10. Effects of Graphing calculator, Autograph, GSP and Conventional strategy on Other Performance Variables

As can be seen from Table 4, the GC group (M=6.98, SD=.154) has a highest mean for the number of problem solved followed by Autograph group (M=6.64, SD=1.203) and the conventional group (M=6.28, SD=1.077). The one way ANOVA test showed significant differences, [$F(2,125) = 6.223$, $p<0.05$]. This implies that both groups solved more problems compared to the conventional group during solving the test problems.

The GC group (M=10.12, SD=3.06) has a highest mean for the total score of the conceptual knowledge followed by the conventional group (M=7.28, SD=3.63) and Autograph group (M=4.97, SD=3.24). Similar results were obtained from the total score of the conceptual knowledge, [$F(2,125) = 24.275$, $p < 0.05$]. This indicated that the GC, Autograph and the conventional groups were scoring differently based on the conceptual knowledge during the test phase. However, results obtained for the total score of the procedural knowledge showed no significant differences [$F(2,125) = 3.034$, $p> 0.05$].

In learning mathematics, the relationship between concepts and procedures has been studied in order to gain better understanding in learners tendencies to learn algorithms by rote without developing any understanding of what they are doing (Hiebert, 1986). According to Hiebert and Lefevre (1986), the students' development of conceptual and procedural knowledge varies throughout their school years. In elementary school, the

algorithm that students learn may not necessarily be connected to conceptual knowledge. They might develop the conceptual understanding of addition and subtraction through a story problem. However, this understanding may not be linked with the symbols used in arithmetic to describe the relationship between the numbers in the story. As students progress in schools, they are expected to learn more rules for manipulating symbols. Hence findings from this analysis indicated that both conceptual and procedural knowledge provide insights into learners understanding or performance. Since the GC group performed better than the other two groups, these findings may suggest that use of GC have impact on learning of algebra. Data analyses also indicated that there is significant difference in the total score of the test and number of error committed between GC and conventional group.

Variables	Group	N	M	SD	SE
No. of problems solved	GC	42	6.98	.154	.024
	Autograph	39	6.64	1.20	.193
	GSP	45	5.98	1.29	.233
	Control	47	6.28	1.08	.157
Total score of the conceptual knowledge	GC	42	10.12	3.06	.47
	Autograph	39	4.97	3.24	.52
	GSP	45	5.99	4.67	.65
	Control	47	7.28	3.63	.53
Total score of the procedural knowledge	GC	42	18.36	2.72	.42
	Autograph	39	16.92	3.86	.62
	GSP	45	18.40	1.39	.32
	Control	47	18.06	1.36	.19
Number of errors committed	GC	42	.79	.09	.09
	Autograph	39	2.29	2.87	.46
	GSP	45	1.95	1.54	.24
	Control	47	1.52	.90	.13

Table 4. Comparisons of selected variables

11. Conclusion

In this study, based on the 2-D instructional efficiency index calculation, utilizing graphing calculator was instructionally more efficient compared to conventional method and Autograph software. Use of GC had enhanced learning conditions with minimal extraneous cognitive load hence creating optimal learning condition.

Graphing calculators require students to apply their understanding of a concept so that it can be used effectively. There are many benefits using a handheld devices for instruction such as graphic calculator as reported by Ellington (2003). It was reported based on teachers'

opinion that using handheld graphing calculator for instruction could increased time using technology, increased technology proficiency, student's motivation, collaboration and communication and individualized instruction.

Saurino et al. (1999) found that the use of graphing calculator technology provide students enjoyment to the use of technology, ease of portability and complete higher-level work with understanding. Meanwhile a study by Thiel and Alagic (2004) in three pre-calculus classes showed that students increased understanding of key concepts and ability to solve difficult problems when using graphing calculator. As they gain a deeper understanding of the material, students acquire the critical thinking and problem-solving skills they need to attain greater academic success.

A research conducted by Quesada and Maxwell (1994) found that students taught using the graphing calculator had significantly higher scores than those taught by traditional method. While Gage (2000) found that using graphics calculators had a significant effect on performance with functions and graphs for algebra students.

These findings suggested that in utilizing any technological tools, a comprehensive measures addressing issues of instructional efficiency is crucial especially when involving large scale and formal implementation of technology integration in teaching and learning. With systematic planning of instructions and good learning package, learning mathematics using graphing calculator and Autograph will give new view in mathematics teaching and learning. Therefore, this shows that dynamic software, particularly graphing calculator provide positive impact upon learners thus becoming potential tools in teaching mathematics at Malaysian secondary school level.

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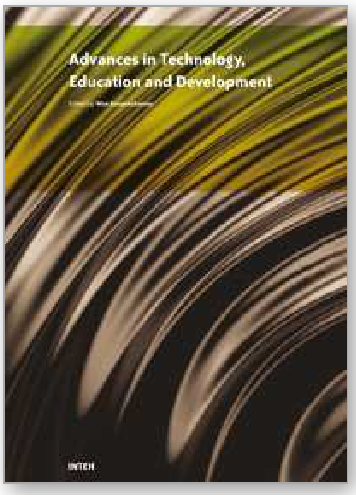
Appendix 1: Example of lesson activity using graphing calculator

Plotting graph of quadratic function f(x) = x^2

STEPS	INSTRUCTION	DISPLAY NOTES
1 To key in the function.	1. Press **Y=**	[**Y =**]
	2. Insert the function by pressing x^2	[**X,T, Θ ,*n***] [**x²**]
3 To plot points on the graph.	3. Set the windows setting to ZDecimal. ♦ Press **ZOOM** ♦ Press **4**	[**ZOOM→ 4**] **:** [**ZDecimal**]
4 To view the graph	4. To view overall of the graph ♦ Press WINDOW ♦ At Xmin , press -2 then press ▼ ♦ At Xmax , press 2 then press ▼▼ ♦ At Ymin, press -4 then press ▼ ♦ At Ymax, press 8 ♦ Press TRACE	[WINDOW] → [Xmin =] [-2] [Xmax =] [2] [Ymin =] [-4] [Ymax =] [8] → [TRACE]



Advances in Technology, Education and Development

Edited by Wim Kouwenhoven

ISBN 978-953-307-011-7
Hard cover, 474 pages
Publisher InTech
Published online 01, October, 2009
Published in print edition October, 2009

From 3rd to 5th March 2008 the International Association of Technology, Education and Development organised its International Technology, Education and Development Conference in Valencia, Spain. Over a hundred papers were presented by participants from a great variety of countries. Summarising, this book provides a kaleidoscopic view of work that is done, all over the world in (higher) education, characterised by the key words 'Education" and 'Development'. I wish the reader an enlightening experience.